A9.1 - 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 9 (Water Environment) of the Environmental Statement for the proposed Aberdeen Western Peripheral Route (AWPR). It focuses specifically on the hydrological impacts of the Northern Leg of the proposed scheme on watercourses crossed by the road, within the Northern 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 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, 17 watercourses / field ditches, one artificial mill lade system, 3 ponds, 2 lochs and the Howemoss Springs may potentially be affected by the construction and operation of the Northern Leg of the proposed scheme. These watercourses range in size, from small ephemeral field drains to larger fast flowing streams and rivers e.g. the River Don.

1.2 Assessment Aims

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

1.2.2 Impacts on hydrology are intrinsically linked to hydrogeology (refer to Chapter 8 Geology, Contaminated Land and Groundwater), water quality (refer to Appendix A9.4), geomorphology (refer to Appendix A9.3) and freshwater ecology (refer to Appendix A10.16. The inter-relationship of the environmental assessment chapters and appendices is illustrated in Figure 1.

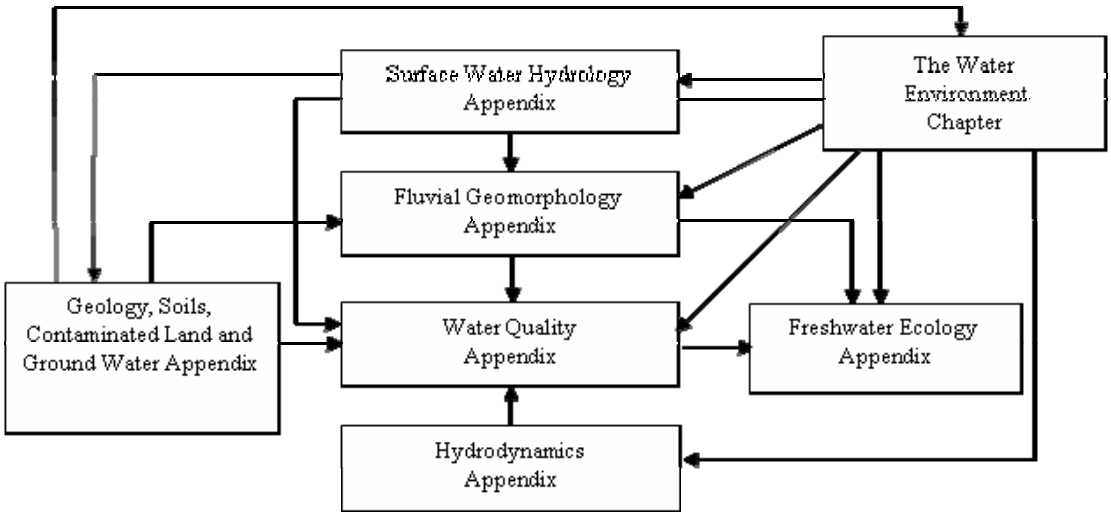

Figure 1: Flow chart illustrating the relationships between the technical appendices and chapters.

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 the potential impacts are defined in Table 2-1 and Table 2-2.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 2-3.

2.1.3 The assessment of sensitivity of water features (Table 2-1) takes into account both the natural and built environments.

Table 2-1 – 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 2-2 – Criteria to Assess the Magnitude of the Predicted 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% (1:200-year return period) or greater annual exceedence 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 2-3 – 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 impacts of the scheme on increasing flood risk.

2.1.5 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).

2.1.6 Controlled Activities (Scotland) Regulations 2005 (CAR) are referred to in this report. Controlled Activities Regulations are regulatory controls that were passed by Scottish Parliament on 1 June 2005 and came into force on 01 April 2006. The regulations 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 implemented through authorisations 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 would require baseline environmental information of the watercourse, details of the proposed design and a detailed construction method statement. Applications would be developed prior to construction and require approval from SEPA. Further information can be found in SEPA, The Water Environment (Controlled Activities) (Scotland) Regulations 2005: A Practical Guide, Version 3, May 2007.

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 give information on gauged catchments.

Existing Conditions

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

- 95-percentile flow (Q_{95});
- mean flow;
- 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 1: 100-year and 1: 200-year flood design peak flows); and
- likely 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 (Institute of Hydrology, 1999).

2.2.4 Table 2-4 identifies the flow parameters and methodologies that were used to calculate these estimates. It is noted that, apart from the Rivers Dee and Don, all watercourses to be crossed by the complete AWPR are small, ungauged catchments. Flow estimation on ungauged watercourses is generally subject to significant uncertainties.

2.2.5 To increase the confidence in the standard desk based flow estimates, site measurements aimed at refining several of hydrological parameters were undertaken during April 2005 at representative catchments. The hydrological analysis used desk-based procedures, gauged data from donor/analogue catchments[1] and where appropriate, spot gauging data.

[1] The procedure uses data transfer from gauged sites to refine flow estimates at ungauged sites. Donor sites are local catchments situated on the same watercourse as the subject site or a tributary thereof. Analogue sites are more distant gauged catchments that are sufficiently similar to the subject catchment.

Table 2-4 - 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 Q_{MED} 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%. For the River Don Q_{MED} estimates were based upon local gauging station records. For completeness, the detailed audit trail of the flood frequency assessment is included in the Annexes. FEH guidance on the degree of uncertainty associated with Q_{MED} estimates from a local gauging station with a 34 year data record is < ± 5% 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 AWPR Northern Leg.
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 but the River Don the average annual maximum flood was estimated following 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 AWPR Northern Leg.
Flood design peak flows **Q-Tyr**	Standard application of the FEH statistical pooling group method was used on a sub set of catchments to determine flood frequency curves for each burn. The curve was defined using the following % AEP 50%, 20%, 10%, 2%, 1%,0.5% AEP (design return periods:1: 2, 1: 5, 1: 10, 1: 50, 1: 100, 1: 200-years). Based upon the similarity of the growth curves and the apparent similarity in catchment characteristics across the area the area of interest, a single average growth curve was derived and applied to the other catchments. No formal quantification of Q-Tyr uncertainty is provided in the FEH but it is likely to be at least in the order of the Q_{MED} uncertainty ± 55% and in some circumstances will be appreciably larger. For the River Don a detailed pooling group and single site assessment using gauging station data was undertaken. For completeness the detailed audit trail of the flood frequency assessment are included in the Annexes. 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 and IH124 is included in Appendix A9.1 Annex 1. The 0.5 % AEP (1: 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. These values will also provide the information necessary to correctly size any structure across the watercourse.
Mean flow **Q_{mean}** 95-percentile flow **Q_{95}**	Q_{mean} and Q_{95} values are baseline conditions and were provided to support water quality (A9.4), ecological (A10.16) and geomorphological (A9.3) assessments. Mean flow (Q_{mean}) and 95-percentile flow (Q_{95}) for ungauged watercourses for which Low Flows 2000 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} (m^3/s) is 1.32 l/s/km² and the uncertainty in the estimate of annual mean flow (m^3/s) is ±11%. These quoted uncertainties are 68% confidence limits on the estimated natural values. For the River Don this was not necessary as gauged data were available.

Description / Parameter	Proposed methodology
Bankfull flow * **Q_{BF}** Embankment full flow** **Q_{EBF}**	Bankfull (Q_{BF}) and embankment full (Q_{EBF}) flow were estimated using Manning's Equation. Q_{BF} and Q_{EBF} were provided to support geomorphological assessments. During a site visit in April 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 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 gradients > 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 Don 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 Don.
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 Low Flows 2000 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%. For the River Don a hydraulic river model has been created for the flood risk assessment component of the ES. This model in combination with the mean monthly was used to determine monthly mean flow velocities.
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 methods 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 (1: 2-year return period) one hour rainfall event should be used to determine the pre-development runoff for the existing site (refer DP300 3/02) (i.e. predevelopment or as a 'Greenfield site'). According to CIRIA C609 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 Northern Leg of the AWPR. The FEH catchment area method uses the 50% AEP (1: 2-year return period / 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 l/s/ha. 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* * *I* (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 (1: 5-year return period) from the standard FSR maps (Wilson et al., 2004) and multiplying this value by the appropriate growth factor for the desired return period (Wilson et al., 2004).

Description / Parameter	Proposed methodology
	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.
SEPA Indicative River and Coastal Flood Map (Scotland)	Where available flood risk assessment for the AWPR river crossing points 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 3-1 describes the flood risk at the proposed road crossing point where flood risk information is available and the relevant annex (A9.5) shows the map. More information regarding the 'Indicative River and Coastal Flood Map (Scotland)' can be found at www.sepa.org.uk/flooding/mapping/how_to_use.htm. Areas not covered by the SEPA 'Indicative River and Coastal Flood Map (Scotland)' have been assessed using 1:25,000 Ordnance Survey Maps.

\# The 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.

2.2.6 Some hydrological features include characteristics that require analysis beyond the methodologies described in Table 2-4. These include: Howemoss Springs and Mill Lade-system. These were assessed via site visits between April 2005 and July 2005 together with supporting information from maps and discussion with other experts from related disciplines.

Allowance for Climate Change in Hydrological Parameters

2.2.7 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 to be used as an allowance for climate change. However, SEPA suggests that the sensitivity of flows within flood risk analysis could be carried out up to a 20% increase in flows for the east of Scotland in allowance for climate change. This is considered to be the maximum change expected. Available evidence suggests that by 2050 there is more likely to be an increase of approximately 15% in the east of Scotland (Price & McKenna, 2003).

2.2.8 The Scottish Executive (2004) states in the SPP7 Planning and Flooding Report that the threshold annual probability values for flood events (0.5% (1: 200-year return period) and 0.1% (1: 1000-year return period)) include an allowance for climate change. The Scottish Executive also indicates that developments should now be designed to accommodate a flood event to a 0.5% annual probability instead of the 1% annual event probability (AEP) in order to provide an allowance for possible future climate change increases.

Assessment of Impacts

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

2.2.10 Potential post-development changes to above parameters (Table 2-4) are highlighted, in addition to potential changes to flood risk and floodplain inundation. These are assessed by recalculating parameters (see Table 2-4) for a catchment with the proposed 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.

2.2.11 Flood risk assessment for the 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 return period) flood event. The SEPA flood risk maps, however, do not show the flood risk for watercourses with a catchment smaller than 3km². Table 3-1 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 at on the SEPA website.

2.2.12 For watercourses outwith the SEPA Indicative Flood Map (Scotland), 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 1:25, 000m Ordnance Survey plans and 1:1250m detailed design plans) between the proposed culvert and any properties upstream from the proposed culvert entrance. Identification of land use upstream of the culvert was also required as wooded areas can potential produce more debris that can block culverts. This approach was used to identify properties that could potentially be at risk during extreme events.

2.2.13 The potential impacts of watercourse realignment were assigned for realignments; these would maintain existing channel dimensions, gradients and surface runoff pathways.

2.2.14 In the assessment, all culverts are assessed as flood flow culverts. Flood flow culverts are designed to convey the 0.5% AEP (1: 200-year return period flow). Network culverts (i.e. part of the drainage system) are designed to the standard 1.33% AEP (1: 75-year return period flow) in line with the road drainage network, which is designed to the standards set out in the DMRB HA 106/04. However, in the Northern Leg only one network culvert is proposed, and this forms a mitigation element to maintain catchment connectivity, as assessed in Section 5.

2.2.15 When assessing the impact of the proposed scheme on a watercourse, the percentage change in total catchment area of an affected watercourse was considered as an indicator of potential impacts. Catchment changes of 1% or less were considered to be of negligible magnitude, changes of less than 10% were considered low, changes of less than 25% were considered medium and changes greater than 25% were 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.

2.3 Limitations to Assessment

2.3.1 The only continuous monitoring of hydrological data are found on the River Don. All of the other watercourses and surface water features considered in this report are ungauged and therefore inherent uncertainties exist in the estimation of flows.

2.3.2 A higher degree of accuracy 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 of the water features in the study area. Table 3-1 details the baseline hydrological conditions of water features in the study area. Figures 9.2a-d presents the location plan of catchments, proposed culverts, flow gauges and rain gauges referred to in the assessment. Figure 9.2e gives a detailed location plan of Corby and Lily Lochs.

3.1.2 Estimated flood flows are provided in Appendix A9.5, Annex 1. Annex 2 of Appendix A9.5, summarises the flow duration curves derived by using Low Flows 2000 (LF2000) software and compares them to check spot gaugings that were taken during a site visit in April 2005 for selected watercourses. The Low Flows 2000 information was then applied to other parameters following donor principles.

3.1.3 Annexes 3-18 of Appendix A9.5 provide information on the parameters indicated in Table 2-4 for each watercourse.

3.2 Site Specific Assessments

3.2.1 There is a range of sensitivities of the watercourses along the Northern Leg of the proposed AWPR caused by sensitive and protected ecosystems including trout and lamprey species. Gough Burn, Craibstone Burn, Bogenjoss Burn, have been assigned medium sensitivity and Goval Burn, River Don, Corby and Lily Loch SSSI (Site of Special Scientific Interest) have been assigned highest water feature sensitivity.

3.2.2 Howemoss Springs are located to the east of the proposed AWPR main line. The springs emerge along a contour line, at hedges within fields. These field ditches flow towards Aberdeen Airport business area. With respect to the groundwater catchment, refer to Chapter 8 (Geology, Soils, Contaminated Land and Groundwater). However, groundwater flow is generally considered to be of low sensitivity in this area. Where wells are in close proximity (within 250m), sensitivity is considered to be moderate to high. In particular, this is evident at the A96 (ch317200-317225) and Newtonhill Overbridge (ch327725-329725).

3.2.3 The River Don valley slightly narrows at the crossing point of the proposed scheme. However, just upstream of this point and at the confluence with Goval Burn the valley gives space for wider flood plains. For further, more detailed information refer to Appendix A9.2 (Hydrodynamic Modelling).

3.2.4 The Mill Lade system has been installed artificially and was used as a source of power for a pumping station. The Mill Lade takes water from the Goval Burn via a sluice gate and contours at a shallow gradient parallel to the Goval Burn. A small reservoir is located along the Mill Lade, both are located at a higher altitude than the Goval Burn. The Mill Lade flows through an artificial channel and a second sluice gate is located at the A947. In the past the Lade terminated above a pumping station near Goval Bridge where it would have fallen a substantial height down a pipe and eventually would have rejoined the Goval Burn. At present the Mill Lade is prevented from entering the pumping station and now outfalls directly to the Goval Burn via an overflow weir and pipe. (See Appendix A9.5, Annex 20 for a detailed description of the present state of the Mill Lade system).

3.2.5 Red Moss Burn originates from Red Moss and flows into Corby Loch, part of the Corby, Lily and Bishops Lochs SSSI. For the significance of the SSSI, refer to Chapter 10 (Ecology and Nature Conservation). Corby Loch has a catchment area of approximately 3.6 km² and is adjacent to Lily Loch (1.2 km²).

3.2.6 During a site visit in April 2005, it was noted that all watercourses within the study area flow within well defined banks/embankments. No signs of recent flooding such as trash-lines were observed in the vicinity of the crossing point of the proposed scheme. Estimates of bankfull flows suggest that none of the watercourses are likely to exceed the capacity of their well-defined watercourse corridors during a 1% AEP (1: 100-year return period) flood. The River Don and Goval Burn have been investigated in further detail with regard to flood risk, as reported in Appendix A9.2).

3.2.7 SEPA were approached for information on existing and indicative flood risk. Most watercourses along the proposed AWPR are relatively small watercourses and SEPA holds no information on these. The River Don is the only main river within the Northern Leg study area. There is a SEPA gauging station at Park Hill Bridge a short distance downstream of the proposed crossing of the AWPR. Previous flooding occurred on the River Don around the Bridge of Don area (more than 10 km downstream of the proposed crossing), but no more detail could be given.

3.2.8 Aberdeen City Council provided a map showing the historic flood extents of the River Don in September 1995, April 2000, October 2002 and November 2002. The November 2002 event was the largest and appears to have a return period of the order of 100 years. The map together with the OS 1:25,000 map shows that the upstream broad River Don floodplain (which extends up to Elphinstone and in some places approaches a width of 1km) narrows to little more than the width of the river about 1km upstream of the proposed crossing. At the actual crossing point the floodplain has again widened but to a lesser extent (Figure 9.3a). The provided flood outline suggests that there are no properties in the immediate vicinity of the crossing at risk from flooding, but that a limited number of roads and property were affected during some of the events at Stoneywood and Bucksburn approximately 5 km downstream, further down at Bridge of Don.

3.2.9 Aberdeenshire Council holds no information on flooding or specific water uses on the watercourses along this stretch of the proposed scheme beyond what was provided by Aberdeen City Council.

3.3 Summary

3.3.1 In total, the Northern Leg of the proposed scheme would cross 17 watercourses / field ditches and one artificial mill lade system. The proposed scheme would also affect three small ponds, Howemoss Springs and two lochs (Corby and Lily Lochs) which are sensitive environments and have been designated SSSI status. The major watercourse along the proposed route is the River Don, whilst the remaining watercourses are all relatively small. Surface water hydrology for each water feature is summarised in Table 3-1.

3.3.2 The watercourse catchments are all predominantly rural in character. The River Don has a catchment area of about 1228 km², but all other watercourses have small catchments between 0.2 and 40 km². Average annual rainfall along the entire route varies between 770 and 840mm, with a slight east to west increase, indicating a drier than average region within Scotland.

3.3.3 Hydrological soil parameters indicate that the ground conditions along the proposed Northern Leg of the AWPR are generally of average permeability with a slight increase in permeability in northern areas. Greenfield runoff rate was calculated at 4-5 l/s/ha for the 50% AEP (1: 2-year return period) design flows. The Greenfield runoff rate defines the discharge rate from water quality treatment ponds (refer to Appendix A9.4: Water Quality).

3.3.4 Soil parameters of the small catchments suggest middle range permeability and that 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 does not reach the watercourse particularly quickly), but they will experience appreciable flood flows during and

immediately following heavy rain. Within the range of responsiveness, the Bogenjoss and Red Moss Burns are likely to have a faster response to rainfall whereas the Goval Burn is likely to be slower to respond. However, it is stressed that none of these catchments exhibit extreme response characteristics.

3.3.5 Existing flood risk from smaller 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 scheme. An assessment of watercourses outwith the SEPA 'Indicative River and Coastal Flood Map (Scotland)' also indicates some potential existing flood risk.

3.3.6 The River Don has relatively wide flood plains in the vicinity of the proposed scheme, the flooding of which has been observed in recent extreme flood events. However, no properties appear to be at risk on the flood plain in the immediate vicinity of the proposed crossings (refer to Appendix A9.2).

Table 3-1 – Baseline Surface Water Hydrological Conditions

Water feature	Annex	Description	Sensitivity
Kepplehill Burn and field ditch	3	Catchment area upstream of the proposed road crossing point: 0.4km² Tributary of Bucks Burn, which flows into the River Don. Lower reaches flow through the suburban area of Bucksburn. A Scottish Water reservoir is located in the upstream headwaters of Kepplehill Burn, a Scottish Water box is located at Kepplestone Farm at the confluence of Kepplehill Burn and field ditch. Desktop assessment of the 1:25,000 OS maps indicates 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 the SEPA Flood Risk maps do not include catchments less than 3km²	Low
Gough Burn	4	Catchment area upstream of the proposed road crossing point : 1.1km² Watercourse displaying potential for trout and lamprey. Rural tributary of Green Burn, which flows into the River Don. Desktop assessment of the 1:25,000 OS maps indicates a potential flood risk to a property located within 100m of the Gough Burn 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 the SEPA Flood Risk maps do not include catchments less than 3km²	Medium
Parkhead Burn	5	Catchment area upstream of the proposed road crossing point : 0.2km² Rural tributary of Craibstone Burn, which flows into Green Burn and River Don. Desktop assessment of the 1:25,000 OS maps indicates 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 the SEPA Flood Risk maps do not include catchments less than 3km²	Low
Parkhead Field Ditch	6	Catchment area upstream of the proposed road crossing point: 0.2km² Rural tributary of Craibstone Burn, which flows into Green Burn and River Don. Desktop assessment of the 1:25,000 OS maps indicates 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 the SEPA Flood Risk maps do not include catchments less than 3km²	Low
Craibstone Burn	7	Catchment area upstream of the proposed road crossing point : 0.5km² Watercourse displaying potential for trout and lamprey. Rural tributary of Green Burn, which flows into the River Don. Desktop assessment of the 1:25,000 OS maps indicates 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 the SEPA Flood Risk maps do not include catchments less than 3km²	Medium
Craibstone field ditch	7	Catchment area upstream of the proposed road crossing point : 0.01km² Field ditch feeding into Craibstone Burn. Desktop assessment of the 1:25,000 OS maps indicates 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 the SEPA Flood Risk maps do not include catchments less than 3km²	Low
Craibstone Pond	n/a	Assessed by freshwater ecology and surveyed for newts – please refer to the Ecology Chapter 10. Desktop assessment of the 1:25,000 OS maps indicates 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 the SEPA Flood Risk maps do not include catchments less than 3km²	N/A
Green Burn	8	Catchment area upstream of the proposed road crossing point :2.8km² Watercourse displaying potential for salmon, trout and lamprey. Tributary of the River Don, lower reaches flow through suburban area of Bankhead.	Medium

Water feature	Annex	Description	Sensitivity
		At the point of interest there appears to be no flood risk to properties, however, the desktop assessment of the 1:25,000 OS maps indicates there may be a potential flood risk to the A96. At the road crossing point the Indicative River and Coastal Flood Maps (Scotland) predict that Green Burn will flood at the 0.5% AEP (1: 200-year return period event). At this location Green Burn is predicted to flood land within 25m of the channel. There appears to be no properties in the flood risk area, with the floodplain consisting of arable and pasture farmland and a section of the A96.	
Walton Field Ditch	9	Catchment area upstream of the proposed road crossing point: 0.1km² Rural field drainage ditch. Desktop assessment of the 1:25,000 OS maps indicates there is a potential flood risk to properties within the Chapel brae hamlet 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 the SEPA Flood Risk maps do not include catchments less than 3km²	Low
Howemoss Springs	n/a	Spring line within agricultural fields. Desktop assessment of the 1:25,000 OS maps indicates there is no flood risk to properties at the site of interest.	Medium
Howemoss Burn	10	Catchment area upstream of the proposed road crossing point : 0.4km² Originates at Howemoss Springs. Tributary of River Don, enters Aberdeen Airport area and is there mostly culverted. Desktop assessment of the 1:25,000 OS maps indicates 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 the SEPA Flood Risk maps do not include catchments less than 3km²	Low
Bogenjoss Burn	11	Catchment area upstream of the proposed road crossing point: 1.18km² Watercourse displaying potential for trout and lamprey. Rural tributary of River Don. Desktop assessment of the 1:25,000 OS maps indicates there is a potential flood risk to three properties located within 100m of the Bogenjoss Burn 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 the SEPA Flood Risk maps do not include catchments less than 3km²	Medium
River Don	12	Catchment area upstream of the proposed road crossing point: 1228km² Watercourse displaying potential for salmon, trout and lamprey. Designated fisheries river. Lower reaches flow through suburban areas. Estuary is a Local Nature Reserve. Refer to Appendix A9.5, Annex 19 for flood estimation audit trail. Refer to Figure 9.3a for historic flood envelopes. At the road crossing point the Indicative River and Coastal Flood Maps (Scotland) predict that the River Don will flood at the 0.5% AEP (1: 200-year return period event). At this location the River Don is predicted to flood land within 150m of the channel. There appears to be no properties in the flood risk area with the floodplain consisting of arable and pasture farmland.	High
Mill Lade	n/a	Artificial watercourse system with a shallow gradient. Refer to Appendix A9.5, Annex 20 for description of the system. Desktop assessment of the 1:25,000 OS maps indicates there is a potential flood risk to the Goval Bridge Hamlet and the A947 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 the SEPA Flood Risk maps do not include catchments less than 3km²	Medium

Water feature	Annex	Description	Sensitivity
Goval Burn	13	Catchment area upstream of the proposed road crossing point : 36.64km² Watercourse displaying potential for salmon, trout and lamprey. Designated fisheries river. Rural tributary of River Don. There is a potential flood risk to Goval Villa. At the road crossing point the Indicative River and Coastal Flood Maps (Scotland) predict that the Goval Burn will flood at the 0.5% AEP (1: 200-year return period event). Flood inundation at the bridge crossing points is shown by the SEPA Indicative River and Coastal Flood Maps to vary between 400-50m of the channel. Within this region there is one property at risk of flooding at Goval Villa and two roads the B977 and the A947. There appears to be properties in the flood risk area shown by the SEPA Indicative River and Coastal Flood Map.	High
Corsehill Pond	n/a	Assessed by freshwater ecology and surveyed for newts – please refer to the Ecology Chapter 10. Desktop assessment of the 1:25,000 OS maps indicates a potential flood risk to the B977 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 the SEPA Flood Risk maps do not include catchments less than 3km²	Low
Corsehill Burn	14	Catchment area upstream of the proposed road crossing point : 1.8km² Watercourse displaying potential for trout. Rural tributary of Goval Burn, which flows into the River Don. Desktop assessment of the 1:25,000 OS maps indicates 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 the SEPA Flood Risk maps do not include catchments less than 3km²	Medium
Lochgreens Pond	n/a	Assessed by freshwater ecology and surveyed for newts – please refer to the Ecology Chapter 10. Desktop assessment of the 1:25,000 OS maps indicates 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 the SEPA Flood Risk maps do not include catchments less than 3km²	Low
Red Moss Burn	15	Catchment area upstream of the proposed road crossing point: 1.3km² Rural stream flowing into Corby Loch (SSSI), which flows into Burn of Mundurno that fringes a Local Plan District Wildlife Site at Perwinnes Moss, and whose estuary is at a costal Aberdeen District Wildlife Site. Drains from Red Moss. Desktop assessment of the 1:25,000 OS maps indicates 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 the SEPA Flood Risk maps do not include catchments less than 3km²	Medium
Corby Loch	n/a	Corby Loch has a catchment area of about 3.6km² . Corby Loch is designated as a SSSI, and shares a basin with Lily Loch. There is no surface channel connecting Corby and Lily Lochs. Red Moss Burn feeds Corby Loch. The loch is also fed by groundwater, rain directly falling on the loch and surface runoff.. Although groundwater may feed the loch, it is thought that disruption to surface flows should be kept to an absolute minimum in order to preserve the water balance of the loch. 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.	High
Lily Loch	n/a	Lily Loch has a catchment of approximately 1.2km². Lily Loch is a sensitive environment and is designated SSSI status. The loch is believed to be fed by a combination of the Lily Loch inflow channel,	High

Water feature	Annex	Description	Sensitivity
		groundwater, rain directly falling on the loch and surface runoff. Although groundwater is likely to feed the loch, it is thought that disruption to surface flows should be kept to an absolute minimum in order to preserve the water balance of the loch. Water level measurements suggest Lily Loch (measured at 76.46m OAD) provides water to Corby Loch (measures as 76.16m AOD). 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 the SEPA Flood Risk maps do not include catchments less than 3km²	
Bishops Loch	n/a	Bishops Loch is part of the Corby, Bishops and Lily Loch SSSI. AWPR is not within the Bishops Loch catchment. Desktop assessment of the 1:25,000 OS maps indicates 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 the SEPA Flood Risk maps do not include catchments less than 3km²	High
Blackdog Burn	16	Catchment area upstream of the proposed road crossing point : 5.4km² Watercourse displaying potential for trout and lamprey downstream of proposed crossing (present only near outflow to sea). Downstream reach fringes a coastal Aberdeen District Wildlife Site. At the road crossing point the Indicative River and Coastal Flood Maps (Scotland) predict that the Blackdog Burn will flood at the 0.5% AEP (1: 200-year return period event). At this location the Blackdog Burn is predicted to flood land within 50m of the channel. There appears to be no properties in the flood risk area with the floodplain consisting of arable and pasture farmland.	Medium
Blackdog Ditch	17	Catchment area upstream of the proposed road crossing point : 0.22km² Rural field drainage ditch. Desktop assessment of the 1:25,000 OS maps indicate there is no flood risk to properties at the site of interest. .At the road crossing point the Blackdog Burn Indicative River and Coastal Flood Maps (Scotland) predict that the Blackdog Ditch will flood at the 0.5% AEP (1: 200-year return period event). At this location the Blackdog Ditch is predicted to flood land within 50m of the channel. There appears to be no properties in the flood risk area with the floodplain consisting of arable and pasture farmland.	Low
Middlefield Burn	18	Catchment area upstream of the proposed road crossing point : 0.4km² Rural stream and drainage ditches. Desktop assessment of the 1:25,000 OS maps indicates there is a potential flood risk to Middlefield hamlet and the A90 (T) 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 the SEPA Flood Risk maps do not include catchments less than 3km²	Low

4 Potential Impacts

4.1 Introduction

4.1.1 Potential impacts associated with the operational phase of the proposed 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.

4.1.2 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 2-2.

4.1.3 It should be noted that the assessments of the Southern Leg (ES Chapter 24) and Fastlink (ES Chapter 39) include consideration of the potential impact of network culverts. These are pipes forming part of the road drainage system, necessary to convey drainage underneath the road. However, in the Northern Leg of the proposed scheme, the only network culvert required is as a mitigation measure for severance of the Lily Loch catchment, and this is therefore discussed in Section 9.5 (Mitigation).

4.1.4 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 area (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.

4.1.5 These impacts have the potentially to result in changes to:

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

4.2 Operation Impacts

4.2.1 Potential impacts of the proposed scheme on surface hydrology are those that could affect the physical flow and water level regimes. Examples of such circumstances might 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 increasing the overall volume of water reaching the watercourse, as less is lost to infiltration. Road runoff may also reach receiving watercourses 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, which has the potential to alter the hydrology and flood regimes of outfall watercourses if not mitigated. Outfall of road drainage may also have an impact on the sediment regime and water quality of the receiving watercourse (refer to the Appendix A9.4 Water Quality and A9.3 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 impact 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. 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.

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

Road Drainage Outfalls

4.2.3 Outfalls to discharge road drainage would be required for:

- Green Burn;
- Bogenjoss Burn;
- River Don;
- Goval Burn;
- Corsehill Burn;
- Red Moss Burn;
- Blackdog Burn; and
- Middlefield Burn

Watercourse Crossings

4.2.4 A bridge is proposed to be constructed to cross the River Don, due to both its size and environmental sensitivity. The bridge is designed to entirely span the watercourse with no in-channel supports. All proposed crossings are marked clearly on Figures A9.2a - d.

4.2.5 Three bridges are also proposed to cross Goval Burn due to the size and environmental sensitivities of these watercourses. The Mill Lade is carried by an aqueduct, and this will require to be extended to pass over the proposed scheme. In addition, a total of 23 culverts would be required, as follows:

- one culvert at Kepplehill Burn, Craibstone Burn, Red Moss Burn, Blackdog Ditch;
- two culverts at Gough Burn, Blackdog Burn;
- three culverts at Green Burn, Corsehill Burn and Middlefield Burn; and
- six culverts at Bogenjoss Burn.

4.2.6 For the purposes of identifying potential impacts, culverts are assessed assuming a box-shaped concrete structure containing no bed substrate. However, it should be noted that modification of this basic design to a depressed invert box culvert incorporating bed substrate is included in the road design as mitigation (Section 5) to reduce the potential impacts identified in this section.

Watercourse Realignments

4.2.7 The following watercourse realignments would be required:

- Kepplehill Burn (one realignment of 200m, overall length maintained);
- Gough Burn (two realignments of 183m and 25m, overall length maintained);
- Craibstone Burn (one realignment of 196m, resulting in a 11m shortening of the channel);
- Green Burn (three realignments in total over 595m, resulting in a 2m lengthening of channel length)
- Bogenjoss Burn (six realignments in total over 948m, resulting in a 156m shortening of the channel);
- Corsehill Burn (three realignments of overall length 585m, resulting in a 15m lengthening of channel length);
- Red Moss Burn (one realignment of 81m in length, overall length maintained);
- Blackdog Burn (two realignment of 146m, overall length maintained);
- Middlefield Burn (three realignments in total over 460m, resulting in a 65m shortening of the channel); and
- Blackdog Ditch (one realignment of 96m, resulting in a 2m shortening of the channel).

Pre-earthworks Drainage

4.2.8 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 small ephemeral ditches:

- Ditch draining into Kepplehill Burn;

- Parkhead Burn;
- Parkhead Field Ditch;
- Craibstone Field Ditch; and
- Walton Field Ditch.

4.2.9 In addition to the above, an area of the Howemoss Burn catchment would also be routed into pre-earthwork drainage.

Catchment Severance

4.2.10 Although Howemoss Burn would not be directly taken into the pre-earthworks drainage, it would lose approximately 70% of its catchment to pre-earthworks drainage. This is ultimately likely to result in a reduction of discharge within Howemoss Burn through a reduction in catchment size.

4.2.11 Approximately 40% of the Lily Loch catchment would be severed by the proposed scheme.

Table 4-1 – Potential Operational Impacts

Water Feature	Sensitivity	Potential Impact Description (assuming no mitigation)	Potential Impact	
			Magnitude	Significance
Kepplehill Burn and field ditch	Low	Culvert at ch315200: Potential to cause localised constriction of flow and flood risk for events exceeding the 200-year return period event.	Negligible*	Negligible
		Potential risk of culvert blockage at ch315200 has been based on a desktop assessment of the site using OS maps. The catchment land use upstream of the culvert consists of pasture and scrub land. Therefore risk of culvert blockage has been assessed as low. At the point of interest there is no known flood risk.	Low	Negligible
		Realignment: Potential to cause a slight increase in channel gradient. Any decrease in bank height may increase localised flood risk.	Low	Negligible
		Field ditch taken into pre-earthworks. The area of the catchment upstream of the road would be taken into pre-earthwork drainage.	Negligible	Negligible
Ditch draining to Kepplehill Burn	Low	The area of the catchment upstream of the road would be taken into pre-earthworks drainage.	Negligible	Negligible
Gough Burn	Medium	Culvert on main AWPR line at ch316390: Potential to cause localised constriction of flow and flood risk for events exceeding the 200-year return period event.	Negligible	Negligible
		Potential risk of culvert blockage at ch316390 has been based on a desktop assessment of the site using OS maps. The catchment land use upstream of the culvert consists of pasture and bracken, heather and / or rough grass. Therefore risk of culvert blockage has been assessed as low. At the point of interest there is a property within 100m. Flood risk has therefore been assessed as medium.	Medium	Moderate
		Culvert on side road at ch316430: Potential to cause localised constriction of flow and flood risk for events exceeding the 200-year return period event.	Negligible*	Negligible
		Potential risk of culvert blockage at ch316430 has been based on a desktop assessment of the site using OS maps. The catchment land use upstream of the culvert also consists of pasture and bracken, heather and / or rough grass. Therefore risk of culvert blockage has been assessed as low. At the point of interest there is a property within 100m. Flood risk has therefore been assessed as medium.	Medium	Moderate
		Realignment: Potential to cause a slight increase in channel gradient. Any decreased bank height may increase localised flood risk.	Low	Slight
Parkhead Burn	Low	The area of the catchment upstream of the road would be taken into pre-earthworks drainage.	Negligible	Negligible
Parkhead Field Ditch	Low	The area of the catchment upstream of the road would be taken into pre-earthworks drainage.	Negligible	Negligible
Craibstone Burn	Medium	Culvert at ch316990: Potential to cause localised constriction of flow and flood risk for events exceeding the 200-year return period event.	Negligible*	Negligible
		Potential risk of culvert blockage at ch316990 has been based on a desktop assessment of the site using OS maps. The catchment land use upstream of the culvert consists of forest and a small area of pasture land. Therefore risk of culvert blockage has been assessed as medium. At the point of interest there is no known flood risk.	Medium	Moderate
		Realignment: Potential to cause a slight increase in channel gradient. Any decrease in bank height may increase localised flood risk.	Low	Slight
Craibstone Field Ditch	Low	The area of the catchment upstream of the road would be taken into pre-earthworks drainage.	Negligible	Negligible

Water Feature	Sensitivity	Potential Impact Description (assuming no mitigation)	Potential Impact	
			Magnitude	Significance
Craibstone Pond	(Refer to Chapter 10	Not impacted in hydrological terms. However, due to the proximity of the road to Craibstone Pond, it is unlikely it would continue be able to support surrounding habitats such as otters (Refer for more details to Ecology Chapter 10, Table 10.10 – Summary of Predicted Construction Impacts on Habitats and Species).	N/A	N/A
Green Burn	Medium	Culvert on main AWPR line at ch317330: Potential to cause localised constriction of flow and flood risk for events exceeding the 200-year return period event.	Negligible	Negligible
		Potential risk of culvert blockage at ch317330 has been based on a desktop assessment of the site using OS maps. The catchment land use upstream of the culvert consists of forest and pasture land. Therefore risk of culvert blockage has been assessed as medium. At the point of interest there are properties located approximately 100m from the channel. Flood risk has therefore been assessed as medium.	Medium	Moderate
		Culvert on A96 mainline: Potential to cause localised constriction of flow and flood risk for events exceeding the 200-year return period event.	Negligible	Negligible
		Potential risk of culvert blockage for the proposed A96 mainline culvert has been based on a desktop assessment of the site using OS maps. The catchment land use upstream of the culvert consists of a forest and pasture land. Therefore risk of culvert blockage has been assessed as medium. At the point of interest flood risk has been assessed as Low.	Medium	Moderate
		Culvert on Kirkhill Industrial Estate Link Road: Potential to cause localised constriction of flow and flood risk for events exceeding the 200-year return period event.	Negligible	Negligible
		Potential risk of culvert blockage for the proposed Kirkhill Industrial Estate Link Road culvert has been based on a desktop assessment of the site using OS maps. The catchment land use upstream of the culvert consists of a forest and pasture land. Therefore risk of culvert blockage has been assessed as medium. At the point of interest there is no known flood risk.	Medium	Moderate
		Realignment: Potential to cause a slight increase in channel gradient. Any decrease in bank height may increase localised flood risk.	Low	Slight
		Outfalls including pre-earthworks (about 3km of road) and road runoff (about 9km of road). Potential to cause increased flows.	Low	Slight
Walton Field Ditch	Low	The area of the catchment upstream of the road would be taken into pre-earthworks drainage.	Negligible	Negligible
Howemoss Springs	Medium	Part of surface water catchment taken into pre-earthworks (about 72% of catchment area), though springs likely not to depend on surface water catchment. Groundwater flow is generally considered to be of low sensitivity in this area. Two springs are evident in this area (refer to Groundwater section in Chapter 8).	Low	Slight
Howemoss Burn	Low	Partial catchment taken into pre-earthworks (about 70% of catchment area). The area of catchment taken into pre-earthworks is less than 1% of the River Don catchment.	Medium	Slight
		Catchment severance	Medium	Slight
Bogenjoss Burn	Medium	Culvert on main AWPR line at ch320870: Potential to cause localised constriction of flow and flood risk for events exceeding the 200-year return period event.	Negligible*	Negligible
		Potential risk of culvert blockage at ch320870 has been based on a desktop assessment of the site using OS maps. The catchment land use upstream of the culvert consists of pasture land and forests. Therefore risk of culvert blockage has been assessed as medium. At the point of interest there is no known flood risk.	Medium	Moderate
		Culvert on main AWPR line at ch320500: Potential to cause localised constriction of flow and flood risk for events exceeding the 200-year return period event.	Negligible*	Negligible

Water Feature	Sensitivity	Potential Impact Description (assuming no mitigation)	Potential Impact	
			Magnitude	Significance
Bogenjoss Burn [cont'd]		Potential risk of culvert blockage at ch320500 has been based on a desktop assessment of the site using OS maps. The catchment land use upstream of the culvert consists of pasture land. Therefore risk of culvert blockage has been assessed as negligible. At the point of interest there are properties within 100m of the channel. At the point of interest flood risk has therefore been assessed as medium.	Medium	Moderate
		Culvert on Kirkhill Access Track at ch320475: Potential to cause localised constriction of flow and flood risk for events exceeding the 200-year return period event.	Negligible	Negligible
		Potential risk of culvert blockage at ch320475 has been based on a desktop assessment of the site using OS maps. The catchment land use upstream of the culvert consists of pasture land. Therefore risk of culvert blockage has been assessed as negligible. At the point of interest there are properties within 100m of the channel. At the point of interest flood risk has therefore been assessed as medium.	Medium	Moderate
		Culvert on Kirkhill Access Track at ch320260: Potential to cause localised constriction of flow and flood risk for events exceeding the 200-year return period event.	Negligible	Negligible
		Potential risk of culvert blockage at ch320260 has been based on a desktop assessment of the site using OS maps. The catchment land use upstream of the culvert consists of forests. Therefore risk of culvert blockage has been assessed as medium. At the point of interest there is no known flood risk.	Medium	Moderate
		Culvert on Kirkhill Access Track at ch320215: Potential to cause localised constriction of flow and flood risk for events exceeding the 200-year return period event.	Negligible	Negligible
		Potential risk of culvert blockage at ch320215 has been based on a desktop assessment of the site using OS maps. The catchment land use upstream of the culvert consists of forests. Therefore risk of culvert blockage has been assessed as medium. At the point of interest there is no known flood risk.	Medium	Moderate
		Culvert on Kirkhill Access Track at ch320100: Potential to cause localised constriction of flow and flood risk for events exceeding the 200-year return period event.	Negligible*	Negligible
		Potential risk of culvert blockage at ch320100 :has been based on a desktop assessment of the site using OS maps. The catchment land use upstream of the culvert consists of forests. Therefore risk of culvert blockage has been assessed as medium. At the point of interest there is no known flood risk.	Medium	Moderate
		Realignment: Potential for a slight increase in channel gradient. Any decrease in bank height may increase localised flood risk.	Low	Slight
		Outfall including pre-earthworks / road runoff (about 1km of road). Potential to cause increased flows.	Low	Slight
River Don	High	Bridge: Potential to cause a localised constriction of flow due to bridge supports and increase flood risk for events exceeding the 200-year return period event.	Low*	Moderate
		Outfall including pre-earthworks / road runoff (about 2km of road). Potential to cause increased flows.	Negligible	Slight / Negligible
Mill Lade	Medium	Channel retained in form of an aqueduct (assuming present gradient and aqueduct dimensions maintained).	Low	Slight
		Bridge: Potential to cause a localised constriction of flow due to bridge supports and increase flood risk for events exceeding the 200-year return period event.	Low*	Slight

Water Feature	Sensitivity	Potential Impact Description (assuming no mitigation)	Potential Impact	
			Magnitude	Significance
Goval Burn	High	Three bridges: Potential to cause a localised constriction of flow due to bridge supports and increase flood risk for events exceeding the 200-year return period event.	Negligible*	Slight / Negligible
		Additional catchment area upstream of the road taken into pre-earthwork drainage (very small area).	Negligible	Slight / Negligible
		Outfall including pre-earthworks / road runoff (about 2km of road). Potential to cause increased flows.	Negligible	Slight / Negligible
Corsehill Pond	Refer to Chapter 10	Pond filled in (refer to Chapter 10).	n/a	n/a
Corsehill Burn	Medium	Culvert on main AWPR line at ch325085: Potential to cause localised constriction of flow and flood risk for events exceeding the 200-year return period event.	Negligible*	Negligible
		Potential risk of culvert blockage at ch325085 has been based on a desktop assessment of the site using OS maps. The catchment land use upstream of the culvert consists of pasture land with small patches of forests further upstream. Risk of culvert blockage has been assessed as low. At the point of interest there is no known flood risk.	Low	Slight
		Culvert on link 1 road: Potential to cause localised constriction of flow and flood risk for events exceeding the 200-year return period event.	Negligible*	Negligible
		Potential risk of culvert blockage for the proposed link 1 road culvert has been based on a desktop assessment of the site using OS maps. The catchment land use upstream of the culvert consists of pasture land with small patches of forests further upstream. Risk of culvert blockage has been assessed as low. At the point of interest there is no known flood risk.	Low	Slight
		Culvert on link 2 road: Potential to cause localised constriction of flow and flood risk for events exceeding the 200-year return period event.	Negligible*	Negligible
		Potential risk of culvert blockage for the proposed link 2 road culvert has been based on a desktop assessment of the site using OS maps. The catchment land use upstream of the culvert consists of pasture land with small patches of forests further upstream. Risk of culvert blockage has been assessed as low. At the point of interest there is no known flood risk.	Low	Slight
		Realignment: Potential to cause a slight increase in channel gradient. Any decrease in bank height may increase localised flood risk.	Low	Slight
		Outfall including pre-earthworks / road runoff (about 3km of road). Potential to cause increased flows.	Low	Slight
Lochgreens Pond	Refer to Chapter 10	Pond filled in. Refer to Chapter 10.	n/a	n/a
Red Moss Burn	Medium	Culvert at ch327500: Potential to cause localised constriction of flow and flood risk for events exceeding the 200-year return period event.	Negligible*	Negligible
		Potential risk of culvert blockage at ch327500 has been based on a desktop assessment of the site using OS maps. The catchment land use upstream of the culvert consists of pasture land and forests. Risk of culvert blockage has been assessed as medium. At the point of interest there is no known flood risk.	Medium	Moderate
		Outfall including pre-earthworks / road runoff (about 1km of road). Potential to cause increased flows.	Low	Slight
		Realignment: Potential to cause a slight increase in channel gradient. Any decrease in bank height may increase localised flood risk.	Low	Slight

Water Feature	Sensitivity	Potential Impact Description (assuming no mitigation)	Potential Impact	
			Magnitude	Significance
Corby Loch	High	Partial catchment taken into pre-earthworks (about 15% of catchment area) but is offset by an area gained from an adjacent catchment from pre-earthworks (approximately 15% of catchment), though baseflow is of higher importance to the loch. Baseflow is the continual contribution of groundwater to rivers and is an important source of flow between rainstorms and is thought to be unaffected if catchment size remains the same.	Low	Moderate
		Connectivity maintained through Red Moss culvert (see Red Moss Burn).	Negligible	Slight / Negligible
Lily Loch	High	The location of the proposed AWPR would sever the Lily Loch SSSI catchment. Although groundwater is believed to be of importance to the loch the loss of 40% of the catchment could potential have detrimental effects to the water level of the loch. Baseflow is the continual contribution of groundwater to rivers and is an important source of flow between rainstorms and is thought to be unaffected if catchment size remains the same.	High	Substantial
Blackdog Burn	Medium	Culvert on main AWPR line at ch329950: Potential to cause localised constriction of flow and flood risk for events exceeding the 200-year return period event.	Negligible*	Negligible
		Potential risk of culvert blockage at ch329950 has been based on a desktop assessment of the site using OS maps. The catchment land use upstream of the culvert consists of pasture land. Risk of culvert blockage has been assessed as negligible. At the point of interest there is no known flood risk.	Negligible	Negligible
		Culvert on side road: Potential to cause localised constriction of flow and flood risk for events exceeding the 200-year return period event.	Negligible*	Negligible
		Potential risk of culvert blockage for the proposed side road culvert has been based on a desktop assessment of the site using OS maps. The catchment land use upstream of the culvert consists of pasture land. Risk of culvert blockage has been assessed as negligible. At the point of interest the A90 and the new Blackdog Estate are situated in close proximity to the channel. The housing estate is, however, elevated by approximately 10m at the point of interest. Flood risk has therefore been assessed as medium.	Medium	Moderate
		Outfalls including pre-earthworks / road runoff (about 5km of road). Potential to cause increased flows.	Low	Slight
		Realignment: Potential to cause a slight increase in channel gradient. Any decrease in bank height may increase localised flood risk.	Low	Slight
Blackdog Ditch	Low	Culvert at ch330065: Potential to cause localised constriction of flow and flood risk for events exceeding the 200-year return period event.	Negligible*	Negligible
		Potential risk of culvert blockage at ch330065 has been based on a desktop assessment of the site using OS maps. The catchment land use upstream of the culvert consists of pasture land. Risk of culvert blockage has been assessed as negligible. At the point of interest there is no known flood risk.	Negligible	Negligible
		Realignment: Potential for a slight increase in channel gradient. Any decrease in bank height may increase localised flood risk.	Low	Negligible
Middlefield Burn	Low	Culvert on A90 (widening): Potential to cause localised constriction of flow and flood risk for events exceeding the 200-year return period event.	Negligible*	Negligible
		Potential risk of culvert blockage for the A90 culvert has been based on a desktop assessment of the site using OS maps. The catchment land use upstream of the culvert consists of pasture land. Risk of culvert blockage has been assessed as negligible. At the point of interest there is a possible risk of flooding to the A90. Flood risk has therefore been assessed as medium.	Low	Negligible
		Culvert on side road: Potential to cause localised constriction of flow and flood risk for events exceeding the 200-year return period event.	Negligible*	Negligible

Water Feature	Sensitivity	Potential Impact Description (assuming no mitigation)	Potential Impact	
			Magnitude	Significance
Middlefield Burn [cont'd]		Potential risk of culvert blockage for the proposed side road culvert has been based on a desktop assessment of the site using OS maps. The catchment land use upstream of the culvert consists of pasture land. Risk of culvert blockage has been assessed as negligible. At the point of interest there is a possible risk of flooding to the Middlefield hamlet. Flood risk has therefore been assessed as medium.	Medium	Slight
		Culvert on side road: Potential to cause localised constriction of flow and flood risk for events exceeding the 200-year return period event.	Negligible*	Negligible
		Potential risk of culvert blockage for the proposed side road culvert has been based on a desktop assessment of the site using OS maps. The catchment land use upstream of the culvert consists of pasture land. Risk of culvert blockage has been assessed as negligible. At the point of interest there is no known flood risk.	Negligible	Negligible
		Realignment: Potential to cause a slight increase in channel gradient. Any decrease in bank height may increase localised flood risk.	Low	Negligible
		Outfall including pre-earthworks / road runoff (about 2.6km of road). Potential to cause increased flows.	Low	Negligible

4.3 Construction Impacts

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

4.3.2 Temporary haul roads may cause a temporary increase in runoff due to reduced infiltration rates in the area of the road. The increase in catchment runoff from temporary haul roads would be likely to have a negligible effect.

4.3.3 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. Details of potential effects of temporary outfalls on the sediment regime of receiving watercourses are provided in the Appendix A9.3 (Fluvial Geomorphology). Further detail would be provided in the CAR application process and the Detailed Design Stage.

4.3.4 During the construction phase other temporary works that may affect surface hydrology include the following:

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

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

4.3.6 Potential impacts (assuming no mitigation) during construction of the proposed scheme for watercourses in the Northern Leg study area are presented in Table 4-2.

Table 4-2 – Potential Construction Impacts

Water Feature	Sensitivity	Impact Description (assuming no mitigation)	Potential Impacts	
			Magnitude	Significance
Kepplehill Burn and field ditch	Low	General construction impacts	Low	Negligible
		Construction of culvert at ch315200.	Medium	Slight
		Realignment of section of channel	Medium	Slight
Ditch draining to Kepplehill Burn	Low	General construction impacts	Low	Negligible
Gough Burn	Medium	General construction impacts	Low	Slight
		Construction of two culverts at ch316390 and ch316430.	Medium	Moderate
		Realignment of sections of channel	Medium	Moderate
Parkhead Burn	Low	General construction impacts	Low	Negligible
Parkhead Field Ditch	Low	General construction impacts	Low	Negligible
Craibstone Burn	Medium	General construction impacts	Low	Slight
		Construction of culvert at ch316990.	Medium	Moderate
		Realignment of section of channel	Medium	Moderate
Craibstone Field Ditch	Low	General construction impacts	Low	Negligible
Craibstone Pond	Refer to Chapter 10	Not impacted in Hydrological terms. However, due to the proximity of the road to Craibstone Pond, it is unlikely it will continue be able to support surrounding habitats such as otters (Refer to Chapter 10).	n/a	n/a
Green Burn	Medium	General construction impacts	Low	Slight
		Construction of three culverts at ch317330, on the A96 and on the Kirkhill Industrial Estate Link Road.	Medium	Moderate
		Realignment of sections of channel	Medium	Moderate
Walton Field Ditch	Low	General construction impacts	Low	Negligible
Howemoss Springs	Medium	General construction impacts Groundwater flow is generally considered to be of low sensitivity in this area. However, where wells are in close proximity (within 250m), sensitivity is considered to be moderate to high (Refer to Chapter 8).	Low	Slight
Howemoss Burn	Low	General construction impacts	Low	Negligible
Bogenjoss Burn	Medium	General construction impacts	Low	Slight
		Construction of six culverts at ch320500, ch320870, ch320100 (side road), ch320215 (side road), ch320260 (side road) and ch320475 (side road).	Medium	Moderate
		Realignment of section of channel	Medium	Moderate
River Don	High	General construction Impacts	Negligible	Slight / Negligible
		Construction of bridge	Medium	Moderate /Substantial

Water Feature	Sensitivity	Impact Description (assuming no mitigation)	Potential Impacts	
			Magnitude	Significance
Mill Lade	Medium	General construction Impacts	Low	Slight
		Temporary realignment / water storage during construction	Medium	Moderate
		Construction of bridge / aqueduct	Medium	Moderate
Goval Burn	High	General construction impacts	Low	Moderate
		Construction of three bridges	Medium	Moderate / Substantial
Corsehill Pond	Refer to Chapter 10	Pond filled in. Refer to Chapter 10.	n/a	n/a
Corsehill Burn	Medium	General construction impacts	Low	Slight
		Construction of three culverts at ch325085, link 1 road and link 2 road.	Medium	Moderate
		Realignment of sections of channel	Medium	Moderate
Lochgreens Pond	Refer to Chapter 10	Pond filled in. Refer to Chapter 10.	N/A	N/A
Red Moss Burn	Medium	General construction impacts	Low	Slight
		Construction of culvert at ch327500.	Medium	Moderate
		Realignment of section of channel	Medium	Moderate
CorbyLoch	High	Obstruction of flow pathways to loch during construction, though baseflow is also of importance to the loch.	Negligible	Slight / Negligible
		Construction impacts on Red Moss Burn (see Red Moss Burn for more details).	Medium	Moderate /Substantial
Lily Loch	High	Obstruction of flow paths to the loch, though baseflow is also of importance to the loch.	Medium	Moderate /Substantial
		General construction impacts	Negligible	Slight / Negligible
Blackdog Burn and field ditches	Medium	General construction impacts	Low	Slight
		Construction of two culverts at ch329950 and side road.	Medium	Moderate
		Realignment of section of channel	Medium	Moderate
Blackdog Ditch	Low	Construction of culvert at ch330065	Medium	Slight
		Realignment of section of channel	Medium	Slight
		General construction impacts	Low	Negligible
Middlefield Burn	Low	General construction impacts	Low	Negligible
		Construction of three culverts A90 (widening) and on two side roads.	Medium	Slight
		Realignment of sections of channel	Medium	Slight

4.4 Summary of Potential Impacts

Operation

4.4.1 There is the potential for changes to downstream flow regimes, particularly where significant modification to catchments is likely and where culvert upgrading is proposed. Culverts have been designed such that they will have a Negligible impact on existing hydrological processes. However, there remains the potential risk of culvert blockage, this has been assessed separately and is detailed in Tables 4-1.

4.4.2 Proposed bridges have been designed with no in-channel supports to minimise impacts on local hydrological processes of the River Don, Goval Burn and the Mill Lade. However, the construction of abutments on the banks has the potential to increase flood risk for these watercourses.

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 identified for Lily Loch due to the high sensitivity of this SSSI. Potential impacts of Moderate significance are identified for Gough Burn, Craibstone Burn, Green Burn, Bogenjoss Burn, River Don, Mill Lade, Red Moss Burn, Corby Loch and Blackdog Burn. Potential impacts on all remaining watercourses are considered to be of Slight or lesser significance.

4.4.5 A site visit in 2007 confirmed that Lily Lochs upstream surface water catchment would be severed by the proposed scheme. Approximately 40% of the Lily Loch catchment would be severed by the road. Given the sensitivity of the site which is designated as a SSSI, significant loss of catchment area could be detrimental to the site.

4.4.6 The catchments of Howemoss Springs, Howemoss Burn and Corby Loch would be affected by catchment severance. Although the severed areas account for a large proportion of the total catchment areas these features are thought to be partly supported by groundwater supply. The impact for these sites has therefore been assessed as Low (also refer to Chapter 8). Red Moss Burn is the main inflow into Corby Loch and is of significance to the hydrological regime of this SSSI. Red Moss Burn would therefore be culverted at the road crossing point.

4.4.7 The Mill Lade system is of cultural heritage importance (associated with a Grade B listed building, as described in Chapter 13: Cultural Heritage). It is proposed to extend the aqueduct such that it can pass over the proposed scheme. Changes to the channel dimensions, and in particular the shallow channel slope, may negatively impact on the hydrological regime of this artificial watercourse.

4.4.8 Two small ponds would be affected by the proposed scheme; Lochgreens and Corsehill Ponds. These lie directly on the road alignment and would be infilled. These features are not considered to be of hydrological importance and therefore the potential impact of removing these features has been assessed as Negligible. Assessment in terms of ecology is provided in Chapter 10.

Construction

4.4.9 Although short-term, construction impacts have the potential to persist as longer term consequences on the watercourses affected.

4.4.10 During construction, potential impacts of Moderate/Substantial significance are predicted for:

- River Don;
- Goval Burn; and
- Corby and Lily Lochs.

4.4.11 Potential impacts on the River Don, Goval Burn and Corby and Lily Loch SSSI are most significant due to their sensitivity.

4.4.12 Potential construction impacts of Moderate significance are predicted for:

- Gough Burn;
- Craibstone Burn;
- Green Burn;
- Bogenjoss Burn;
- Mill Lade;
- Corsehill Burn;
- Red Moss Burn; and
- Blackdog Burn and field ditches.

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

5 Mitigation

5.1 Guidance Documents

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 (CIRIA 2006a), Control of Water Pollution from Linear Construction Projects Site Guide Report (CIRIA, 2006b) and the SUDS Manual Report (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.

5.1.2 These require:

- culvert and bridges are designed to appropriate return period flows. More detail is listed below;
- culvert and bridges do not impinge on flood plains, do not obstruct flows nor easily catch debris and block up. A regular maintenance regime should be set in place;
- new culverts or bridges are not smaller than any existing ones in the vicinity or upstream of the new road scheme (unless obviously over-designed);
- road drainage and pre-earthworks do not enhance flood event runoff into streams compared to the pre-development situation and therefore allow for storage and attenuation before outfall;
- road drainage and pre-earthworks should be designed to minimise transfer of water across catchments, outfalls are located at frequent intervals;

- stream alignment does not impact on flood risk, which may be achieved by maintaining stream capacities and channel length / slope and avoidance of sharp bends; and
- development is designed such that it does not materially increase pre-development flood risk.

5.1.3 Potential impacts on the surface water hydrology of the proposed scheme may 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 suitable to the watercourse characteristics at that point (Appendix A9.3: Fluvial Geomorphology). Other guidance is set out in more detail below.

5.2 Operational Mitigation

Crossing Structures

5.2.1 In order to prevent catchment severance to the SSSI site of Lily Loch a drainage ditch and circular culvert (0.9m diameter) is proposed. At present there is no existing watercourse upstream of the proposed road crossing, and hence this mitigation is similar to a network culvert/drainage scheme design. The culvert specification therefore follows guidance set out in the DMRB (HA 106/04), and is sized to the 1.33% AEP (1: 75-year return period flood event). The proposed ditch and circular culvert will provide connectivity between surface water within the catchment area upstream of the AWPR to the Lily Loch inflow channel. A regular maintenance regime will be set in place to prevent any blockages around the circular culverts that could reduce the capacity of the structure. This may include the removal of debris and dead vegetation from the drainage channel and the banks upstream of the structure.

5.2.2 All remaining culverts and bridges that would be constructed on watercourses have been designed to appropriate return period flows. SEPA requires that culverts are designed to the 0.5% AEP (1: 200-years 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[2] allowance of 300mm over the 0.5%AEP.

5.2.3 With exception of the Lily Loch inflow channel circular culvert, all proposed culverts on existing watercourses will be depressed invert box 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).

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

5.2.5 Where there is potential for significant risk of culvert blockage, due to surrounding land use, a suitable designed 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). A one dimensional model of all proposed culverts has been constructed to test the flow capacity of

[2] Freeboard may be defined as an additional allowance of height in excess of the predicted flood elevation.

the crossings. The results indicate that the culverts are suitably designed and pass the 1: 200-year return period flow with spare capacity.

5.2.6 A regular maintenance regime will be implemented in order to manage debris in and around the crossing structure. This work will include the removal of debris, and dead vegetation, from the channel and the banks upstream of the structure.

5.2.7 The abutments of the River Don and Goval Burn bridges 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 Don and Goval Burn during a 0.5% AEP flow. This has been investigated using a one-dimensional hydraulic model (refer to Appendix A9.2), which predicts a negligible impact on these characteristics for the 0.5% AEP flow.

Realignments

5.2.8 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 be replaced to maintain the capacity of the watercourse, prevent flood risk and sustain connectivity to downstream areas.

Road Drainage

5.2.9 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. Refer to Appendix A9.4 (Water Quality) for more detail on the proposed SUDS detention basins and treatment ponds. Detailed information on site specific SUDS will be provided as part of the CAR application process.

5.2.10 Road drainage and pre-earthworks have been designed to minimise transfer of water across catchments. Outfalls will be located at specified 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 land on the upstream side of newly created road embankments.

5.2.11 The proposed road drainage scheme consists of three stages that ensure flood flows up to the 0.5% AEP (1: 200-year return period event) are accounted for in the road drainage. The components of the proposed road drainage scheme are shown below:

- Filter drains: road runoff 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 (1: 2-year return period flow).
- Pre-earthwork ditches: flow above the 10% AEP threshold will be directed to 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: detention basins are designed to attenuate the 1% AEP (1:100-year return period flood 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 (1: 200-year return period event) to be stored, prior to release. The road drainage design system has been designed to ensure flows between the 1.33% AEP and 0.5% AEP would flow to the detention basins prior to out falling to the receiving watercourse or would flow down the carriageway.

5.2.12 Site-specific operational mitigation measures for each watercourse are summarised in Table 5-1. These site specific mitigation measures have been developed to address potential impacts of Slight to Substantial impacts. All mitigation with respect to ponds (Craibstone,

Corsehill and Lochgreens Pond) is included as part of the ecological assessment and is detailed in Chapter 10.

Table 5-1– Mitigation Measures for Operation

Water Feature	Impact	Mitigation Measure
Gough Burn	Culvert blockages	Conduct regular maintenance, ensure culvert is clear of debris.
	Realignments	Retain flow capacity, gradient and channel roughness in realignment design, planting of embankments.
Craibstone 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.
Green 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 locations.	Provide road drainage (within design limits) to SUDS treatment with suitable outfall rate based on the Q_{MED}.
Howemoss Spring	Part of catchment taken into pre-earthworks	Ensure groundwater flow is not impeded. Care should also be taken to prevent damage of the road embankment by the Howemoss Springs.
Howemoss Burn	Part of catchment taken into pre-earthworks	Ensure water taken into pre-earthworks is out flowed into a tributary of the River Don and therefore ensuring no overall loss of catchment to the River Don.
	Catchment severance	Appropriate SUDS design and outfall of catchment. Ensure Howemoss Springs are not severed from Howemoss Burn.
Bogenjoss 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}.
River Don	Bridge	Not to impinge on flood flows and floodplain
	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}.
Mill Lade	Aqueduct	Retain stream capacity and slope
	Bridge	Not to impinge on flood flows and floodplain
Goval Burn	Bridges	Not to impinge on flood flows and floodplain
	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}.
	Small area of catchment taken into pre-earthworks	Loss of a small area of catchment is offset by the proposed Goval Burn outfall.
Corsehill Burn	Culvert blockage	Conduct regular maintenance, ensure culvert is clear of debris.
	Realignment	Retain flow capacity, slope and channel roughness by naturalising bed sediment and planting of embankments.
Red Moss Burn	Culvert blockage	Conduct regular maintenance, ensure culvert is clear of debris.
	Realignment	Retain flow capacity, slope and channel roughness by naturalising bed sediment and 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}.
Corby Loch	Partial catchment taken into pre-	Catchment area losses are offset by an area (about 20% of the overall catchment area for both Lochs) of the adjacent catchment gained from

Water Feature	Impact	Mitigation Measure
	earthworks (about 20% of catchment area)	pre-earthworks. Water from pre-earthworks ditches should outfall into Red Moss Burn
Lily Loch	Catchment Severance	The Proposed drainage ditch and circular culvert will ensure that connectivity is maintained between the upper sections of the Lily Loch surface water catchment and the Lily Loch inflow channel. The upper sections of the Lily Loch catchment would have otherwise been severed by the AWPR. The Lily Loch culvert will be designed to discharge into the Lily Loch inflow channel just downstream of the point where the inflow channel is culverted. Before road construction begins and following the completion of the road the Lily Loch water level and inflow should be monitored. This should be conducted along side monitoring of groundwater to the loch detailed in the Groundwater section in Chapter 8, Geology, Soils, Contaminated Land and Groundwater. Collectively this monitoring will allow an assessment of the impact of the AWPR on the loch.
Blackdog 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}.
Blackdog Ditch	Realignment	Retain flow capacity, gradient and channel roughness in realignment design, planting of embankments.
Middlefield Burn	Culvert blockage	Conduct regular maintenance, ensure culvert is clear of debris.

5.3 Construction Mitigation

5.3.1 Recommendations for areas with Slight to Substantial construction impact significance with respect to surface water hydrology are highlighted in Table 5-2.

5.3.2 A detailed methodology for construction works at watercourse crossings will be developed as part of the CAR application process. 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.

Crossing Structures

5.3.3 During culvert installation operations flow will be diverted around the works in a suitable sized channel to prevent blockages and flood risk.

5.3.4 Bridges have been designed to avoid in-channel work during installation, and this will help prevent potential impacts on surface water hydrology.

Temporary Realignments

5.3.5 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 to minimise changes to flow characteristics.

Road Drainage

5.3.6 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 manual 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.

Table 5-2 – Mitigation Measures during Construction

Water Feature	Impact	Mitigation Measure
Kepplehill Burn and field 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 capactity as that of existing channel.
	Construction of channel Realignment	Maintain watercourse gradient. Ensure appropriate capacity to limit flood risk to existing position or betterment.
Gough 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 capactity as that of existing channel.
	Construction of channel Realignments	Maintain watercourse gradient. Ensure appropriate capacity to limit flood risk to existing position or betterment.
	General construction impacts	Minimise duration of construction. Avoid periods of high flow and extreme low flow. Keep construction corridors to a minimum. Avoid stock pilling of materials. Surface runoff pathways should be maintained at all times.
Craibstone 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 capactity as that of existing channel.
	Construction of channel Realignment	Maintain watercourse gradient. Ensure appropriate capacity to limit flood risk to existing position or betterment.
	General construction impacts	Minimise duration of construction. Avoid periods of high flow and extreme low flow. Keep construction corridors to a minimum. Avoid stock pilling of materials. Surface runoff pathways should be maintained at all times.
Green 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 capactity as that of existing channel.
	Construction of channel realignment	Maintain watercourse gradient. Ensure appropriate capacity to limit flood risk to existing position or betterment.
	General construction impacts	Minimise duration of construction. Avoid periods of high flow and extreme low flow. Keep construction corridors to a minimum. Avoid stock pilling of materials. Surface runoff pathways should be maintained at all times.
Howemoss Springs	General construction impacts	Minimise duration of construction. Avoid periods of high flow and extreme low flow. Keep construction corridors to a minimum. Avoid stock pilling of materials. Surface runoff pathways should be maintained at all times.
Bogenjoss 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 capactity as that of existing channel.
	Construction of channel Realignment	Maintain watercourse gradient. Ensure appropriate capacity to limit flood risk to existing position or betterment.
	General construction impacts	Minimise duration of construction. Avoid periods of high flow and extreme low flow. Keep construction corridors to a minimum. Avoid stock pilling of materials. Surface runoff pathways should be maintained at all times.
River Don	Construction of bridge	Minimise duration and extent of construction. Avoid periods of high flow and extreme low flow.
Mill Lade	Temporary realignment / water storage during construction	Temporary water management solution to take account of the workings of / passage of flow through the system. Minimise duration of construction. Avoid periods of high flow. Construction of the bridge footprint should not impinge on flood flows and floodplain.

Water Feature	Impact	Mitigation Measure
Mill Lade [cont'd]	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. Keep construction corridors to a minimum. Avoid stock pilling of materials. Surface runoff pathways should be maintained at all times.
Goval 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. Keep construction corridors to a minimum. Avoid stock pilling of materials. Surface runoff pathways should be maintained at all times.
Corsehill 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 capactity as that of existing channel.
	Construction of channel Realignment	Maintain watercourse gradient. Ensure appropriate capacity to limit flood risk to existing position or betterment.
	General construction impacts	Minimise duration of construction. Avoid periods of high flow and extreme low flow. Keep construction corridors to a minimum. Avoid stock pilling of materials. Surface runoff pathways should be maintained at all times.
Red Moss 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 capactity as that of existing channel.
	Construction of channel Realignment	Maintain watercourse gradient. Ensure appropriate capacity to limit flood risk to existing position or betterment.
	General construction impacts	Minimise duration of construction. Avoid periods of high flow and extreme low flow. Keep construction corridors to a minimum. Avoid stock pilling of materials. Surface runoff pathways should be maintained at all times.
Corby Loch	Construction impacts on Red Moss Burn	See mitigation at Red Moss Burn. Avoid excessive sedimentation into Red Moss Burn.
Lily Loch	Obstruction of flow paths to the loch.	Maintain surface water connectivity to Lily Loch during construction.
Blackdog 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 capactity as that of existing channel.
	Construction of channel Realignment	Maintain watercourse gradient . Ensure appropriate capacity to limit flood risk to existing position or betterment.
Blackdog Ditch	Construction of culverts	Minimise duration and extent of construction. Avoid periods of high flow and extreme low flow. Temporary diversion channel to possess same capactity as that of existing channel.
	Construction of channel Realignment	Maintain watercourse gradient. Ensure appropriate capacity to limit flood risk to existing position or betterment.
Middlefield 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 capactity as that of existing channel.
	Construction of channel Realignment	Maintain watercourse gradient. Ensure appropriate capacity to limit flood risk to existing position or betterment.

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 6-1. The residual impacts for construction are provided in Table 6-2.

6.2 Catchment Impacts

6.2.1 Catchment impacts resulting from the construction and operation of the proposed scheme have the potential to affect the River Don. This watercourse is fed by a number of tributaries, which may be affected by the road scheme. Due to the large capacity of the River Don, any catchment impact is likely to have a Negligible effect on the River Don.

6.3 Scheme Summary

6.3.1 As Lily Loch has been assessed as a sensitive environment a drainage ditch and a circular culvert will be constructed at the road crossing point to ensure that surface water may reach Lily Loch. Long term monitoring of the loch is also proposed in order to ensure that it is not significantly affected. The circular culvert will be designed in line with network culverts and will be assessed for flood risk. The circular culvert has been designed to the 1.33% AEP (1: 75-year return period flood event) which is considered sufficient given that there is no existing watercourse upstream of the crossing point of the proposed scheme. Lily Loch is also thought to receive a significant groundwater contribution and therefore it is believed that the loch would not be significantly impacted by the proposed scheme.

6.3.2 The proposed mitigation would limit the potential impacts. Sensitive environments such as the River Don, Goval Burn, Corby and Lily Lochs have been taken into consideration. Residual impacts have been assessed as being of Negligible, Slight/Negligible or Slight significance on all watercourses and features within the study area.

Table 6-1 – Residual Impact for Operation

Water Feature	Sensitivity	Potential Impact Description	Mitigation	Residual Impact	
				Magnitude	Significance
Kepplehill Burn and field ditch	Low	Culvert on the main AWPR line at ch315200: Potential to cause localised constriction of flow and flood risk for events exceeding the 200-year return period event.	Not required. Scheme design incorporates culvert sizing.	Negligible	Negligible
		Potential risk of culvert blockage at ch315200 has been based on a desktop assessment of the site using OS maps. The catchment land use upstream of the culvert consists of pasture and scrub land. Therefore risk of culvert blockage has been assessed as low. At the point of interest there is no known flood risk.	Conduct regular maintenance, ensure culvert is clear of debris.	Negligible	Negligible
		Realignment: Potential to cause a slight increase in channel gradient. Any decrease in bank height may increase localised flood risk.	Follow generic mitigations. Avoid sharp bends. Retain capacity and gradient. Naturalise (e.g. sediment, plants).	Negligible	Negligible
		Field ditch taken into pre-earthworks. The area of the catchment upstream of the road would be taken into pre-earthwork drainage.	Appropriate SUDS design and outfall catchment.	Negligible	Negligible
Ditch draining to Kepplehill Burn	Low	The area of the catchment upstream of the road would be taken into pre-earthwork drainage	Appropriate SUDS design and outfall catchment.	Negligible	Negligible
Gough Burn	Medium	Culvert on the main AWPR line at ch316390: Potential to cause localised constriction of flow and flood risk for events exceeding the 200-year return period event.	Not required. Scheme design incorporates culvert sizing.	Negligible	Negligible
		Potential risk of culvert blockage at ch316390 has been based on a desktop assessment of the site using OS maps. The catchment land use upstream of the culvert consists of pasture and bracken, heather and / or rough grass. Therefore risk of culvert blockage has been assessed as low. At the point of interest there is one property within 100m. Flood risk has therefore been assessed as medium.	Conduct regular maintenance, ensure culvert is clear of debris.	Negligible	Negligible
		Culvert on side road at ch316430: Potential to cause localised constriction of flow and flood risk for events exceeding the 200-year return period event.	Not required. Scheme design incorporates culvert sizing.	Negligible	Negligible
		Potential risk of culvert blockage at ch316430 has been based on a desktop assessment of the site using OS maps. The catchment land use upstream of the culvert also consists of pasture and bracken, heather and / or rough grass. Therefore risk of culvert blockage has been assessed as low. At the point of interest there is a property within 100m. Flood risk has therefore been assessed as medium.	Conduct regular maintenance, ensure culvert is clear of debris.	Negligible	Negligible
		Realignment: Potential to cause a slight increase in channel gradient. Any decrease in bank height may increase localised flood risk.	See Table 5-1. Avoid sharp bends. Retain capacity and gradient. Naturalise (e.g. sediment, plants).	Negligible	Negligible
Parkhead Burn	Low	The area of the catchment upstream of the road would be taken into pre-earthwork drainage	Appropriate SUDS design and outfall catchment.	Negligible	Negligible

Water Feature	Sensitivity	Potential Impact Description	Mitigation	Residual Impact	
				Magnitude	Significance
Parkhead Field Ditch	Low	The area of the catchment upstream of the road would be taken into pre-earthwork drainage	Appropriate SUDS design and outfall catchment.	Negligible	Negligible
Craibstone Pond	N/A.	Not impacted. Refer for more details to Ecology Chapter 10, table 10.10.	N/A.	N/A.	Refer to Chapter 10
Craibstone Burn	Medium	Culvert on the main AWPR line at ch316990: Potential to cause localised constriction of flow and flood risk for events exceeding the 200-year return period event	Not required. Scheme design incorporates culvert sizing.	Negligible	Negligible
		Potential risk of culvert blockage at ch316990 has been based on a desktop assessment of the site using OS maps. The catchment land use upstream of the culvert consists of forest and a small area of pasture land. Therefore risk of culvert blockage has been assessed as medium. At the point of interest there is no known flood risk.	Conduct regular maintenance, ensure culvert is clear of debris.	Negligible	Negligible
		Realignment: Potential to cause a slight increase in channel gradient. Any decrease in bank height may increase localised flood risk.	See Table 5-1. Avoid sharp bends. Retain capacity and gradient. Naturalise (e.g. sediment, plants).	Negligible	Negligible
Craibstone Field Ditch	Low	The area of the catchment upstream of the road would be taken into pre-earthwork drainage.	Appropriate SUDS design and outfall catchment.	Negligible	Negligible
Green Burn	Medium	Culvert on main AWPR line at ch317330: Potential to cause localised constriction of flow and flood risk for events exceeding the 200-year return period event.	Not required. Scheme design incorporates culvert sizing.	Negligible	Negligible
		Potential risk of culvert blockage at ch317330 has been based on a desktop assessment of the site using OS maps. The catchment land use upstream of the culvert consists of forest and pasture land. Therefore risk of culvert blockage has been assessed as medium. At the point of interest there are properties located approximately 100m from the channel. Flood risk has therefore been assessed as medium.	Conduct regular maintenance, ensure culvert is clear of debris.	Negligible	Negligible
		Culvert on A96 mainline: Potential to cause localised constriction of flow and flood risk for events exceeding the 200-year return period event.	Not required. Scheme design incorporates culvert sizing.	Negligible	Negligible
		Potential risk of culvert blockage on the proposed A96 mainline culvert has been based on a desktop assessment of the site using OS maps. The catchment land use upstream of the culvert consists of a forest and pasture land. Therefore risk of culvert blockage has been assessed as medium. At the point of interest flood risk has been assessed as Low.	Conduct regular maintenance, ensure culvert is clear of debris.	Negligible	Negligible
		Culvert on Kirkhill Industrial Estate Link Road: Potential to cause localised constriction of flow and flood risk.	Not required. Scheme design incorporates culvert sizing.	Negligible	Negligible
		Potential risk of culvert blockage on the proposed Kirkhill Industrial Estate Link Road has been based on a desktop assessment of the site using OS maps. The catchment land use upstream of the culvert consists of a forest and pasture land. Therefore risk of culvert blockage has been assessed as medium. At the point of interest there is no known flood risk.	Conduct regular maintenance, ensure culvert is clear of debris.	Negligible	Negligible

Water Feature	Sensitivity	Potential Impact Description	Mitigation	Residual Impact	
				Magnitude	Significance
Green Burn [cont'd]		Realignment: Potential to cause a slight increase in channel gradient. Any decrease in bank height may increase localised flood risk.	See Table 5-1. Avoid sharp bends. Retain capacity and gradient. Naturalise (e.g. sediment, plants).	Negligible	Negligible
		Outfalls including pre-earthworks (about 0.083km² of road) and road runoff (about 0.044km² of road). Potential to cause increased flows.	See Section 5.3.1 to 5.3.9. Road drainage (within design limits) to SUDS treatment. Detention, filter drain and treatment ponds	Negligible	Negligible
Walton Field Ditch	Low	The area of the catchment upstream of the road would be taken into pre-earthwork drainage	Appropriate SUDS design and outfall catchment.	Negligible	Negligible
Howemoss Springs	Medium	Part of surface water catchment taken into pre-earthworks (about 72% of catchment area), though springs likely not to depend on surface water catchment.	Appropriate SUDS design and outfall catchment. Care should also be taken to prevent damage of the road embankment by the Howemoss Springs.	Negligible	Negligible
		Groundwater flow is generally considered to be of low sensitivity in this area. Two springs are evident in this area. (Please refer to Groundwater section in Chapter 8, Geology, Soils, Contaminated Land and Groundwater).	n/a	Negligible	Negligible
Howemoss Burn	Low	Partial catchment taken into pre-earthworks (about 70% of catchment area). The area of catchment taken into pre-earthworks is less than 1% of the River Don catchment.	Appropriate SUDS design and outfall catchment.	Negligible	Negligible
		Catchment severance. Howemoss Burn would loose approximately 70% of its catchment to pre-earthworks, however, this is unlikely to result in a significant impact on the burn due to there being ample groundwater supplies around the source of the burn (Howemoss Springs).	Appropriate SUDS design and outfall catchment.	Low	Negligible
Bogenjoss Burn	Medium	Culvert on main AWPR line at ch320870: Potential to cause localised constriction of flow and flood risk for events exceeding the 200-year return period event.	Not required. Scheme design incorporates culvert sizing.	Negligible	Negligible
		Potential risk of culvert blockage at ch320870 has been based on a desktop assessment of the site using OS maps. The catchment land use upstream of the culvert consists of pasture land and forests. Therefore risk of culvert blockage has been assessed as medium. At the point of interest there is no known flood risk.	See Table 5-1 Avoid sharp bends. Retain capacity and gradient. Naturalise (e.g. sediment, plants). Stream bed characteristics should be naturalised (e.g. addition of sediment and plants) so as to maintain a suitable bed roughness and prevent excessive velocities.	Negligible	Negligible
		Culvert on main AWPR line at ch320500: Potential to cause localised constriction of flow and flood risk for events exceeding the 200-year return period event.	Not required. Scheme design incorporates culvert sizing.	Negligible	Negligible

Water Feature	Sensitivity	Potential Impact Description	Mitigation	Residual Impact	
				Magnitude	Significance
Bogenjoss Burn [cont'd]		Potential risk of culvert blockage at ch320500 has been based on a desktop assessment of the site using OS maps. The catchment land use upstream of the culvert consists of pasture land. Therefore risk of culvert blockage has been assessed as negligible. At the point of interest there are properties within 100m of the channel. At the point of interest flood risk has therefore been assessed as medium.	Conduct regular maintenance on the culvert. Ensure culvert is clear of debris. Remove dead vegetation from banks upstream of the culvert.	Negligible	Negligible
		Culvert on Kirkhill Access Track at ch320475: Potential to cause localised constriction of flow and flood risk for events exceeding the 200-year return period event.	Not required. Scheme design incorporates culvert sizing.	Negligible	Negligible
		Potential risk of culvert blockage at ch320475 has been based on a desktop assessment of the site using OS maps. The catchment land use upstream of the culvert consists of pasture land. Therefore risk of culvert blockage has been assessed as negligible. At the point of interest there are properties within 100m of the channel. At the point of interest flood risk has therefore been assessed as medium.	Conduct regular maintenance, ensure culvert is clear of debris.	Negligible	Negligible
		Culvert on Kirkhill Access Track at ch320260: Potential to cause localised constriction of flow and flood risk for events exceeding the 200-year return period event.	Not required. Scheme design incorporates culvert sizing.	Negligible	Negligible
		Potential risk of culvert blockage at ch320260 has been based on a desktop assessment of the site using OS maps. The catchment land use upstream of the culvert consists of forests. Therefore risk of culvert blockage has been assessed as medium. At the point of interest there is no known flood risk.	Conduct regular maintenance, ensure culvert is clear of debris.	Negligible	Negligible
		Culvert on Kirkhill Access Track at ch320215: Potential to cause localised constriction of flow and flood risk for events exceeding the 200-year return period event.	Not required. Scheme design incorporates culvert sizing.	Negligible	Negligible
		Potential risk of culvert blockage at ch320215 has been based on a desktop assessment of the site using OS maps. The catchment land use upstream of the culvert consists of forests. Therefore risk of culvert blockage has been assessed as medium. At the point of interest there is no known flood risk.	Conduct regular maintenance, ensure culvert is clear of debris.	Negligible	Negligible
Bogenjoss Burn [cont'd]		Culvert on Kirkhill Access Track at ch320100: Potential to cause localised constriction of flow and flood risk for events exceeding the 200-year return period event.	Not required. Scheme design incorporates culvert sizing.	Negligible	Negligible
		Potential risk of culvert blockage at ch320100 has been based on a desktop assessment of the site using OS maps. The catchment land use upstream of the culvert consists of forests. Therefore risk of culvert blockage has been assessed as medium. At the point of interest there is no known flood risk.	Conduct regular maintenance, ensure culvert is clear of debris.	Negligible	Negligible
		Realignment: Potential to cause a slight increase in channel gradient. Any decrease in bank height may increase localised flood risk.	See Table 5-1. Avoid sharp bends. Retain capacity and gradient. Naturalise (e.g. sediment, plants).	Negligible	Negligible
		Outfall including pre-earthworks / road runoff (about 0.018km² of road). Potential to cause increased flows.	See Section 5.3.1 to 5.3.9. Road drainage (within design limits) to SUDS treatment. Detention, filter drain and treatment ponds	Negligible	Negligible

Water Feature	Sensitivity	Potential Impact Description	Mitigation	Residual Impact	
				Magnitude	Significance
River Don	High	Bridge: Potential to cause a localised constriction of flow due to bridge supports and increased flood risk for events exceeding the 200-year return period event.	See Table 5-1	Negligible	Slight / Negligible
		Outfall including pre-earthworks / road runoff (about 0.041km² of road). Potential to cause increased flows.	See Section 5.3.1 to 5.3.9. Road drainage (within design limits) to SUDS treatment. Detention, filter drain and treatment ponds	Negligible	Slight / Negligible
Mill Lade	Medium	Channel retained in form of an aqueduct (assuming present gradient and aqueduct dimensions maintained)	See Table 5-1	Negligible	Negligible
		Bridge: Potential to cause a localised constriction of flow due to bridge supports and increased flood risk for events exceeding the 200-year return period event.	See Table 5-1	Negligible	Negligible
Goval Burn	High	Three bridges: Potential to cause a localised a localised constriction of flow due to bridge supports and increased flood risk for events exceeding the 200-year return period event.	Not required. Scheme design incorporates appropriate sizing.	Negligible	Slight / Negligible
		Additional catchment area upstream of road taken into pre-earthwork drainage (very small area)	n/a	Negligible	Slight / Negligible
		Outfall: including pre-earthworks / road runoff (about 0.035km² of road). Potential to cause increased flows.	See Section 5.3.1 to 5.3.9. Road drainage (within design limits) to SUDS treatment. Detention, filter drain and treatment ponds	Negligible	Slight / Negligible
Corsehill Pond	n/a	Pond filled in. Refer to Ecology Chapter 10.	Compensated by new pond. Refer to Ecology Chapter 10	N/A.	Refer to Chapter 10
Corsehill Burn	Medium	Culvert on main AWPR line at ch325085: Potential to cause localised constriction of flow and flood risk for events exceeding the 200-year return period event.	Not required. Scheme design incorporates culvert sizing.	Negligible	Negligible
		Potential risk of culvert blockage at ch325085 has been based on a desktop assessment of the site using OS maps. The catchment land use upstream of the culvert consists of pasture land with small patches of forests further upstream. Risk of culvert blockage has been assessed as low. At the point of interest there is no known flood risk.	Conduct regular maintenance, ensure culvert is clear of debris.	Negligible	Negligible
		Culvert on link 1 road: Potential to cause localised constriction of flow and flood risk for events exceeding the 200-year return period event.	Not required. Scheme design incorporates culvert sizing.	Negligible	Negligible
		Potential risk of culvert blockage on link 1 road has been based on a desktop assessment of the site using OS maps. The catchment land use upstream of the culvert consists of pasture land with small patches of forests further upstream. Risk of culvert blockage has been assessed as low. At the point of interest there is no known flood risk.	Conduct regular maintenance, ensure culvert is clear of debris.	Negligible	Negligible

Water Feature	Sensitivity	Potential Impact Description	Mitigation	Residual Impact	
				Magnitude	Significance
Corsehill Burn [cont'd]		Culvert on link 2 road: Potential to cause localised constriction of flow and flood risk for events exceeding the 200-year return period event.	Not required. Scheme design incorporates culvert sizing.	Negligible	Negligible
		Potential risk of culvert blockage on link 2 road has been based on a desktop assessment of the site using OS maps. The catchment land use upstream of the culvert is pasture land with small patches of forests further upstream. Risk of culvert blockage has been assessed as low. At the point of interest there is no known flood risk.	Conduct regular maintenance, ensure culvert is clear of debris.	Negligible	Negligible
		Realignment: Potential to cause a slight increase in channel gradient. Any decrease in bank height may increase localised flood risk.	See Table 5-1 Avoid sharp bends. Retain capacity and gradient. Naturalise (e.g. sediment, plants).	Negligible	Negligible
		Outfall including pre-earthworks / road runoff (about 0.039k²m of road). Potential to cause increased flows.	See Section 5.3.1 to 5.3.9. Road drainage (within design limits) to SUDS treatment. Detention, filter drain and treatment ponds.	Negligible	Negligible
Lochgreens Pond	n/a	Pond filled in. Refer to Ecology Chapter 10.	n/a	n/a	Refer to Chapter 10
Red Moss Burn	Medium	Culvert at ch327500: Potential to cause localised constriction of flow and flood risk for events exceeding the 200-year return period event.	Not required. Scheme design incorporates culvert sizing.	Negligible	Negligible
		Potential risk of culvert blockage at ch327500 has been based on a desktop assessment of the site using OS maps. The catchment land use upstream of the culvert consists of pasture land and forests. Risk of culvert blockage has been assessed as medium. At the point of interest there is no known flood risk.	Conduct regular maintenance, ensure culvert is clear of debris.	Negligible	Negligible
		Realignment: Potential to cause a slight increase in channel gradient. Any decrease in bank height may increase localised flood risk.	See Table 5-1. Avoid sharp bends. Retain capacity and gradient. Naturalise (e.g. sediment, plants).	Negligible	Negligible
		Outfall including pre-earthworks / road runoff (about 0.023km² of road). Potential to cause increased flows.	See Section 5.3.1 to 5.3.9. Road drainage (within design limits) to SUDS treatment. Detention, filter drain and treatment ponds	Negligible	Negligible
Corby Loch	High	Partial catchment taken into pre-earthworks (about 15% of catchment area) but is offset by an area gained from an adjacent catchment from pre-earthworks (approximately 15% of catchment), though baseflow is also of importance to the loch. Baseflow is the continual contribution of groundwater to rivers and is an important source of flow between rainstorms and is thought to be unaffected if catchment size remains the same.	Retain connectivity through outfall into Red Moss Burn	Negligible	Slight / Negligible
		Connectivity maintained through Red Moss culvert (See Red Moss Burn).	See Table 5-1	Negligible	Slight/ Negligible

Water Feature	Sensitivity	Potential Impact Description	Mitigation	Residual Impact	
				Magnitude	Significance
Lily Loch	High	The location of the proposed AWPR will sever the Lily Loch SSSI catchment. Although groundwater is believed to be of importance to the loch the loss of 40% of the catchment could potential have detrimental effects to the water level of the loch. Baseflow is the continual contribution of groundwater to rivers and is an important source of flow between rainstorms and is thought to be unaffected if catchment size remains the same.	To maintain connectivity a drainage ditch and a circular culvert will convey surface water runoff from the upper Lily Loch catchment which would otherwise be severed by the road to the lower Lily Loch catchment. Baseflow is also believed to be of importance to the loch. Monitoring of Lily Loch water level before and after construction to provide an assessment of the impact on the SSSI. Monitoring to be carried out in conjunction with an assessment of groundwater conditions surrounding the loch before and after construction (Chapter 8)	Negligible	Slight/ Negligible
		Circular culvert: Potential to cause localised constriction of flow and flood risk for events exceeding the 75-year return period event.	Not required. Scheme design incorporates culvert sizing.	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 consists of pasture land. Risk of culvert blockage has been assessed as negligible. At the point of interest there is no known flood risk.	Conduct regular maintenance on the culvert. Ensure culvert is clear of debris. Remove dead vegetation from banks upstream of the culvert.	Negligible	Slight / Negligible
Blackdog Burn	Medium	Culvert on main AWPR line at ch329950: Potential to cause localised constriction of flow and flood risk for events exceeding the 200-year return period event.	Not required. Scheme design incorporates culvert sizing.	Negligible	Negligible
		Potential risk of culvert blockage at ch329950 has been based on a desktop assessment of the site using OS maps. The catchment land use upstream of the culvert consists of pasture land. Risk of culvert blockage has been assessed as negligible. At the point of interest there is no known flood risk.	Conduct regular maintenance, ensure culvert is clear of debris.	Negligible	Negligible
		Culvert on side road: Potential to cause localised constriction of flow and flood risk for events exceeding the 200-year return period event.	Not required. Scheme design incorporates culvert sizing.	Negligible	Negligible
		Potential risk of culvert blockage on the proposed side road culvert has been based on a desktop assessment of the site using OS maps. The catchment land use upstream of the culvert consists of pasture land. Risk of culvert blockage has been assessed as negligible. At the point of interest the A90 and the new Blackdog Estate are situated in close proximity to the channel. Flood risk has therefore been assessed as high.	Conduct regular maintenance, ensure culvert is clear of debris.	Negligible	Negligible
		Realignment: Potential to cause a slight increase in channel gradient. Any decrease in bank height may increase localised flood risk.	See Table 5-1. 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
Blackdog Burn [cont'd]		Outfalls including pre-earthworks / road runoff (about 0.047km² and 0.036km² of road). Potential to cause increased flows.	See Section 5.3.1 to 5.3.9. Road drainage (within design limits) to SUDS treatment. Detention, filter drain and treatment ponds	Negligible	Negligible
Blackdog Ditch	Low	Culvert at ch330065: Potential to cause localised constriction of flow and flood risk for events exceeding the 200-year return period event.	Not required. Scheme design incorporates culvert sizing.	Negligible	Negligible
		Potential risk of culvert blockage at ch330065 based on a desktop assessment using OS maps. The catchment land use upstream of the culvert is pasture land. Risk of culvert blockage assessed as negligible. At the point of interest there is no known flood risk.	Conduct regular maintenance, ensure culvert is clear of debris.	Negligible	Negligible
		Realignment: Potential to cause a slight increase in channel gradient. Any decrease in bank height may increase localised flood risk.	See Table 5-1. Avoid sharp bends. Retain capacity and gradient. Naturalise (e.g. sediment, plants).	Negligible	Negligible
Middlefield Burn	Low	Culvert on A90 (widening): Potential to cause localised constriction of flow and flood risk for events exceeding the 200-year return period event.	Not required. Scheme design incorporates culvert sizing.	Negligible	Negligible
		Potential risk of culvert blockage for the A90 culvert has been based on a desktop assessment of the site using OS maps. The catchment land use upstream of the culvert consists of pasture land. Risk of culvert blockage has been assessed as negligible. At the point of interest there is a possible risk of flooding to the A90. Flood risk has therefore been assessed as medium.	Conduct regular maintenance, ensure culvert is clear of debris.	Negligible	Negligible
		Culvert on side road: Potential to cause localised constriction of flow and flood risk for events exceeding the 200-year return period event.	Not required. Scheme design incorporates culvert sizing.	Negligible	Negligible
		Potential risk of culvert blockage for the proposed side road culvert has been based on a desktop assessment of the site using OS maps. The catchment land use upstream of the culvert consists of pasture land. Risk of culvert blockage has been assessed as negligible. At the point of interest there is a possible risk of flooding to the Middlefield hamlet. Flood risk has therefore been assessed as medium.	Conduct regular maintenance, ensure culvert is clear of debris.	Negligible	Negligible
		Culvert on side road: Potential to cause localised constriction of flow and flood risk for events exceeding the 200-year return period event.	Not required. Scheme design incorporates culvert sizing.	Negligible	Negligible
		Potential risk of culvert blockage for the proposed side road culvert has been based on a desktop assessment of the site using OS maps. The catchment land use upstream of the culvert consists of pasture land. Risk of culvert blockage has been assessed as negligible. At the point of interest there is no known flood risk.	Conduct regular maintenance, ensure culvert is clear of debris.	Negligible	Negligible
		Realignment: Potential to cause a slight increase in channel gradient. Any decrease in bank height may increase localised flood risk.	See Table 5-1 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
Middlefield Burn [cont'd]		Outfall including pre-earthworks / road runoff (about 0.003km² of road). Potential to cause increased flows.	See Section 5.3.1 to 5.3.9. Road drainage (within design limits) to SUDS treatment. Detention, filter drain and treatment ponds	Negligible	Negligible

Table 6-2 –Residual Impacts during Construction

Water Feature	Sensitivity	Potential Impact	Mitigation	Residual Impact	
				Magnitude	Significance
Kepplehill Burn and field ditch	Low	General construction impacts	General construction mitigation measures	Negligible	Negligible
		Construction of culvert at ch315200	See Table 5-2. General construction mitigation measures	Negligible	Negligible
		Realignment of section of channel	See Table 5-2. General construction mitigation measures	Negligible	Negligible
Ditch draining to Kepplehill Burn	Low	General construction impacts	General construction mitigation measures	Negligible	Negligible
Gough Burn	Medium	General construction impacts	See Table 5-2 General construction mitigation measures	Negligible	Negligible
		Construction of two culverts at ch316390 and ch316430.	See Table 5-2 General construction mitigation measures	Negligible	Negligible
		Realignment of section of channel	See Table 5-2. General construction mitigation measures	Negligible	Negligible
Parkhead Burn	Low	General construction impacts	General construction mitigation measures	Negligible	Negligible
Parkhead Field Ditch	Low	General construction impacts	General construction mitigation measures	Negligible	Negligible
Craibstone Burn	Medium	General construction impacts	See Table 5-2 General construction mitigation measures	Negligible	Negligible
		Construction of culvert at ch316990.	See Table 5-2 General construction mitigation measures	Negligible	Negligible
		Realignment of section of channel	See Table 5-2. General construction mitigation measures	Negligible	Negligible
Craibstone Field Ditch	Low	General construction impacts	General construction mitigation measures	Negligible	Negligible
Green Burn	Medium	General construction impacts	General construction mitigation measures	Negligible	Negligible
		Construction of three culverts at ch317330, on the A96 and on the Kirkhill Industrial Estate Link Road.	See Table 5-2 General construction mitigation measures	Negligible	Negligible
		Realignment of sections of channel	See Table 5-2 General construction mitigation measures	Negligible	Negligible

Water Feature	Sensitivity	Potential Impact	Mitigation	Residual Impact	
				Magnitude	Significance
Walton Field Ditch	Low	General construction impacts	General construction mitigation measures	Negligible	Negligible
Howemoss Springs	Medium	General construction impacts Groundwater flow is generally considered to be of low sensitivity in this area. However, where wells are in close proximity (within 250m), sensitivity is considered to be moderate to high (refer to Chapter 8).	General construction mitigation measures	Negligible	Negligible
Howemoss Burn	Low	General construction impacts	General construction mitigation measures	Negligible	Negligible
Bogenjoss Burn	Medium	General construction impacts	General construction mitigation measures	Negligible	Negligible
		Construction of six culverts at ch320870, ch320500, ch320475, ch320260, ch320215 and ch320100.	See Table 5-2 General construction mitigation measures	Negligible	Negligible
		Realignment of sections of channel	See Table 5-2 General construction mitigation measures	Low	Slight
River Don	High	General construction Impacts	General construction mitigation measures	Negligible	Slight / Negligible
		Construction of bridge	See Table 5-2 General construction mitigation measures	Negligible	Slight / Negligible
Mill Lade	Medium	General construction Impacts	General construction mitigation measures	Negligible	Negligible
		Construction of bridge / aqueduct	See Table 5-2 General construction mitigation measures	Negligible	Negligible
		Temporary realignment / water storage during construction	See Table 5-2 General construction mitigation measures	Low	Slight
Goval Burn	High	General construction impacts	See Table 5-2 General construction mitigation measures	Negligible	Slight / Negligible
		Construction of three bridges	See Table 5-2 General construction mitigation measures	Negligible	Slight / Negligible
Corsehill Burn	Medium	General construction impacts	General construction mitigation measures	Negligible	Negligible
		Construction of three culverts at ch325085 and on link roads 1 and 2.	See Table 5-2 General construction mitigation measures	Negligible	Negligible
		Realignment of sections of channel	See Table 5-2. General construction mitigation measures	Negligible	Negligible

Water Feature	Sensitivity	Potential Impact	Mitigation	Residual Impact	
				Magnitude	Significance
Red Moss Burn	Medium	General construction impacts	General construction mitigation measures	Negligible	Negligible
		Construction of culvert at ch327500.	See Table 5-2 General construction mitigation measures	Negligible	Negligible
		Realignment of section of channel	See Table 5-2 General construction mitigation measures	Negligible	Negligible
CorbyLoch	High	Obstruction of flow pathways to lochs during construction, though baseflow is of higher importance to the loch	See Table 5-2. General construction mitigation measures	Negligible	Slight / Negligible
		Construction impacts on Red Moss Burn	See Table 5-2 General construction mitigation measures	Negligible	Slight / Negligible
Lily Loch	High	Obstruction of flow pathways to loch during construction, though baseflow is of importance to the loch	See Table 5-2. Maintain surface water connectivity to Lily Loch during construction.	Negligible	Slight / Negligible
		Construction of culvert	See Table 5-2 General construction mitigation measures	Negligible	Slight / Negligible
		General construction impacts	General construction mitigation measures	Negligible	Slight / Negligible
Blackdog Burn and field ditches	Medium	General construction impacts	General construction mitigation measures	Negligible	Negligible
		Construction of two culverts at ch329950 and on a side road.	See Table 5-2 General construction mitigation measures	Negligible	Negligible
		Realignment of section of channel	See Table 5-2 General construction mitigation measures	Negligible	Negligible
Blackdog Ditch	Low	General construction impacts	General construction mitigation measures	Negligible	Negligible
		Construction of culvert at ch330065.	See Table 5-2 General construction mitigation measures	Negligible	Negligible
		Realignment of sections of channel	See Table 5-2 General construction mitigation measures	Negligible	Negligible
Middlefield Burn	Low	General construction impacts	General construction mitigation measures	Negligible	Negligible
		Construction of three culverts on the A90 (widening) and on two side roads.	See Table 5-2. General construction mitigation measures	Negligible	Negligible
		Realignment of sections of channel	See Table 5-2. 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 AWPR Northern Leg would affect the surface water hydrology of the watercourses crossed by the proposed scheme.

7.1.2 In total, the Northern Leg of the proposed scheme would cross 17 watercourses / field ditches, three ponds, two lochs, Howemoss Springs and an artificial mill lade system. With the exception of the River Don, all of the watercourses along the proposed route are relatively small.

7.1.3 The baseline hydrological characteristics of the watercourses vary considerably, according to the size of the watercourse, the degree of anthropogenic modification, the role in watercourse balance downstream, habitats within the watercourse and the flood risk.

7.1.4 During operation, (permanent) impacts to surface water hydrology include an increase in supply to a catchment; decreased supply to a catchment or a change/blockage in surface water runoff pathways. During construction, (temporary) similar impacts have been identified which may be more pronounced for a shorter time period.

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9 Glossary

AEP	Annual Exceedence Probability
AREA	Catchment Drainage Area (km²)
AWPR	Aberdeen Western Peripheral Route
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)
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}	Embankmentfull 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 (eg 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)