Appendix A24.1 - Surface Water Hydrology

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Contents

1 Introduction

1.1 General Background

1.1.1 This hydrological assessment report is a technical appendix of Chapter 24 (Water Environment) of the Environmental Statement for the proposed Aberdeen Western Peripheral Route (AWPR). It focuses specifically on the hydrological impacts of the proposed scheme on watercourses that would be crossed by the road, within the Southern Leg study area.

1.1.2 Hydrology is concerned with the natural water cycle and is the earth science of water on or near the land surface. For the purposes of this report, the hydrological assessment addresses impacts on the flow and quantity of water on or near the land surface and associated flood risk.

1.1.3 Road schemes can impact on surface water hydrology through the introduction of structures and by disturbing the natural characteristics of a watercourse and its catchment. Watercourses may be affected, for example, by direct runoff from the road itself. As a result the natural magnitude, direction and timing of flood events can become significantly altered. Alterations to surface water hydrology could have associated implications for the local ecology, society and economy, as has been recognised by the EU Water Framework Directive and the Risk Framework of Scottish Planning Policy Guidance 7 (SPP7).

1.1.4 Within the study area, 19 watercourses, two ponds, two mosses and one loch may potentially be affected by the construction and operation of the Southern Leg section of the proposed scheme. These watercourses range in size, from small ephemeral field drains to larger fast flowing rivers, such as the River Dee, a major river that flows into the North Sea.

1.2 Assessment Aims

1.2.1 This report presents the assessment of potential impacts of the proposed scheme during operation and construction. Mitigation measures to avoid or reduce impacts of the proposed scheme on the hydrology of the local watercourses are provided.

1.2.2 Impacts on hydrology are intrinsically linked to hydrogeology (refer to Chapter 23: Geology, Contaminated Land and Groundwater), water quality (refer to Appendix A24.4), geomorphology (refer to Appendix A24.3) and freshwater ecology (refer to Appendix A25.9). The inter-relationship of the environmental assessment chapters and appendices is illustrated in Figure 1.

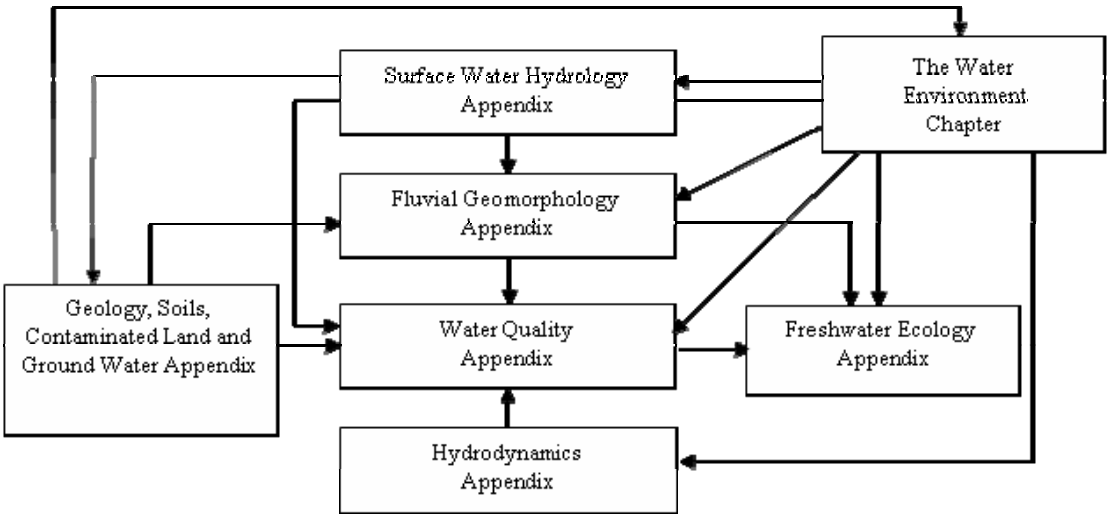

Figure 1: Flow chart illustrating the relationships between the technical appendices and chapters.

2 Approach and Methods

2.1 General Approach

2.1.1 The system of assessment followed the basic methodology detailed below:

- describe the present baseline condition;
- assess the potential impacts of the proposed scheme;
- provide mitigation measures for the potential impacts; and
- assess the residual impacts following adoption of the suggested measures.

2.1.2 The hydrological criteria used to assess the sensitivity of surface water features and the magnitude of potential impacts are defined in Table 1 and Table 2. The resultant significance of impact is defined by reference to both the sensitivity of the feature and the magnitude of impact, according to the matrix presented in Table 3.

2.1.3 The assessment of sensitivity of water features (Table 1) takes into account both the natural and built environments.

Table 1 – Criteria to Assess the Sensitivity of Water Features

Sensitivity	Criteria
High	A watercourse/hydrological feature with hydrological importance to: sensitive and protected ecosystems; critical economic and social uses (e.g. water supply, navigation, recreation, amenity etc); the flooding of property (or land use of great value) that has been susceptible to flooding in the past. Or a watercourse/floodplain/hydrological feature that provides critical flood alleviation benefits. Or any property that is at risk of flooding due to the proposed road scheme.
Medium	A watercourse/hydrological feature with some but limited hydrological importance to: sensitive or protected ecosystems; economic and social uses (e.g. water supply, navigation, recreation, amenity etc); the flooding of property (or land use of value) that may potentially be susceptible to flooding. Or a watercourse/floodplain/hydrological feature that provides some flood alleviation benefits.
Low	A watercourse with minimal hydrological importance to: sensitive or protected ecosystems; economic and social uses (e.g. water supply, navigation, recreation, amenity etc); the flooding of property (or land use of value). Or a watercourse/floodplain/hydrological feature that provides minimal flood alleviation benefits.

Table 2 – Criteria to Assess the Magnitude of the Potential Impact on Water Features

Magnitude	Criteria
High	Major shift away from baseline conditions and major changes to the flow regime (low, mean and or high flows – at the site, upstream and/or downstream). An alteration to a catchment area in excess of a 25% reduction or increase in area. The extent of "medium to high risk" areas [classified by the Risk Framework of Scottish Planning Policy Guidance 7 (SPP7)] will be significantly increased. This means there will be significantly more areas/properties at risk from flooding by the 0.5% (1 in 200-year) or greater annual exceedance probability (AEP).
Medium	Moderate shift away from baseline conditions and moderate changes to the flow regime. An alteration to a catchment area in excess of a 10% but less than 25% reduction or increase in area. The extent of "medium to high risk" areas [classified by the Risk Framework of Scottish Planning Policy Guidance 7 (SPP7)] will be moderately increased.
Low	Minor shift away from baseline conditions and minimum changes to the flow regime. An alteration to a catchment area in excess of a 1% but less than 10% reduction or increase in area. The extent of "medium to high risk" areas [classified by the Risk Framework of Scottish Planning Policy Guidance 7 (SPP7)] will be similar to the magnitude of the errors attached to the estimate of the extent.
Negligible	Very slight shift away from baseline conditions and negligible changes to the flow regime (i.e. changes that are within the monitoring errors). An alteration to a catchment area in excess of a 1% reduction or increase in area. The extent of "medium to high risk" areas [classified by the Risk Framework of Scottish Planning Policy Guidance 7 (SPP7)] will be much smaller than the errors attached to the estimate of the extent.

Table 3 – Impact Significance Matrix

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

2.1.4 The assessment takes into account the Scottish Executive 'Scottish Planning Policy (SPP) 7: Planning and Flooding' (2004) and the Design Manual for Roads and Bridges (DMRB) Volume 4, Section 2 "Drainage". DMRB (Volume 11 Section 3 Part 10 HA 216/06 2.37-2.41) advises that if a scheme has the potential to significant affect floodplain capacity, an assessment should be undertaken on:

- the reduction of capacity;
- the effectiveness of the proposed mitigation works; and
- the residual impact of the scheme on increased flood risk.

2.1.5 Other appropriate studies should be undertaken where other potentially significant hydrological effects are identified that could impinge on any of the current or proposed uses of the receiving waters.

2.1.6 In addition, the requirements of the EU Water Framework Directive were also taken into account when developing the methodology using SEPA policy guidance 'The Future for Scotland's Waters, Guiding Principles on the Technical Requirements of the Water Framework Directive' (SEPA, 2002).

2.1.7 Controlled Activities (Scotland) Regulations 2005 (CAR) state that it is an offence to discharge to all wetlands, surface waters and groundwaters without CAR authorisation. There are three different types of authorisation under CAR: General Binding Rules (GBR), Registration and License (both simple and complex). The level of regulation increases as the activity poses a progressively deleterious impact on the water environment. The level of authorisation required for the AWPR is dependent on the activity proposed but is likely to range from GBR, covering some construction activities and outfalls, to licences required for outfalls (draining over 1km of road in length), culverting and watercourse realignment. The applications will require baseline environmental information of the watercourse, details of the proposed design and a detailed construction method statement. These will be developed prior to construction and will require approval from SEPA before construction can begin.

2.2 Surface Water Assessment Methodology

Consultation

2.2.1 In Scotland, local authorities are responsible for watercourses and flooding matters. Aberdeen City and Aberdeenshire Councils were contacted to obtain baseline information including information on economic and recreational uses of the watercourses, existing and historic flood risk and relevant flood studies. Similarly, SEPA were also contacted with regards to their understanding of the flood risk posed by the various watercourses as well as flow and watercourse information. The 'Hydrological Data United Kingdom: Hydrometric Register and Statistics 1996-2000' (Centre for Hydrology and Ecology, 2003), SEPA, and the HiFlows-UK website were consulted to gain information on gauged catchments.

Existing Conditions

2.2.2 For each identified watercourse the following estimates have been calculated for existing baseline conditions;

- 95-percentile flow (Q_{95});
- mean flow (Q_{mean});
- bankfull (Q_{BF}) and embankment-full (Q_{EBF}) flow;
- median annual maximum flood (Q_{MED});
- mean annual maximum flood (Q_{BAR});
- flood design peak flows including the 1% and 0.5% annual exceedance probability (AEP) flows (also known as the 100-year and 200-year flood design peak flows); and
- present potential flood risk using the SEPA 'Indicative River and Coastal Flood Map (Scotland)' site visits and desktop analysis of 1:25,000 Ordnance Survey maps.

2.2.3 Necessary hydrological catchment characteristics were obtained from Ordnance Survey, soils, geological and land use maps as well as the Flood Estimation Handbook (FEH) CD-ROM (IH, 1999).

2.2.4 Table 4 identifies the flow parameters and methodologies that were used to calculate these estimates. It is noted that, apart from the River Dee, all watercourses in the Southern Leg study area that would be crossed by the proposed scheme are relatively small, ungauged catchments. Flow estimation on ungauged watercourses is generally subject to significant uncertainties.

2.2.5 In order to increase the confidence in the standard desk based flow estimates, site measurements aimed at refining several of the hydrological parameters were undertaken for representative catchments in May 2006. In addition, each watercourse was carefully inspected during site visits in 2006. The hydrological analyses used desk-based procedures; gauged data from donor/analogue catchments; and where appropriate, spot gauging data.

Assessment of Impacts

2.2.6 The significance of a particular impact depends on the baseline conditions of each individual watercourse and the type and position of any road structure.

2.2.7 Potential post-development changes to catchment parameters (Table 4) are highlighted, in addition to potential changes to flood risk and floodplain inundation. These are assessed by recalculating parameters (Table 4) for a catchment with the scheme in place. The most significant parameter that is likely to change is generally the size of catchment area for a watercourse as the presence of the road would sever existing catchments.

2.2.8 Flood risk assessment for scheme watercourse crossing points has been carried out using the SEPA 'Indicative River and Coastal Flood Map (Scotland)'. These maps have been designed to show the flood extent from watercourses and the sea of the 0.5% AEP (1:200-year flood) event. The SEPA flood risk maps, however, do not show the flood risk for watercourses with a catchment smaller than 3km². Table 5 shows the flood risk at the proposed road crossing point where flood risk information is available. More information regarding the 'Indicative River and Coastal Flood Map (Scotland)' can be found on the SEPA website.

2.2.9 For watercourses outwith the SEPA Indicative Flood Maps, flood risk was determined through a desk based assessment of each affected watercourse. The desk based flood risk assessment was based on the distance, position and height difference (assessed using 1:25000m Ordnance Survey plans and 1:1250m detailed design plans) between the proposed culvert and any properties upstream of the proposed culvert entrance. Identification of land use upstream of the culvert was

also required as wooded areas can potentially produce more debris that can block culverts. This approach was used to identify properties that could potentially be at risk during extreme events.

2.2.10 The potential impacts of watercourse realignments is assessed assuming that realigned sections of watercourses would be constructed to a specification that would maintain existing channel dimensions, gradients and surface runoff pathways.

2.2.11 In the assessment, all culverts are considered to be flood flow culverts. Flood flow culverts are designed to convey the 0.5% AEP (200-year flow). All network culverts are designed to the standard 1.33% AEP (75-year flow) in line with the road drainage network, which is designed to the standards set out in the DMRB HA 106/04. While the potential flood risk posed by the presence of network culverts is assessed, they have not been assigned a baseline sensitivity as they are not an existing feature.

2.2.12 When assessing the impact of the proposed scheme on a watercourse, the percentage change in total catchment area of an affected watercourse is viewed as one indicator of potential impacts. Catchment changes of 1% or less are considered to be of negligible magnitude, changes of less than 10% are considered low, changes of less than 25% are considered medium and changes greater than 25% are considered a high impact. These values have been selected as indicators of the likely significance of changes in catchment area to a watercourse. These values are an estimate based on professional hydrological judgement, however they provide a guide to the potential significance of a loss/increase of catchment area on a watercourse.

Allowance for Climate Change in Hydrological Parameters

2.2.13 Guidance on allowance for climate change has been taken from a scoping study regarding climate change and hydrological parameters (SEPA, 2005). SEPA do not define a specific value, but suggests that the sensitivity of flows within flood risk analysis could be carried out up to a 20% increase for the east of Scotland. This is considered the maximum change and evidence suggests that by 2050 there is more likely to be an increase of approximately 15% in the east of Scotland (Price and McKenna, 2003).

2.2.14 The Scottish Executive (2004) states in the SPP7 Planning and Flooding Report that the threshold annual exceedance probability floods 0.5% (200-year) and 0.1% (1000-year) include an allowance for climate change. The Scottish Executive also indicates that developments should now be designed to the 0.5% annual exceedance probability design flood event instead of the 1% annual exceedance probability event (AEP) to allow for possible future climate change increases.

Table 4 – Hydrological Parameters and Methodologies

Description	Parameter	Proposed methodology
Median annual maximum flood	Q_{MED}	Estimation of median annual maximum flood flow (Q_{MED}) was required in order to determine flood design peak flows and was estimated for all watercourses following the guidance of the Flood Estimation Handbook (FEH) (IH, 1999). The QMED from catchment descriptors at ungauged subject sites was refined by using a regional factor based upon interpretation of general performance of the FEH empirical equations against values obtained from gauged sites on the Rivers Don, Dee and Ythan that were deemed to have sufficient hydro-climatic similarity to help refine the estimates. FEH guidance on the degree of uncertainty associated with Q_{MED} estimates from catchment descriptors is ± 55%. This methodology provides a baseline characteristic for each watercourse. Potential impacts may also be assessed using this method if there is an increase or decrease in catchment size caused by the scheme.
Mean annual maximum flood	Q_{BAR}	Estimation of average annual maximum flood (Q_{BAR}) was required in order to determine flood design peak flows and as a comparison to the calculated Q_{MED} values. For all catchments Q_{BAR} was estimated using the methodology of the Institute of Hydrology Report No.124 (IH124) (IH, 1994). IH124 guidance on the degree of uncertainty associated with Q_{BAR} estimates from catchment descriptors is ± 65% This methodology provides a baseline characteristic of each watercourse. Potential impacts may also be assessed using this method if there is an increase or decrease in catchment size caused by the scheme.
Flood design peak flows	Q-Tyr	tandard application of the FEH statistical pooling group method was used on a sub et of catchments to determine flood frequency curves for each burn. The curve was efined using the following % AEP: 50%, 20%, 10%, 2%, 1%, 0.5% AEP (design eturn periods: 2, 5, 10, 50, 100, 200-years). Based upon the similarity of the growth urves and the apparent similarity in catchment characteristics across the area of nterest, a single average growth curve was derived and applied to the other atchments. No formal quantification of Q-Tyr uncertainty is provided in the FEH but it s likely to be at least in the order of the Q_{MED} uncertainty ± 55% and in some ircumstance will be appreciably larger. For comparison purposes and to fulfil the requirements of the DMRB the IH124 method was also followed, using the regional growth curve of the Flood Studies Supplementary Report No.14 (FSSR14). For completeness, a comparison of the results of the FEH (IH, 1999) and IH124 is included in the Appendix A24.7 Annex 1. The 0.5% AEP (200-year return period) design flow was further used for culvert design. Comparison was made with bankfull flows to give an indication of stream capacities and potential flooding. High flows were provided to support fluvial geomorphological assessments. This methodology provides baseline conditions as well as providing the potential impacts for the removal or culverting of any watercourses along the AWPR Southern Leg. These values will also provide the mitigation values to correctly size any structures across watercourses.
Mean flow & 95-percentile flow	Q_{mean} Q_{95}	Q_{mean} and Q_{95} values are baseline conditions and were provided to support water quality (A24.4), ecological (A25.9) and geomorphological (A24.3) assessments. Mean flow (Q_{mean}) and 95-percentile flow (Q_{95}) for ungauged watercourses for which LF2000 was not applied, were estimated by applying the donor catchment principle using the flow duration curves obtained for the ten selected watercourses. A donor for each ungauged watercourse was selected based on hydrological similarity, which was determined on the basis of the parameters SPRHOST and BFIHOST. CEH Wallingford state that the predictive uncertainty associated with the estimate of annual Q_{95} is 1.32 l/s/km² and the uncertainty in the estimate of annual mean flow is ±11%. These quoted uncertainties are 68% confidence limits on the estimated natural values. For the River Dee, this was not necessary as gauged data was available.
Bankfull flow * Embankment-full flow **	Q_{BF} Q_{EBF}	Bankfull (Q_{BF}) and embankment-full (Q_{EBF}) flow were estimated using Manning's Equation. Q_{BF} and Q_{EBF} are baseline conditions and were provided to support geomorphological assessments. During a site visit in May 2005 measurements of the dimension of channel cross-sections and estimates of channel roughness were taken. These were verified with information from OS contour maps and photographs. The parameters presented are indicative only. There is inherent uncertainty

Description	Parameter	Proposed methodology
		associated with empirical measurements. The roughness coefficient is a subjective value based on best estimate, which can vary from 0 to 1. Flow is directly proportional to changes in the roughness coefficient irrespective of gradient. A change in the roughness coefficient of 10% gives a 10% change in flow. Sensitivity to roughness coefficients on a channel with gradient > 0 < 0.05 is in the region of < ±15% for a 0.005 variation in roughness. For a gradient > 0.05 < 0.1 uncertainty for a similar variation in the roughness coefficient is approximately < ±15%. For the River Dee a hydraulic river model has been created for the flood risk assessment component of the work. This model was used to determine bankfull flow for the River Dee and is presented in Appendix A24.2.
Monthly mean flow velocity	v_{month}	Monthly mean flow velocities (v_{month}) are baseline conditions and were provided to support ecological assessments. Long-term mean monthly flow velocities were estimated using Manning's Equation and were based on approximate channel dimensions and mean monthly flows from flow duration curves. Mean monthly flows for ungauged watercourses for which LF2000 was not applied, were estimated by applying the donor principle using the flow duration curves obtained for the ten selected watercourses (see method statement for Q_{mean} and Q_{95}). Uncertainty with this method will incorporate errors associated with the calculation of Q_{BF}, Q_{EBF}, Q_{95} and Q_{mean}. An approximate estimation of the uncertainty of these calculations combined would be in the region of ±20 – 25%. The River Dee hydraulic river model has been created for the flood risk assessment component of the ES. This model in combination with the mean monthly flow was used to determine monthly mean flow velocities (see Appendix A24.2).
Greenfield runoff rate	q green	In order to provide an estimate of Greenfield runoff rates (q green) for each of the drainage outfall locations the average of two methodologies was used. These methodologies are the FEH catchment area method and the Rational Method. SEPA guidance is given in the booklet 'Guidance for Developers and Regulators Drainage Impact Assessment' (DP 300 3/02) and states, that in general the 50% AEP (two-year return period) one hour rainfall event should be used to determine the pre-development runoff for the existing site (refer DP 300 3/02) (i.e. predevelopment or as a 'Greenfield site'). According to CIRIA 609 (CIRIA, 2004) common values used for Greenfield runoff rates vary between 5 to 7 l/s/ha. However, care should be taken if applying these values, as they may not be applicable to individual sites, since the runoff rate is dependent on factors that include soil type and site gradient. Thus, to provide more site specific estimates of Greenfield runoff the average of the FEH catchment area method and the Rational Method was applied to the outfall locations on the scheme. The FEH catchment area method uses the 50% AEP (2-year return period or Q_{MED}, see above method for calculation of median flood flow) FEH flow estimate at the drainage outfall location divided by the area of the catchment to this point to derive a Greenfield runoff rate in litre/second/hectare. The Rational Method assumes a 1 hectare (ha) catchment and a 60 minute storm duration. The basic form of this method is the following equation: Peak Flow (l/s) = 2.78 * *C* */(mm/hr) * *A* (ha) Where: *C* is the coefficient of runoff *I* is the intensity of rainfall *A* is the area under consideration Values of *C* are described as varying from 0.05 to represent flat lawns with sandy soils to a maximum of 0.95 representing almost completely impermeable heavily urbanised areas (Maidment, 1993, Table 9.4.1). In this case, the value of *C* was set at 0.2 to represent rural land with heavy soils. The rainfall intensity value, *I*, is determined by dividing the rain depth (mm) for various return periods by the 'Time of Concentration' or storm duration. The rain depth for each return period is determined using the Flood Studies Report (FSR) method. This approach involves obtaining the depth of rainfall with a 20% AEP (return period of 5-years) from the standard FSR maps (Wilson, 2004, Appendix A) and multiplying this value by the appropriate growth factor for the desired return period (Wilson, 2004, Tables, 2.6 and 2.7). Uncertainty within these methods is likely to be at least in the order of the Q_{MED} uncertainty ± 55% and in some circumstance will be appreciably larger.

Description	Parameter	Proposed methodology
Flow duration Curves	N/A	Key parameters for the Water Quality Modelling are annual and monthly flow duration curves for each of the target model locations. As part of previous work on the AWPR Scheme, Low Flows 2000 estimates were supplied by CEH Wallingford for a number of watercourses within the route corridor. Due to uncertainties inherent in desk based estimates of flow duration curves, check spot gaugings were taken in April 2005 and compared to the Low Flows 2000 predicted curves. The spot gaugings taken on the five streams lend support to the Low Flows 2000 predicted flow duration curves. The watercourses (for which Low Flows 2000 estimates were derived) were then used as donor catchments to provide information for any remaining ungauged target catchments requiring flow duration curves. Selection of appropriate donor sites for each target location is based primarily on examination of the similarity of BFI (Baseflow Index) however area, SPRHOST (Standard Percentage Runoff based on the Hydrology of the Soil Type), SAAR (Standard Annual Average Rainfall), evaporation, presence of waterbodies within the catchment and geographical proximity have also been considered. The following steps were then undertaken to calculate the flow duration curves: Calculate annual mean flow (Q_{mean}) for each of the target sites based on SAAR and an average annual value of evaporation (taken from the CEH calculated values). Monthly mean flow is calculated using the same relative monthly pattern as given for the donor site. Standardise the donor flow duration curves by dividing by the appropriate Q_{mean} value (either annual Q_{mean} or a particular month Q_{mean}). Where there is no single obvious donor corresponding to the target location, a combination of donor sites were investigated, and where appropriate a weighted average of the standardised curves was used. Multiply the standardised flow duration curves by the appropriate mean flow value (annual or specific month) of the target site to give target site flow duration curve (annual or specific month).
Road Runoff Duration Curve	N/A	A further requirement of the Water Quality Modelling is a road runoff duration curve. This is not a common request and no formal guidance on methodology was found. The method followed was to calculate a rainfall duration curve from 15-minute rainfall data from the SEPA tipping bucket gauge Westhill (No. RI849197) and assume that the flow/runoff from the road would be largely similar to the rainfall frequency characteristics. In total, ten complete years of 15-minute rainfall data (1995 to 2004) and two incomplete years of 15-minute rainfall data (1994, 2005) were used to construct the rainfall duration curve. Given that rainfall only occurs on a small sub-set of the 15-minute intervals from the whole period of record and in particular that the intense storms make up an even smaller sub-set it was important to construct the rain duration curve with a suitably finely divided x-axis (x-axis shows the percentage of time that the rainfall exceeds a certain rate). Given the need to potentially capture the highest 15-minute rainfall intensities in the water quality modelling, a rainfall duration curve with 0.01% x-axis resolution was constructed and used within the SIMCAT modelling. The rainfall data in each increment was transferred to flow data by simply converting the rainfall intensity per unit area to a flow by multiplying by the area of the road section in question. This is a rather simplified approach but thought adequate for the required analysis since it gives a conservatively high estimate of runoff from the road.
Construction Site Design Hydrographs	N/A	The Sediment Modelling work required an estimate of potential runoff hydrographs from the proposed construction site at the River Dee (Appendix A24.5). For the purposes of this work the proposed construction site on the River Dee was separated into three distinct sections (one on the south and two on the north). In order to calculate peak runoff volumes from the sites, design rainfall depths were calculated. The design storm duration was calculated for each individual construction site. The Flood Studies Report (FSR) rainfall statistics were used to estimate the design rainfall depths for the construction sites as these are believed to be more appropriate than the FEH statistics for sub half-hourly storm durations. The ground surface of the two construction sites will vary at different stages of the works however flows have been calculated for the worst case scenario of bare compacted surfaces. The SCS (USDA Soil Conservation Service) velocity method was used to calculate the time-of-concentration using the following equation: Tc = (l/v)/3600 Where l is the length of section and v is the velocity in feet per second expected for the type of land cover.

Description	Parameter	Proposed methodology
		Using the FSR design rainfall, the Modified Rational Method was employed to calculate the peak runoff that may be expected from the site. The equation for the modified rational method is as follows: Qp = 0.278.Cv.Cr.i.A Where Cv = volumetric runoff coefficient Cr = dimensionless routing coefficient i = rainfall intensity A = catchment area A simple triangular hydrograph was used as an estimate of the runoff from the sites. The time-to-peak was assumed to occur at Tc/2. The time base of the hydrograph was calculated such that by adjusting the falling limb of the hydrograph, the area under the graph equated to the volume of runoff
SEPA Indicative River and Coastal Flood Map (Scotland)	N/A	Where available, of the watercourses that would be crossed by the scheme has been carried out using the SEPA 'Indicative River and Coastal Flood Map (Scotland)'. The SEPA indicative flood risk maps have been designed to show the flood extent from watercourses and the sea of the 0.5% AEP (1:200-year flood event). The SEPA flood risk maps, however, do not show the flood risk for watercourses smaller than 3km². Table 5 shows the flood risk at the proposed road crossing point where flood risk information is available. More information regarding the 'Indicative River and Coastal Flood Map (Scotland)' can be found on the SEPA website. Areas not covered by the SEPA 'Indicative River and Coastal Flood Map (Scotland)' have been assessed using information obtained during a site visit and a desktop assessment of 1:25,000 Ordnance Survey Maps.

Low Flows 2000 estimates were supplied by CEH Wallingford. Basic input information such as catchment area and boundaries were checked and where necessary refined in line with understanding gained during site visits and mapped information.
* Bankfull flow = the flow capacity of the watercourse with out any water inundating adjacent ground.
** Embankment-full flow = the flow capacity of the watercourse feature including any artificial embankments or berms. It can be thought of as the confined flow that does not spread away from the path of the watercourse corridor.

2.3 Limitations to Assessment

2.3.1 Continuous monitoring of hydrological data in the study area is available for the River Dee. The remaining smaller watercourses are ungauged. The highest degree of accuracy is obtained where long term monitoring data exists (the River Dee). For the smaller, ungauged watercourses, uncertainties are inherently larger.

2.3.2 A higher degree of accuracy, for small ungauged catchments, would require the installation of hydrometric monitoring equipment and the collation of a relatively long period of data (preferably several years of record). This is considered to be outwith the scope of the current study. Where possible, site visits and one-off measurements have been taken to improve the robustness of the estimates.

3 Baseline

3.1 Baseline Assessment

3.1.1 An assessment of baseline hydrological conditions has been carried out for each water feature in the study area. The watercourses within the study area include sensitive and protected ecosystems such as Hare Moss, the Moss of Auchlea and the River Dee, which have been assigned the highest water feature sensitivity. Less sensitive sites include modified natural watercourses, excavated field drainage ditches and ephemeral watercourses.

3.1.2 Table 5 details the baseline hydrological conditions of water features in the study area. Figures 24.2a-c present the location plan of catchments, proposed culverts, flow gauges and rain gauges referred to in this assessment. Figure 24.2d provides a more detailed location plan of the catchment for Hare Moss.

3.1.3 Estimated flood flows are provided in Annex 1 of Appendix A24.7. Annex 22 Appendix A9.5 summarises the flow duration curves derived by using Low Flows 2000 (LF2000) software and compares them to spot gaugings that were taken during site visits in April 2005, for selected watercourses. The LF2000 information was then applied to other parameters following donor principles, and in that sense is pertinent to this report.

3.1.4 Annexes 3-21 of Appendix A24.7 provide information on the parameters indicated in Table 4 for each of the affected watercourses.

Table 5 – Baseline Conditions

Water Feature	Annex	Description	Sensitivity
Loirston Burn/ Loirston Loch	3	Catchment area at the lowest road crossing point (chainage 205585) = 1.79km^2. The burn flows in a north easterly direction. The upper reaches of the catchment drain forested land while the middle and lower reaches pass through farm land with field drainage systems adjoining the Loirston Burn. The burn discharges into Loirston Loch (Local Plan District Wildlife Site) where it is the dominant supply of water and therefore very important in maintaining the water balance of the loch. There are no known abstractions from this watercourse. At the proposed road crossing points the Indicative River and Coastal Flood Maps (Scotland) predict no risk of flooding at the 0.5% AEP (200-year return period event). The Loirston Burn catchment area is larger than 3km² however, it is unclear whether the Indicative River and Coastal Flood Maps (Scotland) extends to the points of interest on Loirston Burn and whether it properly represents the processes occurring at the location of the road crossing point. Further desktop analysis of a 1:25,000 OS map indicates there is a potential flood risk to properties within 100m of the site of interest and within the 5m height resolution of the map.	Medium
Greengate Ditch	4	Catchment area at the proposed road crossing point (chainage 205050) = 0.2km^2. This is a field ditch that appears unconnected to a major watercourse. The catchment predominately drains a forested area to the east of Hare Moss. This watercourse is unconnected to Hare Moss and is therefore unlikely to be important in the water balance of this sensitive environment. The ditch is thought to be ephemeral in character. It is thought the ditch is most likely to drain north to the Loirston Burn catchment. There are no known abstractions from this watercourse. Desktop assessment of the 1:25,000 OS maps indicates there is no flood risk to properties at the site of interest. Flood risk assessment using the SEPA 'Indicative River and Coastal Flood Map (Scotland)' has not been completed for this site as SEPA Flood Risk maps are not available for catchments less than 3km².	Low
Jameston Ditch	5	Catchment area at the proposed outfall point (chainage 204500) = 0.2 km². The field ditch runs along the northern edge of Hare Moss, flowing in a north westerly direction into the Burn of Ardoe. The area it drains is predominantly flat agricultural land. Connectivity between the moss and the ditch may be important in maintaining water level in the Hare Moss area. Based on information available and on site visits it is thought that Jameston Ditch is downstream of the Hare Moss catchment. Thus, although connected to the moss, the ditch allows water to flow away from the moss catchment. The ditch may have an important role to play at the confluence with the Burn of Ardoe in controlling water levels within the area of the moss, particularly during periods of flood. Jameston Ditch has therefore been assigned a sensitivity of high. There are no known abstractions from this watercourse. Desktop assessment of the 1:25,000 OS maps indicates there is no flood risk to properties at the site of interest. Flood risk assessment using the SEPA 'Indicative River and Coastal Flood Map (Scotland)' has not been completed for this site as SEPA Flood Risk maps are not available for catchments less than 3km².	High
Burn of Ardoe	6	Catchment area at the proposed road crossing point (chainage 204000) = 0.1km^2 The smallest of the catchments draining to Hare Moss flowing in a north westerly direction. Although small this burn provides an important supply of water to Hare Moss. The burn provides water year round. The connection with Heathfield Burn may be important in controlling the level of the burn particularly during high flows. The burn has been observed to flood during a site visit (November 2005) from the confluence and upstream of the confluence with Heathfield Burn. This process is important in supplying water to areas of the moss more distant from watercourses. It is likely that the burn has been modified as part of a field drainage system and this may have affected the supply of water to the moss area. There are no known abstractions from this watercourse. Desktop assessment of the 1:25,000 OS maps indicates there is no flood risk to properties at the site of interest. Flood risk assessment using the SEPA 'Indicative River and Coastal Flood Map (Scotland)' has not been completed for this site as SEPA Flood Risk maps are not available for catchments less than 3km².	High
Bishopston Ditch	7	Catchment area at the proposed road crossing point (chainage 203900) = 0.2km^2 A catchment draining into Hare Moss flowing in a northerly direction. This ditch is likely to be important in the water balance of this sensitive environment. Several small drainage ditches join the burn as it flows through rough pasture. It is thought that Bishopton Ditch was constructed as part of a field drainage system. Although	High

Water Feature	Annex	Description	Sensitivity
		seen to be ephemeral (site visit, July 2006) it is likely that this burn is an important supply of water during winter months. This is especially the case during periods of out-of-bank flow when water is supplied to areas of the moss distant from watercourses. There are no known abstractions from this watercourse. At present, there is limited flood risk to 2 dwellings upstream of the proposed AWPR crossing point. This flood risk assessment was conducted using 1:25,000 Ordnance Survey maps and was based on the proximity of the houses to the watercourse. Flood risk assessment using the SEPA 'Indicative River and Coastal Flood Map (Scotland)' has not been completed for this site as SEPA Flood Risk maps are not available for catchments less than 3km².	
Heathfield Burn	8	Catchment area at the proposed road crossing point (chainage 203650) = 0.8km^2 Heathfield Burn has the largest of all catchments of the burns supplying the Hare Moss system and is thus important in maintaining the moss environment. The burn flows in a north easterly direction and runs along the western boundary of the moss. It is likely that the burn has been heavily modified for a field drainage system. The burn appears to have significant connectivity to the moss and supplies water to it throughout the year. The confluence with the Burn of Ardoe is also thought to be of importance during periods of out-of-bank flow in supplying water to areas of the moss more remote from watercourses. A reduction in supply to this burn may have a significantly detrimental impact on the Hare Moss system. Private water supplies (groundwater wells) have been identified in the upper catchment area. Desktop assessment of the 1:25,000 OS maps indicates there is no flood risk to properties at this site of interest. Flood risk assessment using the SEPA 'Indicative River and Coastal Flood Map (Scotland)' has not been completed for this site as SEPA Flood Risk maps are not available for catchments less than 3km².	High
Hare Moss	N/A	Degraded raised bog. Peat exposures just to the south of the moss suggest that at one time the bog extended into an area to the south, presently used as rough grazing. The major watercourse passing through the Moss is the Burn of Ardoe. Heathfield Burn skirts the western boundary of the moss and Jameston Ditch runs along the northern boundary. The moss area is also fringed and fed by several field drainage ditches some of which are ephemeral. Direct rainfall falling on the moss is also thought to be a significance supply of surface water to the moss area. The natural passage of flow through the moss is directed to the northwestern corner of the moss. Numerous trees exist on the bog, which may reflect that a less than ideal water level regime for the bog has existed for some extended period of time. The north west and central area of the moss is likely to receive additional water during heavy winter rainfall when the Burn of Ardoe and Heathfield Ditch overtop their banks. There are no known abstractions from Hare Moss. Desktop assessment of the 1:25,000 OS maps indicates there is no flood risk to properties at the site of interest. Flood risk assessment using the SEPA 'Indicative River and Coastal Flood Map (Scotland)' has not been completed for this site as SEPA Flood Risk maps are not available for catchments less than 3km².	High
Whitestone Burn	9	Catchment area at the proposed road crossing point (chainage 201000) = 0.2km^2 A small tributary of Blaikiewell Burn draining agricultural land and forestry in a southwesterly direction. The burn appears to have been heavily modified and straightened as part of a field drainage system. It has been culverted at its upstream end. There are no known abstractions from this watercourse. Desktop assessment of the 1:25,000 OS maps indicates there is no flood risk to properties at the site of interest. Flood risk assessment using the SEPA 'Indicative River and Coastal Flood Map (Scotland)' has not been completed for this site as SEPA Flood Risk maps are not available for catchments less than 3km².	Low
Burnhead Burn	10	Catchment area at the proposed outfall and road crossing point (chainage 200100) = 4.2km^2 The main small, fast flowing tributary of Blaikiewell Burn drains an area of agricultural land and woodland and flows in a northwesterly direction. Part of the upstream area of the catchment is likely to have been modified and realigned as part of a field drainage system. The burn is potentially able to support trout and thus considered an important habitat, sensitive to the supply of surface water. There are no known abstractions from this watercourse. Burnhead Burn is shown by the SEPA 'Indicative River and Coastal Flood Map (Scotland)' to be at risk of flooding at the 0.5% AEP (200-year return period event). At the site of the proposed culvert, flooding occurs on both the right and left river bank, however, the area inundated is shown to be less than 50 metres either side of Burnhead Burn. There are no properties within 250 meters of the proposed culvert (see Appendix 10). Burnhead Burn has the potential to be affected by sections of both the Fastlink and the Southern Leg parts of the scheme.	Medium

Water Feature	Annex	Description	Sensitivity
Crynoch Burn	N/A	Part of the River Dee SAC in the area of interest. It is designated for its populations of freshwater pearl mussels, otter and Atlantic salmon. Although Crynoch Burn would not be directly crossed by the scheme, there would be indirect impacts on the watercourse as the scheme would cross through the eastern part of its catchment. Crynoch Burn is one of the larger watercourses in the area, it flows in a northern direction with much of the 31.7 km^2 catchment falling within the proposed scheme corridor. The upstream area of the catchment includes the highly sensitive Red Moss of Netherley (refer to Appendix 39.1). From here, the stream flows in a northerly direction into the River Dee. There are several large farm dwellings and existing road crossings along the length of the watercourse. The upper and middle reaches of Crynoch Burn flow through farmland and have floodplain areas on both banks. The lower reaches flow through woodland in more well-defined valleys. As tributaries of Crynoch Burn would be crossed by the road, consideration of this has been included when assigning sensitivities to these watercourses. There are no known abstractions from this watercourse. Crynoch Burn flows through a natural gorge before discharging to the River Dee. Existing flood risk has been assessed using the SEPA 'Indicative River and Coastal Flood Maps (Scotland)' for the area downstream of the first point indirectly impacted by the proposed AWPR route. At present the watercourse is predicted to flood up to 100m out of bank during the 0.5%AEP event (1 in 200-year flood event). Forestry and agricultural land are predominantly at risk but there are properties within Kirkton of Maryculter and near the confluence with the River Dee which are predicted to flood (see Annex 11).	High
Blaikiewell Burn	11	Catchment area at the proposed outfall and road crossing point (chainage 100150) = 4.5km^2 Small tributary of Crynoch Burn that flows in a north westerly direction, draining into Crynoch Burn approximately 1km upstream of the River Dee. In the middle and lower reaches, the watercourse predominantly flows through woodland within a well defined valley. he burn is known to support trout and is thus considered an important habitat and fisheries river, sensitive to the supply of surface water, in addition to its potential impact upon Crynoch Burn. There are no known abstractions from this watercourse. At the proposed crossing point, the SEPA 'Indicative River and Coastal Flood Map (Scotland)' predicts a risk of flooding at the 0.5% AEP (200-year return period event). Flooding of the site is not predicted to exceed 50 meters on the right or left river banks. There are no properties predicted to be at risk of flooding in the area surrounding the proposed bridge location.	Medium
Kingcausie Burn	12	Catchment area at the proposed road crossing point (chainage 101500) = 1.6km^2 This is a small, fast flowing tributary of Crynoch Burn, which is part of the River Dee SAC. The burn drains a steep forested catchment containing some agricultural land and flows in a northwesterly direction. Its confluence with Crynoch Burn is close to the point where Crynoch Burn discharges to the River Dee. Private water supply wells have been identified in the catchment area. Desktop assessments of the 1:25,000 OS maps indicate there is no flood risk to properties at the site of interest. Flood risk assessment using the SEPA 'Indicative River and Coastal Flood Map (Scotland)' has not been completed for this site as SEPA Flood Risk maps are not available for catchments less than 3km^2.	Medium
River Dee	21	Catchment area at the proposed road crossing point (chainage 102000) = 1833km^2 The river has a very large catchment draining the Grampian Mountains, flowing in an easterly direction through the urban area of Aberdeen before discharging into the North Sea. The River Dee is a designated fisheries river and a SAC. At the point of interest, the River Dee floodplain is relatively wide (up to almost 1 km in places) from Peterculter down to Cults. From a review of OS maps, it appears possible that there is an existing flood risk to properties along the banks of the River Dee. For example on the south bank of the River Dee and upstream of the proposed AWPR crossing, properties at Inch of Culter are at risk of flooding. Water is abstracted from the River Dee at the Inchgarth Reservoir to supply drinking water to the Aberdeen area. Two natural springs are also adjacent to the River Dee near Kincairn House (Ch101980). The River Dee is predicted to be at risk of flooding at the 0.5% AEP (1 in 200-year return period event) at the proposed bridge crossing by the SEPA 'Indicative River and Coastal Flood Map (Scotland)'. The River Dee is shown to experience out-of-bank flooding covering approximately 100 metres on the left bank and extensive	High

Water Feature	Annex	Description	Sensitivity
		flooding along the right bank of up to 800m. There are properties located in close proximity to the proposed bridge and the predicted 0.5% AEP flood inundation. Further information concerning the flood risk surrounding the River Dee at the AWPR crossing point can be found in the Hydrodynamic Modelling Assessment (Appendix A24.2).	
Milltimber Burn	13	Catchment area at the proposed road crossing point (chainage 102650) = 0.6km^2 This is a predominantly straightened watercourse that is a very small tributary of the River Dee. The watercourse flows in a southeasterly direction draining a mixture of urban, forested and rural land throughout its catchment. There are several existing culverts along the downstream reaches of the burn passing under roads. There are no known abstractions from this watercourse. Desktop assessment of the 1:25,000 OS maps indicates that although the burn flows through the western edge of Milltimber town there is no flood risk to properties at the site of interest. Flood risk assessment using the SEPA 'Indicative River and Coastal Flood Map (Scotland)' has not been completed for this site as SEPA Flood Risk maps are not available for catchments less than 3km².	Low
Culter House Burn	14	Catchment area of the Burn (chainage 103600) = 0.1km^2 A field ditch that appears unconnected to any major watercourse. The catchment predominately drains agricultural land and only standing water has been observed within the ditch. This burn is thought to be an unused drainage ditch with no significant importance to the surface runoff of the surrounding area. There are no known abstractions from this watercourse. Desktop assessment of the 1:25,000 OS maps indicates there is no flood risk to properties at the site of interest. Flood risk assessment using the SEPA 'Indicative River and Coastal Flood Map (Scotland)' has not been completed for this site as SEPA Flood Risk maps are not available for catchments less than 3km².	Low
Beans Burn	15	Catchment area at the proposed road crossing point (chainage 105150) = 0.08km^2 A tributary of Upper Beanshill Burn and the Murtle Dam Reservoir draining agricultural land and flowing in a southeasterly direction through a District Wildlife Site. The watercourse is thought to have been modified and culverted for a field drainage system. The proposed crossing point would be located in the upper catchment and there is therefore limited risk to the water balance of the reservoir. There are no known abstractions from this watercourse. Desktop assessment of the 1:25,000 OS maps indicates there is no flood risk to properties at the site of interest. Flood risk assessment using the SEPA 'Indicative River and Coastal Flood Map (Scotland)' has not been completed for this site as SEPA Flood Risk maps are not available for catchments less than 3km².	Low
Upper Beanshill Burn/Ponds	16	Catchment area at the proposed road crossing point (chainage 106500) = less than 0.05km^2 At this point, the proposed AWPR would cross over the burn at its upper-most point along the watershed of this catchment and the catchment of Gairn Burn to the west. The burn drains forestry land in its headlands and flows in a southeasterly direction into two ponds. Downstream of these ponds, the burn flows through a District Wildlife Site, joins Beans Burn and continues as the Murtle Den Burn into the Murtle Dam Reservoir. The upper reaches of the burn at the site of interest have been observed to be ephemeral and appear to have been modified for a field drainage system. It is thought that this area of the catchment plays a very limited role in the water balance of the Murtle Dam Reservoir and the ponds downstream of the proposed crossing point of the road. There are no known abstractions from this watercourse. Desktop assessment of the 1:25,000 OS maps indicates there is no flood risk to properties at the site of interest. Flood risk assessment using the SEPA 'Indicative River and Coastal Flood Map (Scotland)' has not been completed for this site as SEPA Flood Risk maps are not available for catchments less than 3km².	Low
Gairn Burn	17	Catchment area at the proposed outfall for road drainage (chainage 106500) = 0.8km^2 The catchment drains agricultural land and Gairn Hill Woodland. The burn flows in a southwesterly direction into Silver Burn. It is likely that the burn has been modified for a field drainage system. The catchment accounts for a small percentage of the Silver Dart Reservoir. However, the proposed crossing point would be located in the upper catchment of this tributary and thus plays only a very minor role in maintaining the water balance of the reservoir. Private water supply wells have been identified in the catchment area.	Medium

Water Feature	Annex	Description	Sensitivity
		Desktop assessment of the 1:25,000 OS maps indicates there is no flood risk to properties at the site of interest. Flood risk assessment using the SEPA 'Indicative River and Coastal Flood Map (Scotland)' has not been completed for this site as SEPA Flood Risk maps are not available for catchments less than 3km².	
Moss of Auchlea drainage system	18	Catchment area at the proposed road crossing point (chainage 107450)= 0.2km^2 Located in the upper catchment of Silver Burn and Ord Burn flowing in a southwesterly direction. The drainage system drains an area of predominantly agricultural land, but also passes through the environmentally sensitive site of the Moss of Auchlea downstream of the proposed AWPR. It is important to the supply of surface water to the Moss of Auchlea throughout the year. The channel has a moderate to steep gradient and shows evidence of past straightening and realignment for a field drainage system around the Moss of Auchlea. This drainage system is also the smallest of four watercourses draining to the Silver Dart Reservoir and thus plays a minor role in maintaining the water balance of the reservoir. Private water supply wells have been identified in the catchment area. A natural spring is also located in the Moss of Auchlea drainage system (ch107500). Desktop assessment of the 1:25,000 OS maps indicates there is a limited existing flood risk to properties to the south east of Moss of Auchlea area. Flood risk assessment using the SEPA 'Indicative River and Coastal Flood Map (Scotland)' has not been completed for this site as SEPA Flood Risk maps are not available for catchments less than 3km².	High
Moss of Auchlea	N/A	This site contains valuable wetland habitats. It is a designated District Wildlife Site (DWS) and, as such, is officially recognised as a place of wildlife importance. 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 the River Dee. The low lying nature of the site has led to waterlogging and over many years, a build up of peat has occurred creating a small basin mire. Most of the site is wet with peaty soils. The supply of surface water is dominated by Silver Burn and augmented by several field drainage ditches in the area local to the moss. Connectivity to these ditches allows the moss to maintain high levels of surface water throughout the year. It is also thought that direct rainfall is an important source of water for the moss. There are no known abstractions from the Moss of Auchlea. Desktop assessments of the 1:25,000 OS maps indicate there is no flood risk to properties at the site of interest. Flood risk assessment using the SEPA 'Indicative River and Coastal Flood Map (Scotland)' has not been completed for this site as SEPA Flood Risk maps are not available for catchments less than 3km².	High
Westholme Burn	19	Catchment area at the proposed road crossing point (chainage 108650) = 0.62km^2 Tributary of Brodiach Burn draining a catchment of agricultural and forestry land, flowing in a southwesterly direction. The channel has a relatively low gradient, is straight and follows field boundaries suggesting past modification through realignment. The burn as appears to be ephemeral. Brodiach Burn is the most significant watercourse supplying the Silver Dart Reservoir. Westholme Burn accounts for a 3% of the total catchment draining to the reservoir and thus only plays a minor role in maintaining the water balance of the reservoir. There are no known abstractions from this watercourse. Desktop assessment of the 1:25,000 OS maps indicates there is no flood risk to properties at the site of interest. Flood risk assessment using the SEPA 'Indicative River and Coastal Flood Map (Scotland)' has not been completed for this site as SEPA Flood Risk maps are not available for catchments less than 3km².	Low
Borrowstone Burn/Pond	20	Although the proposed scheme would not cross this burn, the road would pass through its eastern catchment area. The catchment drains agricultural land and flows in a south westerly direction. Much of the watercourse appears to have been modified as part of a field drainage system. The upper catchment of the burn drains Brimmond Hill and is important in maintaining the water balance in Borrowstone pond. There are no known abstractions from this watercourse. Desktop assessment of the 1:25,000 OS maps indicates there is no flood risk to properties at the site of interest. Flood risk assessment using the SEPA 'Indicative River and Coastal Flood Map (Scotland)' has not been completed for this site as SEPA Flood Risk maps are not available for catchments less than 3km².	Low

3.2 Summary

3.2.1 In total, the Southern Leg section of the proposed scheme would cross 19 watercourses, two ponds and one loch. The proposed route would also pass close to the Moss of Auchlea and Hare Moss, both of which are considered environmentally sensitive sites. Although Crynoch Burn would not be crossed by the proposed scheme, potential impacts on the tributaries within its catchment are considered in the assessment.

3.2.2 The major watercourse in the study area is the River Dee, while the remaining watercourses are all relatively small. All watercourses, except the River Dee, have small catchment areas that range from 0.2 to 4.5km^2. The River Dee has a catchment area of 2039 km^2 at the point where the scheme would cross. Average annual rainfall along the entire AWPR route varies between 780 and 830mm, with a slight east to west increase indicating a drier than average region within Scotland.

3.2.3 Hydrological soil parameters indicate that the ground conditions along the proposed Southern Leg of the AWPR are generally of average permeability. Greenfield runoff rate was calculated at 4.3-l/s/ha for the 50% AEP (2-year return period) design flows. The Greenfield runoff rate defines the discharge rate from water quality treatment ponds (refer to the Water Quality Appendix A24.4).

3.2.4 Soil parameters of the small catchments have middle range permeability and they would be expected to display flow regimes of average sensitivity to rainfall. This indicates that these catchments are unlikely to be especially flashy (i.e. rainfall reaches the watercourse very quickly), but they will experience appreciable flood flows during and immediately following, heavy rain (something that would not be so obvious in particularly permeable catchments, where rainfall takes much longer to reach the watercourse). Within the range of responsiveness, Hare Moss ditches are likely to have the fastest response to rainfall, whereas Loirston Burn is slower to respond. However, it is stressed that none of these catchments exhibit extreme response characteristics.

3.2.5 Existing flood risk from small watercourses is considered to be low where they run through rural areas. A review of the SEPA 'Indicative River and Coastal Flood Map (Scotland)' suggests there is potential flood risk on some watercourses downstream of the proposed road crossing point. An assessment of watercourses outwith the SEPA 'Indicative River and Coastal Flood Map (Scotland)' also indicates some potential existing flood risk.

3.2.6 The River Dee has relatively wide flood plains in the vicinity of the proposed route, the flooding of which has been observed in recent extreme flood events. Simulations of the 1.33% AEP (75-year return period flow event 1070m^3/s) indicate that properties located on the Inch of Culter floodplain area are at risk of flooding. For a fuller appraisal, refer to Appendix A24.2 (Hydrodynamic Modelling Assessment).

3.2.7 The Moss of Auchlea is considered a highly sensitive site due to the requirement of a constant supply of surface water to maintain any remaining peat deposits and the associated flora and fauna of a moss area. The Moss of Auchlea drainage system is essential to the functioning of the moss.

3.2.8 Hare Moss is considered a highly sensitive site, due to the requirement of a constant supply of surface water to maintain any remaining peat deposits, and the associated flora and fauna of the moss area. It is therefore advisable that connectivity of the Hare Moss to the Burn of Ardoe, Bishopton Ditch and Heathfield Burn is maintained in order to prevent a decline in supply of surface water to the moss.

4 Potential Impacts

4.1 Introduction

4.1.1 This section assesses the potential impacts of the scheme on the hydrology of watercourses, without mitigation.

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

4.1.3 Unless otherwise stated, the impacts referred to would have an adverse impact on the hydrological regime of a watercourse, channel morphology or natural fluvial processes and are assigned based on the criteria set out in Table 2. In addition to the potential impacts on existing watercourses, an assessment has also been made of the likely impact of network culverts (culverts which would be required to pass drainage from one side of the road to the other). Network culverts are not considered in the baseline conditions as no watercourse currently exists at that location. Network culverts are included in the assessment of potential impacts as their introduction presents an additional flood risk to the area surrounding a proposed network culvert.

4.2 General

4.2.1 Road schemes have the potential to affect surface water hydrology as a result of:

- installation of structures such as culverts and bridges;
- increased runoff as a result of increased impermeable areas (road surface);
- impeding the functionality of floodplains (flood storage and conveyance);
- realignment of watercourses;
- disturbance of hydrological features (wetlands, lochans, etc);
- alteration of catchment areas; and
- alteration of surface water runoff pathways.

4.2.2 These impacts have the potential to result in changes to:

- magnitude and timing of runoff;
- flow velocities;
- flow pathways; and
- flood risk.

Operation Impacts

4.2.3 Impacts of the scheme on surface hydrology are those that could affect the physical flow and water level regimes. Examples of such circumstances may include:

- Structures: blockage or constriction of structures may lead to localised flood risk, potential for increased sediment release and changes to erosion/depositional patterns indirectly affecting the geomorphological and ecological status of a watercourse.
- Impermeable Areas: impermeable areas increase the overall volume of water reaching the watercourse, as less is lost to infiltration. Road runoff may also reach receiving watercourse earlier than pre-scheme conditions which may result in the flood response of the catchment becoming more ‘flashy’, increasing flood risk and stream power downstream.

- Outfall of Road Drainage: Road drainage would drain to an outfall to discharge into a receiving watercourse. Alterations to the hydrological and flood regimes of outfall watercourses may occur if there is no suitably designed attenuation of surface water runoff. Outfall of road drainage may also have an impact on the sediment regime and water quality of the receiving watercourse (refer to Appendix A24.4 Water Quality and A24.3 Fluvial Geomorphology.
- Increased Catchment: the proposed works may require the re-direction of one watercourse into another or the introduction of an outfall to a watercourse, which may increase local flow rates and flood risk. Alterations to flow may have implications for sedimentation patterns along the watercourse which may increase flood risk elsewhere along the watercourse through changes in channel dimensions.
- Reduced Catchment: constriction or severing of established flow paths may lead to an increased flood risk; changes to sediment regime via changes to gradient and size of watercourse leading to impacts upon geomorphology and subsequently water quality. Alterations to the flow regime could also have associated impacts on the ecological status of a watercourse.
- Catchment Severance: the scheme may act as a barrier to current watercourse catchments; which could increase flows to some watercourses and reduce flows in others. This would be of particular concern if surface water conditions were of particular importance for an environmentally sensitive area such as a raised moss. A reduction in flows may greatly affect the geomorphological, water quality and ecological status of the watercourse.
- Stream Realignment: realignments have the potential to increase flood risk if the correct channel dimensions and gradient are not applied to the realignment design.
- Pre-earthworks drainage: prior to construction, it would be necessary to construct a pre-earthworks drainage system to prepare the work corridor. At this stage any small watercourses or catchment areas identified as suitable are incorporated into the pre-earthworks drainage system. The drainage system would remain in place throughout the operation of the scheme and can result in permanent re-direction of discharge for affected watercourses. Catchment areas would increase or decrease depending on the outfall point of the pre-earthworks drainage system.

Construction Impacts

4.2.4 Potential impacts during construction of the scheme would include soil compaction from works traffic, erosion and sedimentation of watercourses. Impacts on watercourses would also occur from activities such as the construction of outfall locations, pre-earthworks drainage and as a result of alterations to catchment connectivity.

4.2.5 During construction of the River Dee bridge, no construction activities would occur within 9m of the River Dee banks and no in-channel works would be necessary. Therefore, the bridge soffit support would be incorporated into the bridge construction process. This would enable the bridge to be constructed with minimal impact on the hydraulic flow characteristics of the watercourse.

4.2.6 Temporary haul roads may cause a temporary increase in runoff due to reduced infiltration rates in the area of the road.

4.2.7 Temporary outfalls and SUDS ponds would be built as part of the construction phase of the project. This could result in alterations to the hydrological and flood regimes of outfall watercourses if there is no suitably designed attenuation of surface water runoff. Temporary outfall of road drainage may also have an impact on the sediment regime of the receiving watercourse.

4.2.8 During the construction phase, other temporary works that would, or potentially may, have some bearing on the surface hydrology would include the following:

- watercourse diversions to facilitate culvert and bridge construction;
- drainage outfalls (temporary, during works); and
- runoff control measures (temporary, during works), which could include swales and geotextile-wrapped straw bale barriers.

4.2.9 The severity of the impacts would be increased during periods of intense or prolonged rainfall.

4.3 Specific Impacts

4.3.1 This section describes the scope of works that would be required for each watercourse in the study area and assesses the potential impacts from construction and operation.

Road Drainage Outfalls

4.3.2 Outfalls to discharge road drainage would be required for:

- Loirston Burn
- Jameston Ditch;
- Burnhead Burn;
- River Dee;
- Gairn Burn; and
- Westholme Burn.

4.3.3 Although it is not proposed to directly outfall into Hare Moss, any associated impact as a result of outfall into Jameston Ditch or changes to its surface water catchment have been assessed. All drainage runs and their associated outfalls and detention features are marked on Figures 24.5a-h.

Watercourse Crossings

4.3.4 A bridge and a buried structure are proposed for the River Dee and the Blaikiewell Burn respectively, due their environmental sensitivity.

4.3.5 The River Dee would be bridged by a single structure with no piers/supports in the river channel. A buried structure would be constructed over Blaikiewell Burn, which would also not require any in-channel works. The abutments of the structure would be set back from the watercourse by approximately 5m on each side. All crossings are marked clearly on Figures 24.5a-h.

4.3.6 The scheme would cross the remaining watercourses in the study area via culverts. A total of 14 culverts would be required:

- one culvert at Whitestone Burn, Heathfield Burn, Bishopston Ditch, Burn of Ardoe, Kingcausie Burn, Burnhead Burn, Milltimber Burn and; Moss of Auchlea drainage system
- two culverts have been proposed for Gairn Burn and Loirston Burn plus the extension of two existing culverts at Loirston Burn.

4.3.7 Culverts would be sized to convey a range of flows and would be installed level with the existing bed, resulting in an artificial bed and banks.

Watercourse Realignments

4.3.8 The following watercourse realignments would be required:

- Whitestone Burn (one realignment of 123m, overall length maintained);
- Heathfield Burn (one realignment of 89m, overall length maintained);
- Bishopston Ditch (one realignment of 95m, overall length maintained);
- Burn of Ardoe (one realignment of 80m, overall length maintained);
- Loirston Burn (four extensive realignments totalling 778m, overall length maintained);
- Burnhead Burn (one realignment of 118m, overall length maintained);
- Kingcausie Burn (one realignment of 404m, resulting in a 37m shortening of the channel);
- Milltimber Burn (one realignment of 107m overall length maintained);
- Gairn Burn (one realignment of 163m, resulting in a 13m shortening of the channel); and
- Moss of Auchlea drainage system (one realignment of 84m, resulting in a 9m shortening of the channel).

4.3.9 Loirston Burn would be extensively realigned along its length in four separate places.

Pre-earthworks Drainage

4.3.10 As noted previously, certain minor watercourses and drainage ditches would not be culverted, but would be routed into pre-earthworks ditches and subsequently into the road drainage system. This is proposed for the following burns, which are effectively ephemeral ditches:

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

Catchment Severance

4.3.11 Although Culter House Burn would not be taken into pre-earthworks drainage, it would lose 100% of its catchment to pre-earthworks drainage. This is likely to ultimately result in the loss of this watercourse as its source of flow disappears.

Network Culverts

4.3.12 At certain locations along the scheme, network culverts would be installed to pass drainage from one side of the road to the other. Network culvert sites have not been considered in the baseline conditions as no watercourse presently exists at the proposed location. The potential impacts of these structures are assessed as their introduction to a locality represents the addition of a flood risk in the surrounding area. The following network culverts are proposed:

- one network culvert near Loirston Burn at ch205955;
- one network culvert near Gairn Burn at ch106175;
- one network culvert near Moss of Auchlea at ch107305; and
- one network culvert near Westholme Burn at ch108585.

4.3.13 Potential impacts (assuming no mitigation) during operation of the scheme are presented in Table 6. Potential impacts during construction of the scheme for watercourses in the Southern Leg study area are presented in Table 7.

Table 6 – Potential Operational Impacts

Water Feature	Sensitivity	Potential Impact Description (Assuming No Mitigation)	Potential Impact	
			Magnitude	Significance
Network Culvert: Loirston Burn	N/A	Culvert on the main AWPR line (ch205955) has the potential to cause localised constriction of flow and flood risk. The culvert would be 63m long and 0.9m in diameter	Negligible	N/A
		Potential risk of culvert blockage has been based on a desktop assessment of the site using OS maps. The catchment land use upstream of the culvert comprises of coniferous woodland and therefore risk of culvert blockage has been assessed as Medium. At the point of interest flood risk may be assessed as Negligible given the distance of properties away from the culvert	Medium	N/A
Loirston Burn	Medium	Culvert on the main AWPR line (ch205580) has the potential to cause localised constriction of flow and flood risk. The culvert would be 34m long, 1.2m high and 2.4m wide.	Negligible	Negligible
		Potential risk of culvert blockage has been based on a desktop assessment of the site using OS maps. The catchment immediately upstream of the culvert composes mainly of trees. Risk of culvert blockage may therefore be assessed as medium. At this point of interest, there is no flood risk.	Medium	Moderate
		Culvert on A90 has the potential to cause localised constriction of flow and flood risk. The culvert would be 47m long, 1.5m high and 2.7m wide.	Negligible	Negligible
		Potential risk of culvert blockage has been based on a desktop assessment of the site using OS maps. The catchment immediately upstream of the culvert composes of bracken/heather/rough grass and some trees. The culvert is the third culvert proposed for this section of the watercourse. Risk of culvert blockage may therefore be assessed as low. At the point of interest there are two properties within 200m of the culvert. The properties are upstream of the culvert on the side road and therefore flood risk may be assessed as low.	Low	Slight
		Culvert on A956 realignment has the potential to cause localised constriction of flow and flood risk. The culvert would be 45m in length, 1.2m high and 2.7m wide.	Negligible	Negligible
		Potential risk of culvert blockage has been based on a desktop assessment of the site using OS maps. The catchment upstream of the area has compositions of bracken/heather/rough grass and some trees. This culvert is the fourth culvert proposed for this section of the watercourse.. Risk of culvert blockage may therefore be assessed as low. At the point of interest flood risk may be assessed as medium due to the presence of some building in close proximity to the culvert.	Medium	Moderate
		Culvert on minor side road south of ch206400 has the potential to cause localised constriction of flow and flood risk. The culvert would be 24m in length, 1.5m high and 2.7m wide.	Negligible	Negligible
		Potential risk of culvert blockage has been based on a desktop assessment of the site using OS maps. The catchment upstream and in close proximity to the culvert consists of heather/bracken/rough grass and some trees. The culvert is the second culvert proposed for this section of the watercourse. Risk of culvert blockage may therefore be assessed as medium. At the point of interest flood risk may be assessed as medium due to the presence of a building in close proximity to the culvert.	Medium	Moderate
		Realignment has the potential to cause a slight increase in channel gradient. Any decrease in bank height may increase localised flood risk.	Low	Slight
		Blockage of surface water runoff pathways has the potential to cause a decrease in catchment at the point of the road crossing of approximately 2%.	Low	Slight

Water Feature	Sensitivity	Potential Impact Description (Assuming No Mitigation)	Potential Impact	
			Magnitude	Significance
		Outfall location for drainage detention basin has the potential to cause a minor change to the timing of flows within Loirston Burn. There would be no increase to the catchment as a result of the position of the road and the direction of road drainage. Drainage would include 0.026km^2 of road hard standing.	Low	Slight
		Possible outfall location to existing A90/A956 network has the potential to cause a minor decrease in flows due to the position of the AWPR and the drainage scheme.	Low	Slight
Greengate Ditch	Low	The area of the catchment upstream of the road would be taken into pre-earthworks drainage. There is no evidence of connectivity to Hare Moss to the west and it is more likely that the burn drains north to the Loirston Burn catchment.	Negligible	Negligible
Jameston Ditch	High	Outfall location for drainage detention basin has the potential to cause an increase in flows. There is likely to be an increase of approximately 28% in the catchment size at the point of the road outfall due to the position of the road and the direction of the road drainage. Drainage would also accommodate 0.071km^2 of road hard standing. Due to the potential increase in flows flooding may increase, however, as there is no known flood risk at this location impacts are likely to be minimal.	Negligible	Slight/ Negligible
		The sustainability of the sensitive water balance of Hare Moss is likely to be improved by increased flows within Jameston ditch as a direct result of the road outfall. Providing water quality standards are met (A24.4) there is a potential for an increased supply of surface water to the moss area through flooding at the confluence of the Burn of Ardoe and Jameston Ditch.	Beneficial	Negligible
Burn of Ardoe	High	Culvert on the main AWPR line (ch204040) has the potential to cause localised constriction of flow and flood risk. The culvert would be 59m in length, 1.2m high and 2.4m wide.	Negligible	Slight/ Negligible
		Potential risk of culvert blockage has been based on a desktop assessment of the site using OS maps. The catchment land use upstream of the culvert comprises of pasture land and is therefore unlikely to cause culvert blockage. Risk of culvert blockage has therefore been assessed as negligible. At the point of interest flood risk may be assessed as low. Some properties are present but at a distance from the culvert.	Low	Moderate
		Realignment has the potential to cause a slight increase in channel gradient. Any decrease in bank height may increase localised flood risk.	Low	Moderate
		Blockage of surface water runoff pathways to Hare Moss.	Low	Moderate
Bishopton Ditch	High	Culvert on the main AWPR line (ch203900) has the potential to cause localised constriction of flow and flood risk. The culvert would be 55m in length, 1.2m high and 2.4m wide.	Negligible	Slight/ Negligible
		Potential risk of culvert blockage has been based on a desktop assessment of the site using OS maps. The catchment land use upstream of the culvert composes of pasture land and is therefore unlikely to cause culvert blockage. Risk of culvert blockage has therefore been assessed as negligible. However, at the point of interest flood risk is considered to be of low magnitude as some properties are present within close proximity of the culvert. The overall risk of culvert blockage, taking into account the likelihood of culvert blockage and the flood risk, is considered to be of low magnitude.	Low	Moderate
		Realignment has the potential to cause a slight increase in channel gradient. Any decrease in bank height may increase localised flood risk.	Low	Moderate
		Blockage of surface water runoff pathways.	Low	Moderate

Water Feature	Sensitivity	Potential Impact Description (Assuming No Mitigation)	Potential Impact	
			Magnitude	Significance
Heathfield Burn	High	Culvert on the main AWPR line (ch203650) has the potential to cause localised constriction of flow and flood risk. The culvert would be 46 m in length, 1.5m high and 2.4m wide.	Negligible	Slight/ Negligible
		Potential risk of culvert blockage has been based on a desktop assessment of the site using OS maps. The catchment land use upstream of the culvert comprises of pasture land and is therefore unlikely to cause culvert blockage. Risk of culvert blockage has therefore been assessed as negligible. At the point of interest, there is no flood risk.	Negligible	Slight/ Negligible
		Realignment has the potential to cause a slight increase in channel gradient. Any decrease in bank height may increase localised flood risk.	Low	Moderate
		Blockage of surface water runoff pathways to Hare Moss.	Low	Moderate
Hare Moss	High	The AWPR crosses to the south of the moss and upstream of all watercourses draining to the moss. Although the road does not have a direct impact on Hare Moss there is potential for the road to alter the water balance of the moss through changes in the hydrological inputs to the moss area particularly concerning the outfall of Jameston Ditch. Hare Moss is currently considered to be in a degraded state and is sensitive to the supply of water to the site. Given the sensitivity of the moss, it is likely that the magnitude of impact to the road prior to mitigation would be high.	High	Substantial
Whitestone Burn	Low	Culvert on the main AWPR line (ch200990) has the potential to cause localised constriction of flow and flood risk. The culvert would be 51 m in length, 1.2m high and 2.4m wide.	Negligible	Negligible
		Potential risk of culvert blockage has been based on a desktop assessment of the site using OS maps. The catchment land use upstream of the culvert composes of predominantly trees and therefore risk of culvert blockage is medium. At the point of interest there are properties in the vicinity, however, they are raised and therefore flood risk may be assessed as low.	Medium	Slight
		Realignment has the potential to cause a slight increase in channel gradient. Any decrease in bank height may increase localised flood risk.	Low	Negligible
Burnhead Burn	Medium	Culvert (ch200100) has the potential to cause localised constriction of flow and flood risk. The culvert would be 65 m in length, 2.1m high and 3.0m wide.	Negligible	Negligible
		Potential risk of culvert blockage has been based on a desktop assessment of the site using OS maps. The catchment land use upstream of the culvert composes of heather/bracken/rough grass and therefore risk of culvert blockage is low. At the point of interest there are properties in the vicinity and the ground is relatively flat. Therefore flood risk may be assessed as high. The overall risk of culvert blockage based on the risk of blockage and the flood risk has therefore been assessed as medium.	Medium	Moderate
		Realignment has the potential to cause a slight increase in channel gradient. Any decrease in bank height may increase localised flood risk.	Low	Slight
		Outfall location for drainage detention basins: Potential to cause an increase in flows. There is likely to be an approximate 2% increase in the catchment size at the point of the road outfall due to the position of the road and the direction of the road drainage. Drainage would also accommodate 0.09km^2 of road hard standing. This burn would also be used in the road drainage system for the Fastlink of the AWPR.	Low	Slight
Crynoch Burn	High	There would be no direct impacts to Crynoch Burn assuming that the catchment area draining to the burn would be maintained. Possible blockage of surface water runoff pathways may occur.	Low	Moderate
Blaikiewell Burn	Medium	Bridge has been designed to avoid localised constriction of flow from bridge supports.	Low	Slight

Water Feature	Sensitivity	Potential Impact Description (Assuming No Mitigation)	Potential Impact	
			Magnitude	Significance
Kingcausie Burn	Medium	Culvert on the main AWPR line (ch101470) has the potential to cause localised constriction of flow and flood risk. The culvert would be 47m in length, 1.5m high and 2.7m wide.	Negligible	Negligible
		Potential risk of culvert blockage has been based on a desktop assessment of the site using OS maps. The catchment land use upstream of the culvert composes of forestry and therefore risk of culvert blockage has been assessed as high. At the point of interest there are properties uphill from the burn. Due to the elevation of the properties flood risk may be assessed as low. The overall risk of culvert blockage, taking into account the likelihood of culvert blockage and the flood risk, is considered to be of medium magnitude.	Medium	Moderate
		Substantial realignment of 404m has the potential to change channel capacity and cause a slight increase in channel gradient. Potential indirect affect on Crynoch Burn downstream.	Low	Slight
River Dee	High	Potential loss of floodplain storage due to construction of the bridge abutments in the area of the floodplain. However, model results suggest there would be no significant change in water levels for the 1.33% AEP (75-year return period) flow ($1070m^3/s$) and the impact significance is therefore considered to be low. For a more detail analysis of the potential impact up to the 0.5%AEP (1 in 200-year event) please refer to the Hydrodynamic Modelling Assessment (Appendix A24.2).	Low	Moderate
		Outfall location for drainage detention basins has the potential to cause a minor increase in flows. The outfall would increase catchment size by less than 1%. Drainage would include $0.107km^2$ of road hard standing.	Negligible	Slight/ Negligible
Milltimber Burn	Low	Culvert on the main AWPR line (ch 102670) has the potential to cause localised constriction of flow and flood risk. The culvert would be 77m in length, 1.5m high and 2.4m wide.	Negligible	Negligible
		Potential risk of culvert blockage has been based on a desktop assessment of the site using OS maps. The catchment land use upstream of the culvert composes of sparse forest. Therefore risk of culvert blockage has been assessed as medium. At the point of interest there are properties uphill from the burn. Due to the elevation of the properties flood risk may be assessed as low.	Medium	Slight
		Realignment has the potential to cause a slight increase in channel gradient. Any decrease in bank height may increase localised flood risk.	Low	Negligible
Culter House Burn	Low	This watercourse would be lost through catchment severance. The area of the catchment upstream of the road would be taken into pre-earthworks drainage This catchment would still drain to the Milltimber Burn via the road drainage outfall and there would be no loss of catchment to Milltimber or the River Dee.	Negligible	Negligible
Beans Burn	Low	The area of the catchment upstream of the road would be taken into pre-earthworks drainage. Approximately 17% of the total Beans Burn catchment (to the confluence with the Murtle Den Burn) would be lost causing a reduction in flows. This catchment area would drain to the Gairn Burn and River Dee road outfalls.	Medium	Slight
Network Culvert: Gairn Burn	N/A	Culvert on the main AWPR line (ch106175) has the potential to cause localised constriction of flow and flood risk. The culvert would be 62 m in length, and 0.9m in diameter.	Negligible	N/A
		Potential risk of culvert blockage has been based on a desktop assessment of the site using OS maps. The catchment land use upstream of the culvert comprises of pasture land and coniferous woodland and therefore risk of culvert blockage has been assessed as Medium. At the point of interest, flood risk may be assessed as Negligible. Only sparse properties are present and at a distance from the proposed culvert location.	Medium	N/A
Upper Beanshill Burn/Ponds	Low	The area of the catchment upstream of the road would be taken into pre-earthworks drainage. Approximately less than 1% of the total Beans Burn catchment would be lost causing a slight reduction in flows. This catchment area would drain to the Gairn Burn road outfall.	Negligible	Negligible

Water Feature	Sensitivity	Potential Impact Description (Assuming No Mitigation)	Potential Impact	
			Magnitude	Significance
Gairn Burn	Medium	Culvert on the main AWPR line (ch163) has the potential to cause localised constriction of flow and flood risk. The culvert would be 12m in length, 1.5m high and 2.4m wide.	Negligible	Negligible
		Potential risk of culvert blockage has been based on a desktop assessment of the site using OS maps. The catchment land use upstream of the culvert composes of forest therefore risk of culvert blockage has been assessed as high. At the point of interest there are properties uphill from the burn. Due to the elevation of the properties flood risk may be assessed as low. In assessing the overall risk of culvert blockage taking into account the likelihood of culvert blockage and flood risk the overall risk may be considered to be medium.	Medium	Moderate
		Culvert on the pond access road (ch270) has the potential to cause localised constriction of flow and flood risk. The culvert would be 8m in length, 1.2m high and 2.4m wide.	Negligible	Negligible
		Risk of culvert blockage has the potential risk of culvert blockage has been based on a desktop assessment of the site using OS maps. The catchment land use upstream of the culvert comprises of pasture land and forestry and therefore risk of culvert blockage has been assessed as Medium. At the point of interest flood risk may be assessed as Low due to the elevation of nearby properties	Medium	Moderate
		Realignment has the potential to cause a slight increase in channel gradient. Any decrease in bank height may increase localised flood risk.	Low	Slight
		Outfall location for drainage detention basins has the potential to cause an increase in flows. Catchment area would be likely to increase by approximately 14%. Drainage would include 0.047km^2 of road hard standing.	Medium	Moderate
Network Culvert: Moss of Auchlea	N/A	Culvert on the main AWPR line (ch107305): Potential to cause localised constriction of flow and flood risk. The culvert would be 56m in length and 0.9m in diameter	Negligible	N/A
		Potential risk of culvert blockage has been based on a desktop assessment of the site using OS maps. The catchment land use upstream of the culvert comprises of pasture land and therefore unlikely to cause culvert blockage. Risk of culvert blockage has therefore been assessed as negligible. At the point of interest flood risk may be assessed as low. Some properties are present but at a distance from the culvert	Low	N/A
Moss of Auchlea drainage system	High	Culvert on the main AWPR line (ch107440) has the potential to cause localised constriction of flow and flood risk. The culvert would be 75m in length, 1.5m high and 2.4m wide.	Negligible	Slight/ Negligible
		Risk of culvert blockage on the main AWPR line: Potential risk of culvert blockage has been based on a desktop assessment of the site using OS maps. The catchment land use upstream of the culvert composes of forest. The forest is not in immediate vicinity to the culvert. Therefore risk of culvert blockage has been assessed as medium. At the point of interest there are properties uphill from the burn. Due to the elevation of the properties flood risk may be assessed as low.	Medium	Moderate/ Substantial
		Realignment: Potential to cause a slight increase in channel gradient. Any decrease in bank height may increase localised flood risk.	Low	Moderate
		Blockage of surface water runoff pathways.	Low	Moderate
Moss of Auchlea	High	There would be no direct hydrological impacts to the Moss of Auchlea, assuming that the catchment area draining to the burn is maintained. The culvert on the Moss of Auchlea drainage system allows connectivity of the moss to the catchment area upstream of the road.	Negligible	Slight/ Negligible
Network Culvert:	N/A	Culvert on the main AWPR line (ch108585) has the potential to cause localised constriction of flow and flood risk. The culvert would be 113m in length and 0.9m in diameter.	Negligible	N/A

Water Feature	Sensitivity	Potential Impact Description (Assuming No Mitigation)	Potential Impact	
			Magnitude	Significance
Westholme		Potential risk of culvert blockage has been based on a desktop assessment of the site using OS maps. The catchment land use upstream of the culvert comprises of pasture land and therefore unlikely to cause culvert blockage. Risk of culvert blockage has therefore been assessed as negligible. At the point of interest flood risk may be assessed as low. Some properties are present, but at a distance from the culvert and the minor road is elevated.	Low	N/A
Westholme Burn	Low	Outfall location for drainage detention basins has the potential to cause an increase in flows. The catchment area of the outfall includes existing catchment of the burn and the added cathment from the road (0.082km^2 of hard standing).	Low	Negligible
Borrowstone Burn/Pond	Low	Although the burn or ponds would not be crossed by the AWPR, there would be a minor (less than 1%) reduction in the catchment area due to the position of the AWPR and the drainage scheme. This catchment area would drain to the Westholme Burn outfall before discharging into the Ord Burn further downstream.	Negligible	Negligible

Table 7 – Potential Construction Impacts

Water Feature	Sensitivity	Potential Impact Description (Assuming No Mitigation)	Potential Impact	
			Magnitude	Significance
Loirston Burn/ Loirston Loch	Medium	Construction of four culverts at ch205580, side road, A90 and A056.	Medium	Moderate
		Realignment of a section of channel.	Medium	Moderate
		General construction impacts.	Low	Slight
		Obstruction of flow pathways to Loirston Loch during construction.	Low	Slight
Greengate Ditch	Low	General construction impacts.	Low	Negligible
Jameston Ditch	High	General construction impacts.	Low	Moderate
Burn of Ardoe	High	Construction of culvert at ch204040.	Medium	Moderate/ Substantial
		Realignment of a section of channel.	Medium	Moderate/ Substantial
		General construction impacts.	Low	Moderate
		Obstruction of flow pathways to Hare Moss during construction.	Low	Moderate
Bishopton Ditch	High	Construction of culvert at ch203900.	Medium	Moderate/ Substantial
		Realignment of a section of channel.	Medium	Moderate/ Substantial
		General construction impacts.	Low	Moderate

Water Feature	Sensitivity	Potential Impact Description (Assuming No Mitigation)	Potential Impact	
			Magnitude	Significance
		Obstruction of flow pathways to Hare Moss during construction.	Low	Moderate
Heathfield Burn	High	Construction of culvert at ch203650.	Medium	Moderate/ Substantial
		Realignment of a section of channel.	Medium	Moderate/ Substantial
		General construction impacts.	Low	Moderate
		Obstruction of flow pathways to Hare Moss during construction.	Low	Moderate
Hare Moss	High	Hare Moss would be downstream of the AWPR crossing. Although there should be no direct impacts to the moss connectivity to the catchment could be reduced during construction.	Medium	Moderate/ Substantial
Whitestone Burn	Low	Construction of culvert at ch200990.	Medium	Slight
		Realignment of a section of channel.	Medium	Slight
		General construction impacts.	Low	Negligible
Burnhead Burn	Medium	Construction of culvert at ch200100.	Medium	Moderate
		Realignment of a section of channel.	Medium	Moderate
		General construction impacts.	Low	Slight
		Potential flood risk during construction to hamlet at Burnhead.	Medium	Moderate
Crynoch Burn	High	Crynoch Burn would be downstream of the AWPR crossing. Although there should be no direct impacts to the burn connectivity to the catchment could be reduced during construction.	Low	Moderate
Blaikiewell Burn	Medium	Construction of bridge.	Medium	Moderate
		General construction impacts.	Low	Slight
Kingcausie Burn	Medium	Construction of culvert.	Medium	Moderate
		Realignment of a section of channel. Due to the length of realignment the impact is thought to be more significant than other realignments within the scheme.	Medium	Moderate
Kingcausie Burn continued	as above	General construction impacts.	Low	Slight
River Dee	High	Construction of Bridge.	Medium	Moderate/ Substantial
		General construction impacts would be negligible given the size of the watercourse.	Negligible	Slight/ Negligible
Milltimber Burn	Low	Construction of culvert at ch102670.	Medium	Slight
		Realignment of a section of channel.	Medium	Slight

Water Feature	Sensitivity	Potential Impact Description (Assuming No Mitigation)	Potential Impact	
			Magnitude	Significance
		General construction impacts.	Low	Negligible
Culter House Burn	Low	General construction impacts.	Low	Negligible
Beans Burn	Low	General construction impacts.	Low	Negligible
Upper Beanshill Burn/Ponds	Low	General construction impacts.	Low	Negligible
Gairn Burn	Medium	Construction of two culverts at ch163 and ch270.	Medium	Moderate
		Realignment of a section of channel.	Medium	Moderate
		General construction impacts.	Low	Slight
Moss of Auchlea drainage system	High	Construction of culvert at ch107440.	Medium	Moderate/ Substantial
		Realignment of a section of channel.	Medium	Moderate/ Substantial
		Obstruction of surface water flow pathways to the Moss of Auchlea during construction.	Low	Moderate
		General construction impacts.	Low	Moderate
Moss of Auchlea	High	Construction work and equipment should not affect the Moss of Auchlea directly as the proposed road lies to the east. However, the site would be upstream of the moss so there is potential for indirect affects through other surface water pathways.	Negligible	Slight/ Negligible
Westholme Burn	Low	General construction impacts.	Low	Negligible
Borrowstone Burn/Pond	Low	Construction work and equipment should not affect the Borrowstone Burn or Pond directly as the proposed road lies to the east. However, the site would be upstream of the burn and pond so there is potential for indirect effects through other surface water pathways although this is thought to be negligible.	Negligible	Negligible

4.4 Summary of Potential Impacts

Operational Impacts

4.4.1 Throughout its operation, the road has the potential to affect downstream flow regimes, particularly where significant modification to overland flow paths is likely and where culvert upgrading is proposed. Adequately designed culverts are predicted to have a Negligible impact on existing hydrological processes. Network culverts that would be installed for scheme drainage introduce a flood risk to a location that previously had no watercourse. Adequately designed network culverts are predicted to have a Negligible impact on hydrological processes. However, there remains the potential risk of culvert blockage.

4.4.2 Appropriately designed bridges with no in-channel supports would also have a minimal impact on hydrological processes. However, the construction of abutments on the river banks has the potential to increase flood risk. Hydrodynamic modelling (refer to Appendix A24.2) predicts no significant change to water levels with the bridge in place. No increase in potential flood risk during the operation of the scheme has been identified.

4.4.3 Based on the gradient of the road, import and export of runoff from parts of other catchments may occur on a small scale. This transfer of water from one catchment to another could have significant impacts for small catchments over long periods of time.

4.4.4 Potential impacts of Substantial significance are predicted for Hare Moss due to the sensitivity of the hydrological environment. Potential impacts of Moderate/Substantial significance are also anticipated for the Moss of Auchlea Drainage System,

4.4.5 Potential impacts of Moderate significance are predicted for:

- River Dee;
- Loirston Burn;
- Burnhead Burn;
- Crynoch Burn (potential Catchment impacts);
- Kingcausie Burn;
- burns draining to Hare Moss (Heathfield Burn, Bishopston Ditch and the Burn of Ardoe); and
- Gairn Burn.

4.4.6 Potential impacts on all remaining watercourses have been assessed as Slight or lesser significance.

4.4.7 Hare Moss receives water from numerous sources such as watercourses, ditches and groundwater, which all have the potential to be affected by the road. In order to maintain the existing quality of the moss, water levels should be maintained or increased from their present levels. During the operation of the road, there is a potential for either a single or multiple water sources to be severed from the moss. Due to the sensitivity of the moss the impact of this potential has been assessed as Substantial.

4.4.8 Jameston Ditch is proposed to be a receiving watercourse for road drainage. In hydrological terms an outfall to Jameston Ditch may prove beneficial to the moss by increasing the supply of surface water to Hare Moss. Flooding occurs periodically at the confluence of Jameston Ditch and the Burn of Ardoe. This was observed during site visits in November 2005 and July 2006. Due to the location of the watercourses through the sensitive moss area and the depth of the ditches during normal flows, this flooding is thought to be an important supply of water to the northwest and central area of the moss. Increased flows to Jameston ditch from the proposed road drainage outfall and additional catchment size may contribute more water to the wetland, which will aid in the maintenance of water levels in the moss.

4.4.9 Considering potential impacts assuming that no mitigation is in place, the possibility of severance of one or more source watercourses for the moss area is considered more significant than the potential beneficial effects of the outfall to Jameston Ditch. For this reason, the potential impact assessment remains at Substantial.

4.4.10 The Moss of Auchlea is a Local Plan District Wildlife Site and is likely to be highly sensitive to any changes in the volume of flows reaching from upstream. Loirston Loch is also a Local Plan District Wildlife Site and alterations to the water balance to the loch could have consequences over a long period of time.

4.4.11 As they are tributaries, Burnhead Burn, Blaikiewell Burn and Kingcausie Burn have the potential to affect Crynoch Burn on a catchment level. Potential impacts include increased or decreased catchment area draining to the catchment. Crynoch Burn may also be potentially affected by impacts on a number of watercourses that have been assessed for the Fastlink section of the scheme in Appendix A39.1(Craigentath Burn, Circle Burn, Square Burn and Wedderhill Burn). However, such impacts are likely to be Negligible due to the size of these watercourses.

4.4.12 All watercourses located within the Southern Leg study area (with the exception of Loirston Burn catchment) ultimately flow into the River Dee. The river may potentially be affected by changes in the drainage to these watercourses. The catchment impacts resulting from changes to the drainage of these watercourses would be unlikely to significantly affect the River Dee due to the size of the river. Catchment impacts of the scheme are considered in more detail in Part E (Cumulative Impact Assessment) of the ES.

Construction Impacts

4.4.13 Although short term, construction impacts have the potential to lead to significant long-term consequences on the watercourses affected.

4.4.14 During construction, potential impacts of Moderate/Substantial significance are anticipated for:

- Hare Moss;
- burns draining to Hare Moss (Heathfield Burn, Bishopston Ditch and the Burn of Ardoe);
- River Dee; and
- Moss of Auchlea Drainage System.

4.4.15 Potential impacts of Moderate significance are predicted for:

- Loirston Burn;
- Jameston Ditch;
- Burnhead Burn;
- Blaikiewell Burn;
- Crynoch Burn (potential catchment impacts);
- Kingcausie Burn; and
- Gairn Burn.

4.4.16 Potential impacts on all remaining watercourses are considered to be of Slight or lesser significance.

4.4.17 The most potential for construction impact would be to Hare Moss. Although there would be no direct impacts to the moss during construction, connectivity to the catchment could be temporarily reduced. Due to its high sensitivity this may result in substantial consequences.

4.4.18 The potential impacts associated with the construction of the River Dee crossing have been assessed as Moderate/Substantial significance. Although no in-channel works would be required,

there is potential for increased flood risk from construction works being carried out on the floodplain.

4.4.19 The construction impacts on Kingcausie Burn have been assessed as Moderate. A significant stretch of river (200–300m) would be realigned and a culvert installed. During construction, there is a risk of blockage of flow pathways and subsequent erosion of the bed and banks. This has the potential to alter the dimensions of the watercourse increasing flood risk and/or affect the hydrological connectivity further downstream. As a result, there may be implications for the ecology and fluvial geomorphology of the downstream section of the watercourse as well as Crynoch Burn.

4.4.20 The construction impacts on Loirston Burn have been classified as Moderate due to its connectivity and role in the water balance of Loirston Loch. Any alteration in the hydrology of Loirston Burn could have effects on the water quality, geomorphology and ecology of the loch further downstream.

4.4.21 Catchment impacts due to the construction of the proposed scheme may affect Crynoch Burn and the River Dee. Increases or decreases in flow may occur during construction if drainage areas are modified. Kingcausie Burn, for example, may experience decreased flow during culvert construction, which may cause lower flows to occur in Crynoch Burn. As Crynoch Burn is fed by three watercourses, decreased flow in one watercourse is unlikely to be a major issue. The River Dee may also be affected by catchment impacts. However, these are unlikely to significantly affect the watercourse due to its size.

5 Mitigation

5.1 Generic Mitigation

5.1.1 Mitigation measures are based on current good practice for highway drainage design, including the DMRB and guidance provided in Sustainable Urban Drainage Systems: Design Manual for Scotland and Northern Ireland CIRIA C521 (Construction Industry Research and Information Association (CIRIA), 2000), Control of Water Pollution from Linear Construction Projects, Report No C648 (CIRIA 2006), Control of Water Pollution from Linear Construction Projects Site Guide Report No C649 (CIRIA, 2006) and the SUDS Manual Report No. C967 (CIRIA, 2007). It is presumed that legal regulations and guidance as outlined in the Water Environment and Water Services (Scotland) Act 2003 and supported by the Controlled Activities Regulations (Scotland) 2005, and SPP7 are followed. These require that development is designed such that it does not materially increase pre-development flood risk.

5.1.2 Most impacts on the surface water hydrology of the scheme and side roads would result from the presence of culverts, bridges, watercourse realignments, pre-earthworks and road drainage outfalls. These will be designed to current industry standards and legislation and where possible will be constructed in manner most suited to the watercourse characteristics at that point (see Fluvial Geomorphology A39.2). Other guidelines are set out in more detail below.

Operational Mitigation

5.1.3 The following mitigation measures are provided to address potential operational impacts on surface water hydrology.

Crossing Structures

5.1.4 The culverts and buried structures that would be constructed on watercourses will be designed to appropriate return period flows. SEPA requires that culverts are designed to the 0.5% AEP (200-year return period event). SPP7 states that this return period already includes an allowance for

climate change consequently all culverts have been designed to this standard. Culvert design further includes a freeboard allowance of 300mm over the 0.5% AEP.

5.1.5 All culverts on existing watercourses will be box depressed invert culverts, which will allow the provision of substrate on the culvert bed. The design of the culverts is in accordance with guidance from the Scottish Executive on culverts and migratory fish (SEERAD, 2000).

5.1.6 Crossing structures have been designed so that current flood flow capacity will not be reduced. Culverts and buried structures installed as part of the scheme will not be smaller than existing structures on the watercourse (unless obviously over-designed).

5.1.7 Where there is potential for significant risk of culvert blockage due to surrounding land use, a suitably designed culvert trash screen could also be considered to reduce the risk of blockage. Guidance is provided in the Culvert Design Guide Report No. C168 (CIRIA, 1997) and the Design and operation of trash screens, Interim Guidance Notes, (NRA, 1993). Network Culverts will be designed to the 1.33% AEP (1 in 75-year flood event) as these are part of the drainage network (DMRB HA 106/04). A one dimensional model of all proposed culverts has been constructed to test the flow capacity of the crossings. The results indicate that the culverts are suitably designed and pass the 200-years flow with spare capacity.

5.1.8 A regular maintenance regime will be implemented in order manage debris in and around the crossing structures. This work will include the removal of debris and dead vegetation from the channel and the banks upstream of the structure. The River Dee bridge abutments will be situated at least 4m away from the SAC boundary, which is delineated by a 5m inland boundary. This will occur in order to limit sediment connectivity with the SAC and the River Dee during construction of the road scheme. However this will mean that during the majority of flows the works will not impinge on the functioning of the watercourses.

5.1.9 The abutments of the River Dee will be set back from the bank top of the river at a sufficient in order to minimise potential impacts on the conveyance and flood storage area of the River Dee during a 0.5% AEP flow. This has been investigated using a one-dimensional hydraulic model (refer to Appendix A24.2), which predicts a negligible impact on these characteristics for the 0.5% AEP flow.

5.1.10 The abutments of the Blaikiewell Burn structure will be set back approximately 5m from the top bank of the watercourse. This will limit floodplain constriction during operation and ensue that the structure will not affect the hydrological function of the watercourse. The design of the bridge is not anticipated to affect the conveyance and flood storage of the 0.5% AEP flow at this location.

Realignments

5.1.11 The realignment of watercourses will maintain existing channel dimensions (width and depth) and, where possible, the overall length and gradient. Any existing flood storage areas within the realigned area will also be replaced to maintain the capacity of the watercourse, prevent flood risk and sustain connectivity to downstream areas. At sites of long realignments (greater than 50m watercourse length), where appropriate, a period of monitoring will be undertaken after construction to reassess the effects on flood risk.

Road Drainage

5.1.12 Road drainage and pre-earthworks will not enhance flood event runoff into watercourses compared to the pre-development situation and will allow for storage and attenuation before outfalling into the receiving watercourse.

5.1.13 Road drainage and pre-earthworks have been designed to minimise the transfer of water across catchments. Outfalls would be located at intervals along the route in order to avoid the transfer of

surface water from one catchment to another. The drainage system has been designed to avoid flooding of water on lands on the upstream side of newly created road embankments.

5.1.14 The proposed road drainage scheme consists of three stages that ensure flood flows up to the 0.5%AEP (200-year event) are accounted for in the road drainage scheme (based on SPP7, which uses the 0.5%AEP as a guide to account for climate change). The components of the road drainage scheme are shown below:

- Filter drains: road runoff would drain into filter drains at the road edge, then into detention basins before outfalling to the receiving watercourse. The filter drains will be designed to accommodate the 50% AEP (2-year flow).
- Pre-earthwork ditches: flow above the 10% AEP threshold will be taken into pre-earthwork ditches, which have been designed to the 1.33% AEP as specified in the DMRB (reference HA106/04). This includes all network culverts required to pass drainage from one side of the AWPR to the other.
- Detention basins: designed to attenuate the 1% AEP (100-year return period event) to the pre-development Q_{MED} flow. In order to account for climate change, the basins are designed to include a freeboard allowance of 0.5% AEP (200-year event) to be stored, prior to release. The road drainage system has been designed to ensure where possible flows between the 1.33% AEP and the 0.5% AEP will flow to the detention basins prior to out falling to the receiving watercourse.

Construction Mitigation

5.1.15 Mitigation measures to be implemented during construction of the proposed scheme include:

- guidance detailed in CIRIA reports C648 and C697 where appropriate,
- minimising the duration of construction;
- method statement detailing measures to control erosion and sediment control will be provided to SEPA prior to the commencement of works;
- areas of vegetation removal and excavation will be minimised to reduce the potential for sediment laden runoff reaching watercourses;
- work compounds will not be located on floodplain/flood storage areas;
- stockpiles will be located upslope of excavated areas;
- the siting of work compounds and stockpiles will avoid environmentally sensitive areas;
- excavation will not take place during periods of heavy rainfall;
- erosion and sediment control measures will be inspected on a regular basis, and after rainfall events, for their effectiveness. Any defects found will be rectified immediately;
- the works will be conducted in a manner that will not block or reduce flow in or to local watercourses;
- construction equipment and activities will be selected to ensure minimal damage to the watercourse and the surrounding catchment.

<u>Crossing Structures</u>

5.1.16 The River Dee bridge crossing has been designed so that it does not require in-channel work during construction. The flow regime of the watercourse will not be altered during the works, which will avoid increased flood risk or reduced downstream connectivity.

<u>Temporary Realignments</u>

5.1.17 During the installation of culverts, watercourse flows will be diverted around the works in a temporary channel. The diversion channel will be of similar size and gradient to the existing channel.

Road Drainage

5.1.18 During construction, temporary drainage systems will alleviate localised flood risk and prevent obstruction of surface runoff pathways. This will be achieved through the use of geotextile matting, ditches, or other methods detailed in the SUDS CIRIA manuals C648 and C697. A number of these temporary SUDS will be incorporated into the operational drainage network when the road is completed, but additional site specific SUDS may be required during construction and will be removed once construction is complete.

5.2 Site Specific Mitigation

5.2.1 In addition to these generic mitigation measures, site specific mitigation is specified for each watercourse for operation (refer to Table 8) and during construction (refer to Table 9). These site specific mitigation measures have been developed to address potential impacts of Slight to Substantial impacts only.

Operation Mitigation

Table 8 –Mitigation Measures for Operation

Water Feature	Impact	Mitigation Measure
LoirstonBurn/ Loirston Loch	Culvert blockage	Conduct regular maintenance, ensure culvert is clear of debris.
	Loss of catchment area/blockage of surface water runoff pathways.	Limit the catchment area lost to an absolute minimum or provide an outfall to the same catchment system to maintain similar water supply to downstream areas.
	Potential to cause a minor change to the timing of flows within Loirston Burn catchment downstream of the proposed outfall location.	Provide road drainage (within design limits) to SUDS treatment with suitable outfall rate based on the Q_{MED}.
	Realignment	Retain flow capacity, gradient and channel roughness in realignment design, planting of embankments.
	Increased discharge to watercourse at outfall location	Provide road drainage (within design limits) to SUDS treatment with suitable outfall rate based on the Q_{MED}.
Jameston Ditch	Increased discharge to watercourse at outfall location	Provide road drainage (within design limits) to SUDS treatment with suitable outfall rate based on the Q_{MED}. Locate SUDS outside the designated area of the moss
Burn of Ardoe	Culvert blockage	Conduct regular maintenance, ensure culvert is clear of debris.
	Realignment	Retain flow capacity, gradient and channel roughness in realignment design, planting of embankments.
	Blockage of surface runoff pathways	Provide suitable connectivity and maintain where possible the existing catchment size drainage.
Bishopston Ditch	Culvert blockage	Conduct regular maintenance, ensure culvert is clear of debris.
	Realignment	Retain flow capacity, gradient and channel roughness in realignment design, planting of embankments.
	Blockage of surface runoff pathways	Provide suitable connectivity and maintain the existing catchment size drainage.
Heathfield Burn	Culvert blockage	Conduct regular maintenance, ensure culvert is clear of debris.
	Realignment	Retain flow capacity, gradient and channel roughness in realignment design, planting of embankments.
	Blockage of surface runoff pathways	Provide suitable connectivity and maintain where possible the existing catchment size drainage.
Hare Moss	Blockage of surface runoff pathways	Provide suitable connectivity to the moss area and maintain the existing catchment size draining to the moss.

Water Feature	Impact	Mitigation Measure
Whitestone Burn	Culvert blockage	Conduct regular maintenance, ensure culvert is clear of debris.
Burnhead Burn	Culvert blockage	Conduct regular maintenance, ensure culvert is clear of debris.
	Realignment	Retain flow capacity, gradient and channel roughness in realignment design, planting of embankments.
	Increased discharge to watercourse at outfall location	Provide road drainage (within design limits) to SUDS treatment with suitable outfall rate based on the $Q_{MED.}$
Crynoch Burn	Blockage of surface runoff pathways	Provide suitable connectivity and maintain where possible the existing catchment size drainage.
Blaikiewell Burn	Buried structure	Not to impinge any further than specified in the design on floodplain storage area or flood flows and not to cause a significant alteration to flood inundation.
Kingcausie Burn	Culvert blockage	Conduct regular maintenance, ensure culvert is clear of debris.
	Realignment	Retain flow capacity, gradient and channel roughness in realignment design, planting of embankments.
River Dee	Bridge	Avoid impinging any further than specified in the design on the floodplain storage area or on flood flows to prevent any significant alteration to flood risk (please refer to the Hydrodynamic Modelling Assessment (Appendix A24.2).
	Increased discharge to watercourse at outfall location	Provide road drainage (within design limits) to SUDS treatment with suitable outfall rate based on the $Q_{MED.}$
Milltimber Burn	Culvert blockage	Conduct regular maintenance, ensure culvert is clear of debris.
Beans Burn	Loss of 17% of the catchment when taken into pre-earthwork drainage	Ensure appropriate SUDS design and outfall catchment.
Gairn Burn	Culvert blockage	Conduct regular maintenance, ensure culvert is clear of debris.
	Realignment	Retain flow capacity, gradient and channel roughness in realignment design, planting of embankments.
	Increased discharge to watercourse at outfall location	Provide road drainage (within design limits) to SUDS treatment with suitable outfall rate based on the $Q_{MED.}$
Moss of Auchlea drainage system	Culvert blockage	Conduct regular maintenance, ensure culvert is clear of debris.
	Realignment	Retain flow capacity, gradient and channel roughness in realignment design, planting of embankments.
	Blockage of surface runoff pathways	Provide suitable connectivity to the moss area and maintain the existing catchment size draining to the moss.
Moss of Auchlea	Blockage of surface runoff pathways	Provide suitable connectivity to the moss area and maintain the existing catchment size draining to the moss.

Construction Mitigation

Table 9 – Mitigation Measures for Construction

Water Feature	Impact	Mitigation Measure
Loirston Burn/ Loirston Loch	Construction of culverts	Minimise duration and extent of construction. Avoid periods of high flow and extreme low flow. Temporary diversion channel to possess same capacity as that of existing channel.
	Construction of channel realignment	Maintain watercourse gradient. Ensure appropriate erosion and sediment control measures are in place during construction in order to prevent erosion of channel banks.
	General construction impacts	Minimise duration of construction. Avoid periods of high flow and extreme low flow. Essential that construction corridors are kept to a minimum and stock pilling of materials is prevented. Surface runoff pathways should be maintained at all times.
	Obstruction of flow pathways to Loirston Loch during construction	Maintain connectivity to the upstream end of the catchment. Avoid altering surface water flow pathways where possible.
Jameston Ditch	General construction impacts	Minimise duration of construction. Avoid periods of high flow and extreme low flow. Essential that construction corridors are kept to a minimum and stock pilling of materials is prevented. Surface runoff pathways should be maintained at all times.
Burn of Ardoe	Construction of culvert	Minimise duration and extent of construction. Avoid periods of high flow and extreme low flow. Temporary diversion channel to possess same capacity as that of existing channel.
	Construction of channel realignment	Maintain watercourse gradient. Ensure appropriate erosion and sediment control measures are in place during construction in order to prevent erosion of channel banks.
	General construction impacts	Minimise duration of construction. Avoid periods of high flow and extreme low flow. Essential that construction corridors are kept to a minimum and stock pilling of materials is prevented. Surface runoff pathways should be maintained at all times.
	Obstruction of flow pathways to Hare Moss during construction	Maintain connectivity to the upstream end of the catchment. Avoid altering surface water flow pathways where possible.
Bishopton Ditch	Construction of culvert	Minimise duration and extent of construction. Avoid periods of high flow and extreme low flow. Temporary diversion channel to possess same capacity as that of existing channel.
	Construction of channel realignment	Maintain watercourse gradient. Ensure appropriate erosion and sediment control measures are in place during construction in order to prevent erosion of channel banks.
	General construction impacts	Minimise duration of construction. Avoid periods of high flow and extreme low flow. Essential that construction corridors are kept to a minimum and stock pilling of materials is prevented. Surface runoff pathways should be maintained at all times.
	Obstruction of flow pathways to Hare Moss during construction	Maintain connectivity to the upstream end of the catchment. Avoid altering surface water flow pathways where possible.
Heathfield Burn	Construction of culvert	Minimise duration and extent of construction. Avoid periods of high flow and extreme low flow. Temporary diversion channel to possess same capacity as that of existing channel.
	Construction of channel realignment	Maintain watercourse gradient. Ensure appropriate erosion and sediment control measures are in place during construction in order to prevent erosion of channel banks.
	General construction impacts	Minimise duration of construction. Avoid periods of high flow and extreme low flow. Essential that construction corridors are kept to a minimum and stock pilling of materials is prevented. Surface runoff pathways should be maintained at all times.
	Obstruction of flow pathways to Hare Moss during construction	Maintain connectivity to the upstream end of the catchment. Avoid altering surface water flow pathways where possible.

Water Feature	Impact	Mitigation Measure
Hare Moss	General construction impacts	Minimise duration of construction. Avoid periods of high flow and extreme low flow. Essential that construction corridors are kept to a minimum and stock pilling of materials is prevented. Surface runoff pathways should be maintained at all times.
Whitestone Burn	Construction of culvert	Minimise duration and extent of construction. Avoid periods of high flow and extreme low flow. Temporary diversion channel to possess same capacity as that of existing channel.
	Construction of channel realignment	Maintain watercourse gradient. Ensure appropriate erosion and sediment control measures are in place during construction in order to prevent erosion of channel banks.
Burnhead Burn	Construction of culvert	Minimise duration and extent of construction. Avoid periods of high flow and extreme low flow. Temporary diversion channel to possess same capacity as that of existing channel.
	Construction of channel realignment	Maintain watercourse gradient. Ensure appropriate erosion and sediment control measures are in place during construction in order to prevent erosion of channel banks.
	Potential flood risk during construction to hamlet at Burnhead	Ensure stream pathways are not blocked. Obstruction to flow within the channel should be carefully managed.
	General construction impacts	Minimise duration of construction. Avoid periods of high flow and extreme low flow. Essential that construction corridors are kept to a minimum and stock pilling of materials is prevented. Surface runoff pathways should be maintained at all times.
Crynoch Burn	General construction impacts	Minimise duration of construction. Avoid periods of high flow and extreme low flow. Essential that construction corridors are kept to a minimum and stock pilling of materials is prevented. Surface runoff pathways should be maintained at all times.
Blaikiewell Burn	Construction of bridge	Minimise duration and extent of construction. Avoid periods of high flow and extreme low flow.
	General construction impacts	Minimise duration of construction. Avoid periods of high flow and extreme low flow. Essential that construction corridors are kept to a minimum and stock pilling of materials is prevented. Surface runoff pathways should be maintained at all times.
Kingcausie Burn	Construction of culvert	Minimise duration and extent of construction. Avoid periods of high flow and extreme low flow. Temporary diversion channel to possess same capacity as that of existing channel.
	Construction of channel realignment	Maintain watercourse gradient. Ensure appropriate erosion and sediment control measures are in place during construction in order to prevent erosion of channel banks.
	General construction impacts	Minimise duration of construction. Avoid periods of high flow and extreme low flow. Essential that construction corridors are kept to a minimum and stock pilling of materials is prevented. Surface runoff pathways should be maintained at all times.
River Dee	Construction of bridge	Minimise duration and extent of construction. Avoid periods of high flow and extreme low flow.
	General construction impacts	Minimise duration of construction. Avoid periods of high flow and extreme low flow. Essential that construction corridors are kept to a minimum and stock pilling of materials is prevented. Surface runoff pathways should be maintained at all times.
Milltimber Burn	Construction of culvert	Minimise duration and extent of construction. Avoid periods of high flow and extreme low flow. Temporary diversion channel to possess same capacity as that of existing channel.
	Construction of channel realignment	Maintain watercourse gradient. Ensure appropriate erosion and sediment control measures are in place during construction in order to prevent erosion of channel banks.
Gairn Burn	Construction of culverts	Minimise duration and extent of construction. Avoid periods of high flow and extreme low flow. Temporary diversion channel to possess same capacity as that of existing channel.
	Construction of channel realignments	Maintain watercourse gradient. Ensure appropriate erosion and sediment control measures are in place during construction in order to prevent erosion of channel banks.

Water Feature	Impact	Mitigation Measure
	General construction impacts	Minimise duration of construction. Avoid periods of high flow and extreme low flow. Ensure that construction corridors are kept to a minimum and stock pilling of materials is prevented. Surface runoff pathways should be maintained at all times.
Moss of Auchlea drainage system	Construction of culvert	Minimise duration and extent of construction. Avoid periods of high flow and extreme low flow. Temporary diversion channel to possess same capacity as that of existing channel.
	Construction of channel realignment	Maintain watercourse gradient. Ensure appropriate erosion and sediment control measures are in place during construction in order to prevent erosion of channel banks.
	Obstruction of surface water flow pathways to Moss of Auchlea during construction	Maintain connectivity to the upstream end of the catchment. Avoid altering surface water flow pathways.
Moss of Auchlea	General construction impacts	Minimise duration of construction. Avoid periods of high flow and extreme low flow. Essential that construction corridors are kept to a minimum and stock piling of materials is prevented. Surface runoff pathways should be maintained at all times.

6 Residual Impacts

6.1 General

6.1.1 The long-term predicted residual impacts remaining once the mitigation described has been successfully implemented for operation are provided in Table 10. The residual impacts for construction are provided in Table 11.

6.2 Catchment Impacts

6.2.1 Catchment impacts resulting from the construction and operation of the road scheme have the potential to affect the River Dee and Crynoch Burn. Both of these watercourses are fed by a number of tributaries that may be affected by the road scheme. Due to the large capacity of the River Dee, any catchment impact is likely to have a Negligible effect on the River Dee. Crynoch Burn, despite being a smaller watercourse, is also likely to be only experience Negligible catchment impacts as several watercourses flow into it.

Table 10 – Residual Impacts During Operation

Water Feature	Sensitivity	Potential Impact Description	Mitigation	Residual Impact	
				Magnitude	Significance
Network Culvert: Loirston Burn	N/A	Culvert on the main AWPR line (ch205955) has the potential to cause localised constriction of flow and flood risk. The culvert would be 63m long and 0.9m in diameter.	Scheme design incorporates culvert sizing for 1:75-year return period events.	Negligible	N/A
		Potential risk of culvert blockage has been based on a desktop assessment of the site using OS maps. The catchment land use upstream of the culvert comprises of coniferous woodland and therefore risk of culvert blockage has been assessed as Medium. At the point of interest flood risk may be assessed as Negligible given the distance of properties away from the culvert.	Conduct regular maintenance, ensure culvert is clear of debris.	Negligible	N/A
Loirston Burn	Medium	Culvert on the main AWPR line (ch205580) has the potential to cause localised constriction of flow and flood risk. The culvert would be 34m in length, 1.2m high and 2.4m wide.	Scheme design incorporates culvert sizing for 1:200-year return period events.	Negligible	Negligible
		Potential risk of culvert blockage has been based on a desktop assessment of the site using OS maps. The catchment immediately upstream of the culvert composes mainly of trees. Risk of culvert blockage may therefore be assessed as medium. At this point of interest, there is no flood risk.	Conduct regular maintenance, ensure culvert is clear of debris.	Negligible	Negligible
		Culvert on A90 widening has the potential to cause localised constriction of flow and flood risk. The culvert would be 47m in length, 1.5m high and 2.7m wide.	Scheme design incorporates culvert sizing for 1:200-year return period events.	Negligible	Negligible
		Potential risk of culvert blockage has been based on a desktop assessment of the site using OS maps. The catchment immediately upstream of the culvert composes of bracken/heather/rough grass and some trees. The culvert is the third proposed culvert on this river section. Risk of culvert blockage may therefore be assessed as low. At the point of interest, there are sparse properties within 200m of the culvert. The properties are upstream of the culvert on the side road and therefore flood risk may be assessed as low.	Conduct regular maintenance, ensure culvert is clear of debris.	Negligible	Negligible
		Culvert on A956 realignment has the potential to cause localised constriction of flow and flood risk. The culvert would be 45m in length, 1.2 m high and 2.7m wide.	Scheme design incorporates culvert sizing for 1:200-year return period events.	Negligible	Negligible
		Potential risk of culvert blockage has been based on a desktop assessment of the site using OS maps. The catchment upstream of the area has compositions of bracken/ heather/rough grass and some trees. This culvert is the fourth proposed culvert on this river section. Risk of culvert blockage may therefore be assessed as low. At the point of interest flood risk may be assessed as medium due to the presence of some building in close proximity to the culvert.	Conduct regular maintenance, ensure culvert is clear of debris.	Negligible	Negligible
		Culvert on minor side road south of chainage 206400 has the potential to cause localised constriction of flow and flood risk. The culvert would be 24m in length, 1.5m high and 2.7m wide.	Scheme design incorporates culvert sizing for 1:200-year return period events.	Negligible	Negligible

Water Feature	Sensitivity	Potential Impact Description	Mitigation	Residual Impact	
				Magnitude	Significance
(Loirston Burn continued)	(as above)	Potential risk of culvert blockage has been based on a desktop assessment of the site using OS maps. The catchment upstream and in close proximity to the culvert consists of heather/ bracken/rough grass and some trees. This culvert is the second proposed culvert on this section of the watercourse. Risk of culvert blockage may therefore be assessed as medium. At the point of interest flood risk may be assessed as medium due to the presence of a building in close proximity to the culvert.	Conduct regular maintenance, ensure culvert is clear of debris.	Negligible	Negligible
		Realignment has the potential to cause a slight increase in channel gradient. Any decrease in bank height may increase localised flood risk.	See Table 8. Avoid sharp bends. Retain capacity and gradient. Naturalise (e.g. sediment, plants).	Negligible	Negligible
		Blockage of surface water runoff pathways has the potential to cause a decrease in catchment at the point of the road crossing of approximately 2%.	Provide suitable connectivity through the AWPR. Maintain groundwater supplies (Geology, Contaminated Land and Groundwater: Chapter 23).	Negligible	Negligible
		Discharge of road drainage has the potential to cause a minor change to flows within Loirston Burn. There would be no increase to its catchment as a result of the position of the road and the direction of road drainage. Drainage would include 0.026km^2 of road hard standing.	See sections 5.1.13 to 5.1.19. SUDS design of drainage system. Detention, filter drain and treatment ponds	Negligible	Negligible
		Possible outfall location to existing A90/A956 network has the potential to cause a minor decrease in flows.	See sections 5.1.13 to 5.1.19. SUDS design of drainage system. Detention, filter drain and treatment ponds.	Negligible	Negligible
Greengate Ditch	Low	The area of the catchment upstream of the road would be taken into pre-earthworks drainage There is no evidence of connectivity to Hare Moss to the west and it is more likely that the burn drains north to Loirston Burn catchment.	SUDS design of drainage system.	Negligible	Negligible
Jameston Ditch	High	Discharge of road drainage has the potential to cause an increase in flows. There is likely to be an approximate 28% increase in the catchment size at the point of the road outfall due to the position of the road and the direction of the road drainage. Drainage would also accommodate 0.071km^2 of road hard standing. Due to the potential increase in flows, flooding may increase. However, as there is no known existing flood risk at this location, impacts would be minimal.	See sections 5.1.13 to 5.1.19. SUDS design of drainage system. Detention, filter drain, treatment ponds all located outside the designated area of the moss.	Negligible	Slight/ Negligible
		The sensitive water balance of Hare Moss would likely be improved by increased flows within Jameston Ditch as a direct result of the road outfall. With no deterioration of water quality, there is a potential for an increased supply of surface water to the moss area through flooding at the confluence of the Burn of Ardoe and Jameston Ditch.	See sections 5.1.13 to 5.1.19. SUDS design of drainage system. Detention, filter drain, treatment ponds.	Beneficial	Negligible

Water Feature	Sensitivity	Potential Impact Description	Mitigation	Residual Impact	
				Magnitude	Significance
Burn of Ardoe	High	Culvert on the main AWPR line (ch204040) has the potential to cause localised constriction of flow and flood risk. The culvert would be 59m in length, 1.2m high and 2.4m wide.	Scheme design incorporates culvert sizing for 1:200-year return period events.	Negligible	Slight/ Negligible
		Potential risk of culvert blockage has been based on a desktop assessment of the site using OS maps. The catchment land use upstream of the culvert comprises of pasture land and is therefore unlikely to cause culvert blockage. Risk of culvert blockage has therefore been assessed as negligible. At the point of interest flood risk may be assessed as low. Some properties are present but at a distance from the culvert.	Conduct regular maintenance, ensure culvert is clear of debris.	Negligible	Slight/ Negligible
		Realignment has the potential to cause a slight increase in channel gradient. Any decrease in bank height may increase localised flood risk.	See Table 8. Avoid sharp bends. Retain capacity and gradient. Naturalise (e.g. sediment, plants).	Negligible	Slight/ Negligible
		Blockage of surface water runoff pathways.	Provide suitable connectivity through the AWPR. Maintain groundwater connectivity.	Negligible	Slight/ Negligible
Bishopton Ditch	High	Culvert on the main AWPR line (ch203900) has the potential to cause localised constriction of flow and flood risk. The culvert would be 55m in length, 1.2m high and 2.4m wide.	Scheme design incorporates culvert sizing for 1:200-year return period events.	Negligible	Slight/ Negligible
		Potential risk of culvert blockage has been based on a desktop assessment of the site using OS maps. The catchment land use upstream of the culvert composes of pasture land and is therefore unlikely to cause culvert blockage. Risk of culvert blockage has therefore been assessed as negligible. At the point of interest flood risk may be assessed as medium as some properties are present within close proximity of the culvert. The overall risk of culvert blockage taking into account the likelihood of culvert blockage and the flood risk has been assessed as low.	Conduct regular maintenance, ensure culvert is clear of debris.	Negligible	Slight/ Negligible
		Realignment has the potential to cause a slight increase in channel gradient. Any decrease in bank height may increase localised flood risk.	See Table 8. Avoid sharp bends. Retain capacity and gradient. Naturalise (e.g. sediment, plants).	Negligible	Slight/ Negligible
(Bishopton Ditch continued)	(as above)	Blockage of surface water runoff pathways.	Provide suitable connectivity through the AWPR. Maintain groundwater connectivity.	Negligible	Slight/ Negligible
Heathfield Burn	High	Culvert on the main AWPR line (ch203650) has the potential to cause localised constriction of flow and flood risk. The culvert would be 46m in length, 1.5m high and 2.4m wide.	Scheme design incorporates culvert sizing for 1:200-year return period events.	Negligible	Slight/ Negligible

Water Feature	Sensitivity	Potential Impact Description	Mitigation	Residual Impact	
				Magnitude	Significance
		Risk of culvert blockage on the main AWPR line: Potential risk of culvert blockage has been based on a desktop assessment of the site using OS maps. The catchment land use upstream of the culvert comprises of pasture land and is therefore unlikely to cause culvert blockage. Risk of culvert blockage has therefore been assessed as negligible. At the point of interest, there is no flood risk.	Conduct regular maintenance, ensure culvert is clear of debris.	Negligible	Slight/ Negligible
		Realignment has the potential to cause a slight increase in channel gradient. Any decrease in bank height may increase localised flood risk.	See Table 8. Avoid sharp bends. Retain capacity and gradient. Naturalise (e.g. sediment, plants).	Negligible	Slight/ Negligible
		Blockage of surface water runoff pathways.	Provide suitable connectivity through the AWPR. Maintain groundwater connectivity.	Negligible	Slight/ Negligible
Hare Moss	High	The AWPR would cross to the south of the moss and upstream of all watercourses draining to the moss. Although the road would not have a direct impact on Hare Moss, there is potential for the road to alter the water balance of the moss through changes in the hydrological inputs, particularly the proposed outfall to Jameston Ditch. Hare Moss is in a state of decline and is sensitive to the supply of water to the site. Given the sensitivity of the moss, the magnitude of potential impacts prior to mitigation would be high.	Provide suitable connectivity through the AWPR. Maintain groundwater connectivity. Following mitigation the cumulative effect on Hare Moss is considered beneficial due to the provision of additional surface water from the Jameston Ditch outfall.	Beneficial	Negligible
Whitestone Burn	Low	Culvert on the main AWPR line (ch200990) has the potential to cause localised constriction of flow and flood risk. The culvert would be 51m in length, 1.2m high and 2.4m wide.	Scheme design incorporates culvert sizing for 1:200-year return period events.	Negligible	Negligible
		Potential risk of culvert blockage has been based on a desktop assessment of the site using OS maps. The catchment land use upstream of the culvert composes of predominantly trees and therefore risk of culvert blockage is medium. At the point of interest there are properties in the vicinity, however, they are raised and therefore flood risk may be assessed as low.	Conduct regular maintenance, ensure culvert is clear of debris.	Negligible	Negligible
		Realignment has the potential to cause a slight increase in channel gradient. Any decrease in bank height may increase localised flood risk.	See Table 8 Avoid sharp bends. Retain capacity and gradient. Naturalise (e.g. sediment, plants).	Negligible	Negligible
Burnhead Burn	Medium	Culvert (ch200100) has the potential to cause localised constriction of flow and flood risk. The culvert would be 65m in length, 2.1m high and 3.0m wide.	Scheme design incorporates culvert sizing for 1:200-year return period events.	Negligible	Negligible

Water Feature	Sensitivity	Potential Impact Description	Mitigation	Residual Impact	
				Magnitude	Significance
		Potential risk of culvert blockage has been based on a desktop assessment of the site using OS maps. The catchment land use upstream of the culvert composes of heather/ bracken/rough grass and therefore risk of culvert blockage is low. At the point of interest there are properties in the vicinity and the ground is relatively flat. Therefore flood risk may be assessed as high. The overall risk of culvert blockage based on the risk of blockage and the flood risk has therefore been assessed as Medium.	Conduct regular maintenance, ensure culvert is clear of debris.	Negligible	Negligible
		Realignment has the potential to cause a slight increase in channel gradient. Any decrease in bank height may increase localised flood risk.	See Table 8 Avoid sharp bends. Retain capacity and gradient. Naturalise (e.g. sediment, plants).	Negligible	Negligible
		Discharge of road drainage has the potential to cause an increase in flows. There is likely to be an approximate 2% increase in the catchment size at the point of the road outfall due to the position of the road and the direction of the road drainage. Drainage would also accommodate 0.090km^2 of road hard standing. This burn would also be used in the road drainage system for the Fastlink of the AWPR.	See sections 5.1.13 to 5.1.19. SUDS design of drainage system. Detention, filter drain and treatment ponds.	Negligible	Negligible
Burnhead Burn	as above	Potential flood risk to existing properties as a result of culvert blockage.	The culvert needs to be sized appropriately. If the culvert has a risk of blockage regular inspection and maintenance of the culvert should be carried out. This may include clearance of dead vegetation upstream of the culvert.	Negligible	Negligible
Crynoch Burn	High	There would be no direct impacts to Crynoch Burn assuming that the catchment area draining to the burn is maintained. Possible blockage of surface water runoff pathways may occur.	Provide suitable connectivity through the AWPR. Maintain groundwater connectivity.	Negligible	Slight/ Negligible
Blaikiewell Burn	Medium	Buried structure has the potential to cause a localised constriction of flow due to bridge supports.	See Table 8.	Negligible	Negligible
Kingcausie Burn	Medium	Culvert on the main AWPR line (ch101470) has the potential to cause localised constriction of flow and flood risk. The culvert would be 47m in length, 1.5 m high and 2.7m wide.	Scheme design incorporates culvert sizing for 1:200-year return period events.	Negligible	Negligible

Water Feature	Sensitivity	Potential Impact Description	Mitigation	Residual Impact	
				Magnitude	Significance
		Potential risk of culvert blockage has been based on a desktop assessment of the site using OS maps. The catchment land use upstream of the culvert composes of forestry and therefore risk of culvert blockage has been assessed as high. At the point of interest, there are properties uphill from the burn. Due to the elevation of the properties, flood risk may be assessed as low. In assessing the risk of culvert blockage, taking into account the likelihood of culvert blockage and flood risk, the overall risk has been assessed as medium.	Conduct regular maintenance, ensure culvert is clear of debris.	Negligible	Negligible
		Realignment has the potential to change channel capacity and cause a slight increase in channel gradient: Potential indirect affect on Crynoch Burn downstream.	See Table 8. Avoid sharp bends. Retain capacity and gradient. Naturalise (e.g. sediment, plants).	Negligible	Negligible
River Dee	High	Bridge has the potential to cause a localised constriction of flow due to bridge supports and increase flood risk. Loss of floodplain storage would also occur due to the bridge abutments. However, model results suggest there is no significant change in water levels for the 1.33% AEP (75-year return period flow) (1070m^3/s) and the impact significance is therefore considered to be low. For a more detail analysis of the potential impact up to the 0.5%AEP (1 in 200-year event) please refer to the Hydrodynamic Modelling Assessment (Appendix A24.2).	See Table 8.	Negligible	Slight/ Negligible
		Discharge of road drainage has the potential to cause an increase in flows. The outfall would increase catchment size by less than 1%. Drainage would include 0.107km^2 of road hard standing.	See sections 5.1.13 to 5.1.19. SUDS design of drainage system. Detention, filter drain and treatment ponds.	Negligible	Slight/ Negligible
Milltimber Burn	Low	Culvert on the main AWPR line (ch102670) has the potential to cause localised constriction of flow and flood risk. The culvert would be 77 m in length, 1.5m high and 2.4m wide.	Scheme design incorporates culvert sizing for 1:200-year return period events.	Negligible	Negligible
		Potential risk of culvert blockage has been based on a desktop assessment of the site using OS maps. The catchment land use upstream of the culvert composes of sparse forest. Therefore risk of culvert blockage has been assessed as medium. At the point of interest there are properties uphill from the burn. Due to the elevation of the properties flood risk may be assessed as low.	Conduct regular maintenance, ensure culvert is clear of debris.	Negligible	Negligible
		Realignment has the potential to cause a slight increase in channel gradient. Any decrease in bank height may increase localised flood risk.	See Table 8. Avoid sharp bends. Retain capacity and gradient. Naturalise (e.g. sediment, plants).	Negligible	Negligible

Water Feature	Sensitivity	Potential Impact Description	Mitigation	Residual Impact	
				Magnitude	Significance
Culter House Burn	Low	This watercourse would be lost as a result of catchment severance. The area of the catchment upstream of the road would be taken into pre-earthworks drainage This catchment would still drain to the Milltimber Burn via the road drainage outfall and there would be no loss of catchment to Milltimber or the River Dee.	SUDS design of drainage system.	Negligible	Negligible
Beans Burn	Low	The area of the catchment upstream of the road would be taken into pre-earthworks drainage. Approximately 17% of the total Beans Burn catchment (to the confluence with the Murtle Den Burn) would be lost causing a reduction in flows. This catchment area would drain to the Gairn Burn and the River Dee road outfalls.	SUDS design of drainage system.	Negligible	Negligible
Network Culvert: Gairn Burn	N/A	Culvert on the main AWPR line (ch106175) has the potential to cause localised constriction of flow and flood risk. The culvert would be 62 m in length, and 0.9m in diameter	Scheme design incorporates culvert sizing for 1:75-year return period events.	Negligible	N/A
		Potential risk of culvert blockage has been based on a desktop assessment of the site using OS maps. The catchment land use upstream of the culvert comprises of pasture land and coniferous woodland and therefore risk of culvert blockage has been assessed as Medium. At the point of interest flood risk may be assessed as Negligible. Only sparse properties are present and at a distance from the proposed culvert location.	Conduct regular maintenance, ensure culvert is clear of debris.	Negligible	N/A
Upper Beanshill Burn/Ponds	Low	The area of the catchment upstream of the road would be taken into pre-earthworks drainage. Approximately less than 1% of the total Beans Burn catchment would be lost causing a slight reduction in flows. This catchment area would drain to the Gairn Burn road outfall.	SUDS design of drainage system.	Negligible	Negligible
Gairn Burn	Medium	Culvert on the main AWPR line (ch163) has the potential to cause localised constriction of flow and flood risk. The culvert would be 12m in length, 1.5m high and 2.4m wide.	Scheme design incorporates culvert sizing for 1:75-year return period events.	Negligible	Negligible
		Potential risk of culvert blockage has been based on a desktop assessment of the site using OS maps. The catchment land use upstream of the culvert composes of forest therefore risk of culvert blockage has been assessed as high. At the point of interest there are properties uphill from the burn. Due to the elevation of the properties flood risk may be assessed as low. In assessing the overall risk of culvert blockage taking into account the likelihood of culvert blockage and flood risk the overall risk may be assessed as medium.	Conduct regular maintenance on the culvert, ensure culvert is clear of debris.	Negligible	Negligible
		Culvert on the pond access road (ch270) has the potential to cause localised constriction of flow and flood risk. The culvert would be 8m in length, 1.2m high and 2.4m wide.	Scheme design incorporates culvert sizing for 1:200-year return period events.	Negligible	Negligible
		Potential risk of culvert blockage has been based on a desktop assessment of the site using OS maps. The catchment land use upstream of the culvert comprises of pasture land and forestry and therefore risk of culvert blockage has been assessed as Medium. At the point of interest flood risk may be assessed as Low due to the elevation of nearby properties In assessing the overall risk of culvert blockage taking into account the likelihood of culvert blockage and flood risk the overall risk may be assessed as medium	Conduct regular maintenance, ensure culvert is clear of debris.	Negligible	Negligible

Water Feature	Sensitivity	Potential Impact Description	Mitigation	Residual Impact	
				Magnitude	Significance
		Realignment has the potential to cause a slight increase in channel gradient. Any decrease in bank height may increase localised flood risk.	See Table 8. Avoid sharp bends. Retain capacity and gradient. Naturalise (e.g. sediment, plants).	Negligible	Negligible
		Discharge of road drainage has the potential to cause an increase in flows. Catchment area is likely to increase by approximately 14%. Drainage would include 0.047km^2 of road hard standing.	See sections 5.1.13 to 5.1.19. SUDS design of drainage system. Detention, filter drain and treatment ponds.	Negligible	Negligible
Network Culvert: Moss of Auchlea	N/A	Culvert on the main AWPR line (ch107305) has the potential to cause localised constriction of flow and flood risk. The culvert would be 56m in length and 0.9m in diameter	Scheme design incorporates culvert sizing for 1:75-year return period events.	Negligible	N/A
		Potential risk of culvert blockage has been based on a desktop assessment of the site using OS maps. The catchment land use upstream of the culvert comprises of pasture land and therefore unlikely to cause culvert blockage. Risk of culvert blockage has therefore been assessed as negligible. At the point of interest, flood risk may be assessed as low. Some properties are present but at a distance from the culvert	Conduct regular maintenance, ensure culvert is clear of debris.	Negligible	N/A
Moss of Auchlea drainage system	High	Culvert on the main AWPR line (ch107440) has the potential to cause localised constriction of flow and flood risk. The culvert would be 75m in length,1.5m high and 2.4m wide.	Scheme design incorporates culvert sizing for 1:200-year return period events.	Negligible	Slight/ Negligible
		Potential risk of culvert blockage has been based on a desktop assessment of the site using OS maps. The catchment land use upstream of the culvert composes of forest. The forest would not be in immediate vicinity to the culvert. Therefore, risk of culvert blockage has been assessed as medium. At the point of interest, there are properties uphill from the burn. Due to the elevation of the properties flood risk may be assessed as low.	Conduct regular maintenance, ensure culvert is clear of debris.	Negligible	Slight/ Negligible
Moss of Auchlea drainage system continued	as above	Realignment has the potential to cause a slight increase in channel gradient. Any decrease in bank height may increase localised flood risk.	See Table 8 Avoid sharp bends. Retain capacity and gradient. Naturalise (e.g. sediment, plants).	Negligible	Slight/ Negligible
		Blockage of surface water runoff pathways.	Provide suitable connectivity through the AWPR. Maintain groundwater supplies.	Negligible	Slight/ Negligible
Moss of Auchlea	High	There would be no direct hydrological impacts to the Moss of Auchlea assuming that the catchment area draining to the burn would be maintained. The culvert on the Moss of Auchlea drainage system allows connectivity of the moss to the catchment area upstream of the road.	Provide suitable connectivity through the AWPR. Maintain groundwater connectivity.	Negligible	Slight/ Negligible

Water Feature	Sensitivity	Potential Impact Description	Mitigation	Residual Impact	
				Magnitude	Significance
Network Culvert: Westholme	N/A	Culvert on the main AWPR line (ch108585) has the potential to cause localised constriction of flow and flood risk. The culvert would be 113m in length and 0.9m in diameter	Scheme design incorporates culvert sizing for 1:75-year return period events.	Negligible	N/A
		Potential risk of culvert blockage has been based on a desktop assessment of the site using OS maps. The catchment land use upstream of the culvert comprises of pasture land and therefore unlikely to cause culvert blockage. Risk of culvert blockage has therefore been assessed as negligible. At the point of interest flood risk may be assessed as low. Some properties are present but at a distance from the culvert and the minor road is elevated.	Conduct regular maintenance, ensure culvert is clear of debris.	Negligible	N/A
Westholme Burn	Low	Outfall location for drainage detention basins has the potential to cause an increase in flows. The catchment area of the outfall includes the burn's existing catchment and the road (0.082km^2 of hard standing).	See sections 5.1.13 to 5.1.19. SUDS design of drainage system. Detention, filter drain, treatment ponds and swale.	Negligible	Negligible
Borrowstone Burn/ Pond	Low	Although the burn or ponds would not be crossed by the AWPR, there would be a minor (less than 1%) reduction in the catchment area due to the position of the AWPR and the drainage scheme. This catchment area would drain to the Westholme Burn outfall before discharging into the Ord Burn further downstream	Provide suitable connectivity through the AWPR. Maintain groundwater connectivity.	Negligible	Negligible

Table 11 – Residual Impacts During Construction

Water Feature	Sensitivity	Potential Impact	Mitigation	Residual Impact	
				Magnitude	Significance
Loirston Burn	Medium	Construction of four culverts at ch205580, side road, A90 and A956.	See Table 9. General construction mitigation measures.	Negligible	Negligible
		Realignment of a section of channel	See Table 9. General construction mitigation measures.	Negligible	Negligible
		General construction impacts	See Table 9. General construction mitigation measures.	Negligible	Negligible
		Obstruction of flow pathways to Loirston Loch during construction	See Table 9. General construction mitigation measures. Maintain clear pathways.	Negligible	Negligible
Greengate Ditch	Low	General construction impacts	General construction mitigation measures.	Negligible	Negligible
Jameston Ditch	High	General construction impacts	See Table 9. General construction mitigation measures.	Negligible	Slight/ Negligible
Burn of Ardoe	High	Construction of culvert at ch204040	See Table 9. General construction mitigation measures.	Negligible	Slight/ Negligible
		Realignment of a section of channel	See Table 9. General construction mitigation measures.	Negligible	Slight/ Negligible
		General construction impacts	See Table 9. General construction mitigation measures.	Negligible	Slight/ Negligible
		Obstruction of flow pathways to Hare Moss during construction	See Table 9. General construction mitigation measures.	Negligible	Slight/ Negligible
Bishopton Ditch	High	Construction of culvert at ch203900	See Table 9. General construction mitigation measures.	Negligible	Slight/ Negligible
		Realignment of a section of channel	See Table 9. General construction mitigation measures.	Negligible	Slight/ Negligible
		General construction impacts	See Table 9. General construction mitigation measures.	Negligible	Slight/ Negligible

Water Feature	Sensitivity	Potential Impact	Mitigation	Residual Impact	
				Magnitude	Significance
		Obstruction of flow pathways to Hare Moss during construction	See Table 9. General construction mitigation measures.	Negligible	Slight/ Negligible
Heathfield Burn	High	Construction of culvert at ch203650	See Table 9. General construction mitigation measures.	Negligible	Slight/ Negligible
		Realignment of a section of channel	See Table 9. General construction mitigation measures.	Negligible	Slight/ Negligible
		General construction impacts	See Table 9. General construction mitigation measures.	Negligible	Slight/ Negligible
		Obstruction of flow pathways to Hare Moss during construction.	See Table 9. General construction mitigation measures.	Negligible	Slight/ Negligible
Hare Moss	High	Hare Moss would be downstream of the AWPR crossing. Although there should be no direct impacts to the moss connectivity to the catchment could be reduced during construction.	See Table 9. General construction mitigation measures. Avoid construction within the moss area.	Negligible	Slight/ Negligible
Whitestone Burn	Low	Construction of culvert at ch 200990	See Table 9. General construction mitigation measures.	Negligible	Negligible
		Realignment of a section of channel	See Table 9. General construction mitigation measures.	Negligible	Negligible
		General construction impacts	General construction mitigation measures.	Negligible	Negligible
Burnhead Burn	Medium	Construction of culvert at ch200100	See Table 9. General construction mitigation measures.	Negligible	Negligible
		Realignment of a section of channel	See Table 9. General construction mitigation measures.	Negligible	Negligible
		General construction impacts	General construction mitigation measures.	Negligible	Negligible
		Potential flood risk during construction to hamlet at Burnhead	Ensure stream pathways are not blocked. Obstruction to flow within the channel should be carefully managed.	Negligible	Negligible
Crynoch Burn	High	Crynoch Burn would be downstream of the AWPR crossing. Although there should be no direct impacts to the burn connectivity to the catchment could be reduced during construction.	See Table 9. General construction mitigation measures.	Negligible	Slight/ Negligible

Water Feature	Sensitivity	Potential Impact	Mitigation	Residual Impact	
				Magnitude	Significance
Blaikiewell Burn	Medium	Construction of bridge	See Table 9. General construction mitigation measures.	Negligible	Negligible
		General construction impacts	General construction mitigation measures.	Negligible	Negligible
Kingcausie Burn	Medium	Construction of culvert at ch101470	See Table 9. General construction mitigation measures.	Negligible	Negligible
		Realignment of a 407m section of channel. Due to the length of realignment the impact is thought to be more significant than other realignments within the scheme.	See Table 9 General construction mitigation measures.	Low	Slight
		General construction impacts	See Table 9 General construction mitigation measures.	Negligible	Negligible
River Dee	High	Construction of bridge	See Table 9. General construction mitigation measures.	Negligible	Slight/ Negligible
		General construction impacts would be negligible given the size of the watercourse.	General construction mitigation measures.	Negligible	Slight/ Negligible
Milltimber Burn	Low	Construction of culvert at ch102670	See Table 9. General construction mitigation measures.	Negligible	Negligible
		Realignment of a section of channel	See Table 9. General construction mitigation measures.	Negligible	Negligible
		General construction impacts	General construction mitigation measures.	Negligible	Negligible
Culter House Burn	Low	General construction impacts	General construction mitigation measures.	Negligible	Negligible
Beans Burn	Low	General construction impacts	General construction mitigation measures.	Negligible	Negligible
Upper Beanshill Burn/Ponds	Low	General construction impacts.	General construction mitigation measures.	Negligible	Negligible
Gairn Burn	Medium	Construction of two culverts at ch163 and ch270.	See Table 9. General construction mitigation measures.	Negligible	Negligible
		Realignment of a section of channel	See Table 9. General construction mitigation measures.	Negligible	Negligible

Water Feature	Sensitivity	Potential Impact	Mitigation	Residual Impact	
				Magnitude	Significance
		General construction impacts.	General construction mitigation measures.	Negligible	Negligible
Moss of Auchlea drainage system	High	Construction of culvert at ch107440.	See Table 9. General construction mitigation measures.	Negligible	Slight/ Negligible
		Realignment of a section of channel	See Table 9. General construction mitigation measures.	Negligible	Slight/ Negligible
		Obstruction of surface water flow pathways to the Moss of Auchlea during construction.	See Table 9. General construction mitigation measures.	Negligible	Slight/ Negligible
		General construction impacts.	General construction mitigation measures.	Negligible	Slight/ Negligible
Moss of Auchlea	High	Construction work and equipment should not affect the Moss of Auchlea directly as the proposed road lies to the east. However, the site would be upstream of the moss so there is potential for indirect affects through other surface water pathways.	See Table 9. General construction mitigation measures.	Negligible	Slight/ Negligible
Westholme Burn	Low	General construction impacts.	General construction mitigation measures.	Negligible	Negligible
Borrowstone Burn/Pond	Low	Construction work and equipment should not affect the Borrowstone Burn or Pond directly as the proposed road lies to the east. However, the site would be upstream of the burn and pond so there is potential for indirect effects through other surface water pathways although this is thought to be Negligible.	General construction mitigation measures.	Negligible	Negligible

7 Summary

7.1.1 This technical appendix has focused on the degree to which the operation and construction of the Southern Leg section of the AWPR would affect the surface water hydrology of the watercourses that would be crossed by the scheme.

7.1.2 The Southern Leg section of the proposed scheme has the potential to affect 19 watercourses, two ponds, one loch, Hare Moss and the Moss of Auchlea. Except for the River Dee, the watercourses along the proposed route are relatively small. The baseline hydrological characteristics of the watercourses vary considerably in size, the degree of anthropogenic modification, the role the watercourse plays in water balance downstream, the habitats within the watercourse and the flood risk.

7.1.3 During operation, residual impacts to surface water hydrology include increased localised flood risk around culverts, bridges and realigned sections; increases or decreases to catchment supplies or a change/blockage in surface water runoff pathways. During construction, similar temporary impacts have been identified, which may be more pronounced effect for a shorter period of time.

7.1.4 Changes to catchment areas can be most pronounced if there is an increase or decrease in the supply of water from several watercourses supplying the same catchment. In this instance, it is necessary to consider impacts upon sub-catchments made up from a number of watercourses that would be affected by the proposal. Within the Southern Leg section of the proposed scheme, this is thought to be most relevant for Crynoch Burn, Hare Moss and the Moss of Auchlea. However, with correct implementation and maintenance of mitigation measures, the impact of the proposed road scheme on each watercourse would be limited. Residual impacts have been assessed as being of Negligible, Slight/Negligible or Slight significance on the watercourses and features within the study area.

7.1.5 The residual impacts on Hare Moss have been assessed as Slight/Negligible with the effective implementation of the mitigation described. Assuming all mitigation procedures are implemented, the existing water balance of Hare Moss would be maintained. Furthermore, increased flows to Jameston Ditch due to the outfall of road runoff and additional catchment size may contribute more water to the wetland, which would aid in the maintenance of water levels within the moss.

8 References

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9 Glossary

AEP	Annual exceedence probability
AREA	Catchment Drainage Area (km^2)
AWPR	Aberdeen Western Peripheral Road
Baseflow	is the continual contribution of groundwater to rivers and is an important source of flow between rainstorms.
BFIHOST	Base Flow Index derived using the HOST classification.
FARL	Index of Flood Attenuation due to Reservoirs and Lakes
FDC	Flow Duration Curve – A cumulative frequency curve that shows the percentage of time that specified discharges are equalled or exceeded.
FEH	Flood Estimation Handbook (see references (IH, 1999))
FFC	Flood Frequency Curve – A graph showing the recurrence intervals (return periods) that floods of magnitude are equalled or exceeded
HOST	Hydrology of Soil Types Classification
LF2000	Low Flows 2000
OS	Ordnance Survey
Q_{BAR}	Mean Annual Flood (m^3/s)
Q_{BF}	Bankfull Flow: the bank is defined at the point where vegetation/soil cover obviously changes between water and air
Q_{EBF}	Embankment-full Flow: the embankment (top of) is defined as the point where water would spill into wider areas (fields/road)
q green	Greenfield runoff rate (l/s/ha)
Q_{mean}	Mean Flow (m^3/s)
Q_{MED}	Median Annual Flood Flow (m^3/s) (flow with a 2-year return period)
Q_{95}	Flow that is expected to be exceeded 95% of the time (m^3/s)
Q-Tyr (eg Q-5yr)	Flow associated with a T-year return period (e.g. 5-year flow)
SAAR	1961-90 standard-period average annual rainfall (mm)
SAC	Special Area of Conservation
SPRHOST	Standard Percentage Runoff (%) derived using HOST classification
SSSI	Site of Special Scientific Interest

SUDS	Sustainable Urban Drainage Systems
URBEXT1990	FEH index of fractional urban extent for 1990.
V	Velocity (m/s)