Appendix 16B – Method of Assessment

Outfall Assessment

The DMRB outlines the procedures to be used in the assessment of impacts from road drainage outfalls. The assessment methodology has involved:

- Collation of data on existing baseline conditions within the affected watercourses through desk study, consultation and field surveys;
- assessment in relation to the proposed scheme, including information on the drainage design, proposed water quality treatment and predicted traffic volumes;
- assessment of pollution impacts from routine road runoff – this assessment includes the use of the Highways Agency Water Risk Assessment Tool (HAWRAT) & Environmental Quality Standard (EQS) assessments;
- assessment of the risk to groundwater quality from the road drainage treatment ponds and/or wetlands;
- assessment of pollution impacts from accidental spillage; and
- assessment of the overall significance of the impact from each outfall, taking into account the results of the above assessments and a qualitative assessment of the physical impact of the outfall structure and the peak discharge on the watercourse geomorphology and flood risk.

A summary of the above information has been compiled into individual datasheets for each outfall, which are presented in Appendix 16D. This data has also been entered into the A5WTC GIS database.

Further details on the assessment methods listed above are provided in the following sections

Datasheet Data Sources

Details of the information presented in the Watercourse Outfall Datasheets and the sources of this information, is given in Table 16B.1 overleaf.

Table 16B.1 Outfall Datasheet Source of Data

Datasheet Field	Data Source
Outfall ID	Naming convention as used by the A5 Drainage Design team for cross-referencing purposes
Grid Reference	National grid reference for the discharge point on the receiving watercourse
Chainage (m)	Approximate road chainage at the outfall location, as defined by the A5 Drainage Design team
Watercourse ID	Both naming conventions used by the A5 Drainage Design and Ecology teams are used for cross-referencing purposes
WFD Waterbody ID	Unique ID assigned by NIEA under the Water Framework Directive, taken from the NIEA River Basin Plan Interactive Map at: http://maps.ehsni.gov.uk/wmuviewer/. Multiple outfalls may be within a single waterbody area.
Designations	Details of protected area designations taken from NIEA website at: http://www.ni-environment.gov.uk/protected_areas_home.html
WFD Class / Objectives	Current WFD Classification and objectives were taken from the NIEA River Basin Management Plan (RBMP) Interactive Map at: http://maps.ehsni.gov.uk/wmuviewer/. For the purposes of this assessment it has been assumed that the classification of a river can be extrapolated and applied to all its tributary streams and drains. The status of heavily modified rivers is quoted in terms of ecological potential, in line with the WFD classifications systems used by the NIEA.
FFD Category	Details of Freshwater Fisheries Directive Designations (Salmonid / Cyprinid) taken from the NIEA RBMP Interactive Map at: http://maps.ehsni.gov.uk/wmuviewer/. The description of the size of population supported has been derived by the A5 Ecology team, based on desk study and field survey work as discussed below.
Significant Species	Ecology data has been provided by the A5 Ecology team and has been gathered from both desk study and field survey work. . A brief summary of the studies undertaken is given below:
River Habitat Survey	• Desk studies including collation of historical survey records from the Loughs Agency (LA), NIEA and the Agri-Food and Biosciences Institute (AFBI)
Biodiversity Value	• River Habitat Surveys (RHS) and Fish Habitat Surveys (FHS) • Riverine Plants/Aquatic Macrophytes Survey • Aquatic Macro-Invertebrate Surveys • Electrofishing & Netting Surveys • Freshwater Pearl Mussel and White-Clawed Crayfish Surveys European protected rivers such as a SACs and/or identified as being a classified watercourse, either under the WFD or the FFD, were selected for RHS assessment as these rivers have been identified as being of significance for salmonids species. Further to this, any significant tributaries to these watercourses were also subject to RHS as these could have still contained significant habitat for salmonids despite not being classified. At Stage 2 a total of 47 watercourses were identified for RHS assessment, all other significant watercourses, with the exception of field drains, were subject to rapid assessment from "drive by" surveys and the presence of any notable culvert, weir or any other potential barrier to fish migration was noted. Following the Stage 2 assessment a subset of 16 watercourse sites were identified for more detailed Stage 3 fish fauna survey and assessment. The ecology information presented in the datasheets within this report has been selected to provide a summary and broad overview of the baseline ecological condition of the affected watercourses. The **Significant Species** information has been derived from both the desk study and field surveys.

Datasheet Field	Data Source
	The **RHS** is a method designed to broadly characterise and assess the physical structure of freshwater rivers, which has been developed in collaboration by the Environment Agency (EA), Scottish Environmental Protection Agency (SEPA) and NIEA. RHS is undertaken along 500m lengths of river channel, with observations / target notes on flow structure, physical features in the channel and on the banks, substrates, vegetation characteristics and land use in the river channel made at ten equally spaced spot-checks along the channel. An overall assessment of the reach, with valley form, artificial structures, etc. is also made. The information gathered from the RHS can be used to identify the diversity and naturalness through completion of a Habitat Quality Assessment (HQA) and the level of modification identified from a Habitat Modification Score (HMS), which can identify the corresponding Habitat Modification Class. **HQA** – the HQA scores do not have a specific grading as per the HMS (see below), rather the score indicates the geomorphological quality and diversity of the habitat. The higher the score, the more diverse the watercourse with more habitat 'pockets' (i.e. a variety of substrates, flow and bank conditions), the lower the score the more uniform the channel, with flow structure dominated by one flow type and one substrate with uniform bank structure (e.g. slope and vegetation type). **HMS** – the HMS scoring system is graded dependant upon the level of modification ranging from 'Pristine / Semi-natural' through to 'Severely Modified' as shown below.

HMS Score	HMS Modification Class
0 – 16	Pristine / semi-natural
17 – 199	Predominantly unmodified
200 – 499	Obviously modified
500 – 1399	Significantly modified
1400 +	Severely modified

The **Biodiversity Value** has been based on the evaluation guidelines published by the Institute of Ecology and Environmental Management (IEEM) which details how the relative value and importance of a species can be determined and states that the value of a species should be measured against published selection criteria where available. In addition, when valuing a species reference should also be made to UK and Local BAPs and subsequent Species Action Plans (SAPs). The evaluation criteria distinguishes between the biodiversity value of a receptor and it's legal status. For the purposes of the ecology assessment each population has been assessed as valuable, or potentially valuable, based on the following geographic frame of reference:

Biodiversity Value	Description
International	a population warranting designation as a SAC and/or of significant conservation status for Europe
National	a population warranting designation as a Site of Special Scientific Interest (ASSIs) and/or of significant conservation status for NI
County	a population warranting designation as a Site of Local Nature Conservation Importance (SLNCI) of county significance e.g. of significance for County Tyrone
District	a population of significant conservation status for the local districts
Local	a population of significant conservation status within a local context (i.e. within ~5 km of the proposed works areas)
Site	a population of significance for the immediate survey site only

Datasheet Field	Data Source
Temp / Cond / pH / DO / TSS	Water quality data for the following parameters has been presented in the datasheets: temperature, conductivity, pH, dissolved oxygen and total suspended solids. Water quality data has been derived from a number of sources. Long term monitoring data for the major rivers within the study area has been provided by NIEA. This data has been supplemented with monthly monitoring carried out by Mouchel between November 2009 and May 2010 at 28 locations. These locations were selected to 'fill in the gaps' in the NIEA coverage, and are concentrated on the larger tributary streams that the A5WTC route crosses. Details of the monitoring programme, the water quality results and a comparison with the NIEA long term monitoring data are provided in the Technical Appendix 16D: Water Quality Monitoring – Appendix 16G. In addition in-situ one-off monitoring was carried out by the ecologists whilst undertaking the various freshwater ecology surveys. The water quality data quoted in the individual datasheets is generally taken from the closest monitoring location to the crossing under consideration and average figures have been derived from the dataset used i.e. NIEA or Mouchel data. In some instances there is no monitoring data available for the particular watercourse or reach affected. In these cases the water quality data has been extrapolated from nearby monitoring locations, taking into consideration the relative catchment sizes and ground conditions.
Low / Mean / High Flow	Low and mean flow figures have been calculated for each outfall location using the Institute of Hydrology Report No. 108: Low Flow Estimation in the United Kingdom. Using this method the derived annual low flow, Q_{95}, is the flow exceeded 95% of the year. The high flow figures quoted have been provided by the Drainage Design team. They represent the Q_{100} flow i.e. a high flow with a return period of 1 in 100 years, which has been calculated using either the Poots & Cochrane or Flood Estimation Handbook (FEH) method, dependant on catchment size and characteristics.
Bed Width / Channel Depth / Top of Bank Width	Details of the channel dimensions have been determined by undertaking topographic surveys of all affected watercourses. In addition to measuring the channel cross-section and gradient each watercourse has been photographed and basic information on watercourse type, flow type and nature of the channel and substrate recorded.
Bed Gradient	
Bed Material	Information on the bed material has come from a variety of sources and is therefore of varying detail. Where ecological or geomorphological surveys have been carried out information on the percentage composition of boulders / cobbles/ gravel / sand / silt & clay are presented. For the remaining watercourses (mainly minor drains and streams) broad estimates of the bed material have been made based on site photographs and the information gathered on channel nature during the drainage design topographic surveys.
In-Channel / Bankside Vegetation	Information on the in-channel and bankside vegetation has come from a variety of sources including, ecological surveys broad estimates of the vegetation have been made based on site photographs and the information gathered on channel nature during the drainage design topographic surveys. The bankside vegetation descriptions have been broadly based on the RHS nomenclature.
Flood Risk	Flood risk modelling has been undertaken for a number of the larger rivers within the A5WTC study area. Mapping of the 1 in 100 year plus climate change floodplains has been produced from this modelling work. The floodplain mapping produced has been used to determine whether the proposed crossings are in a flood risk area. Where flood modelling has not been carried out data has been taken from the River's Agency Strategic Flood Mapping at: http://www.riversagencyni.gov.uk/index/stategic-flood-maps.htm
Fluvial Geomorphology	A phased fluvial geomorphology assessment has been carried out in the A5WTC study area. Firstly, a desk based review of the affected watercourses was undertaken, using the available mapping, aerial photography and site photos from the Drainage topographic survey work. Based on this review, watercourses that were unlikely to have any geomorphological / ecological interest i.e. minor field drains were screened out. The remaining watercourses were divided into two categories: those requiring a site walkover and qualitative fluvial assessment by a geomorphologist, primarily the larger rivers and streams with significant fish interest, and those requiring qualitative assessment from site photographs collected by the Drainage Design survey team. Where applicable the desk study and field survey has been supplemented with information from the RHS. Further details of the locations assessed, the assessment methods and the results are provided in the Geomorphology Assessment Methodology below. A brief summary of the primary findings of the geomorphology assessment at each crossing location are presented in the individual datasheets.
Surface Water Abstractions	Details of all surface water abstractions located downstream of the outfall location that may potentially be affected by the outfall. Data on surface water abstractions has been collated as part of the private water supply survey, details of which are available in Technical Appendix 16E: Groundwater & Private Water Supply Assessment Report
Outfall Structure Type	Description of the proposed outfall type.
Peak Discharge Rate	Calculated peak discharge rate and approved in principle by Rivers Agency
Aerial View	Each datasheet has an aerial image of the relevant crossing. Superimposed on the aerial image is the V3.1 highways alignment, V3.1 drainage design and watercourse centrelines.
Assumed Environmental Mitigation	The assumed environmental mitigation measures are those required above and beyond the design to date. The final impact significance has been derived on the basis that these measures will be implemented.

Datasheet Field	Data Source
Soluble Copper Acute Impact	The Pass/Fail result of the HAWRAT assessment for soluble copper. For information on the assessment method and parameters required to carry out the assessment see the HAWRAT methodology section below. Note this is the post-mitigation result.
Soluble Zinc Acute Impact	The Pass/Fail result of the HAWRAT assessment for soluble zinc. For information on the assessment method and parameters required to carry out the assessment see the HAWRAT methodology section below. Note this is the post-mitigation result.
Sediment Chronic Impact	The Pass/Fail result of the HAWRAT sediment assessment. For information on the assessment method and parameters required to carry out the assessment see the HAWRAT methodology section below. Note this is the post-mitigation result.
Low Flow Vel (m/s) / Deposition index	The flow velocity within the receiving watercourse under low flow conditions – this determines whether polluted sediment from the outfall will accumulate in the receiving watercourse. Sediment accumulation is likely to occur where the low flow velocity is less than 0.1m/s. The deposition index gives an indication of the extent of sediment accumulation. For further information on these parameters see the HAWRAT methodology section below. Note this is the post-mitigation result.
Dissolved Copper EQS (µg/l)	The Pass / Fail result of the EQS assessment for dissolved copper. For information on the assessment method and parameters required to carry out the assessment see the HAWRAT methodology section below. Note this is the post-mitigation result.
Dissolved Zinc EQS (µg/l)	The Pass / Fail result of the EQS assessment for dissolved zinc. For information on the assessment method and parameters required to carry out the assessment see the HAWRAT methodology section below. Note this is the post-mitigation result.
Groundwater Risk Score	Groundwater risk score and category as derived from the groundwater risk assessment. For information on the assessment method and parameters required to carry out the assessment see the groundwater methodology section below.
Accidental Spillage Return Period	The return period of a serious pollution incident as a result of accidental spillage on the operational road. For information on the assessment method and parameters required to carry out the assessment see the accidental spillage methodology section below. Note this is the post-mitigation result.
Attribute Importance	Importance or sensitivity of the receiving watercourse, based on the baseline information collected and using the assessment criteria outlined in the DMRB guidance and discussed in the Significance Criteria section below.

Outfall Impact Assessment Routine Runoff – Method A

To assess the water quality impacts from routine runoff on receiving watercourses two separate assessments are carried out. These comrpised:

- The Highways Agency Water Risk Assessment Tool (HAWRAT) is a Microsoft Excel application which has been developed to assess the acute and chronic pollution impacts on aquatic ecology associated with soluble and sediment bound pollutants respectively.
- The EQS assessment considers the long-term chronic impacts associated with soluble pollutants. The in-river annual average concentrations for soluble pollutants, including the contribution from road runoff are calculated and compared with published Environmental Quality Standards (EQSs), to assess whether there is likely to be a long-term impact on ecology.

Each assessment method is discussed in more detail in the following sections.

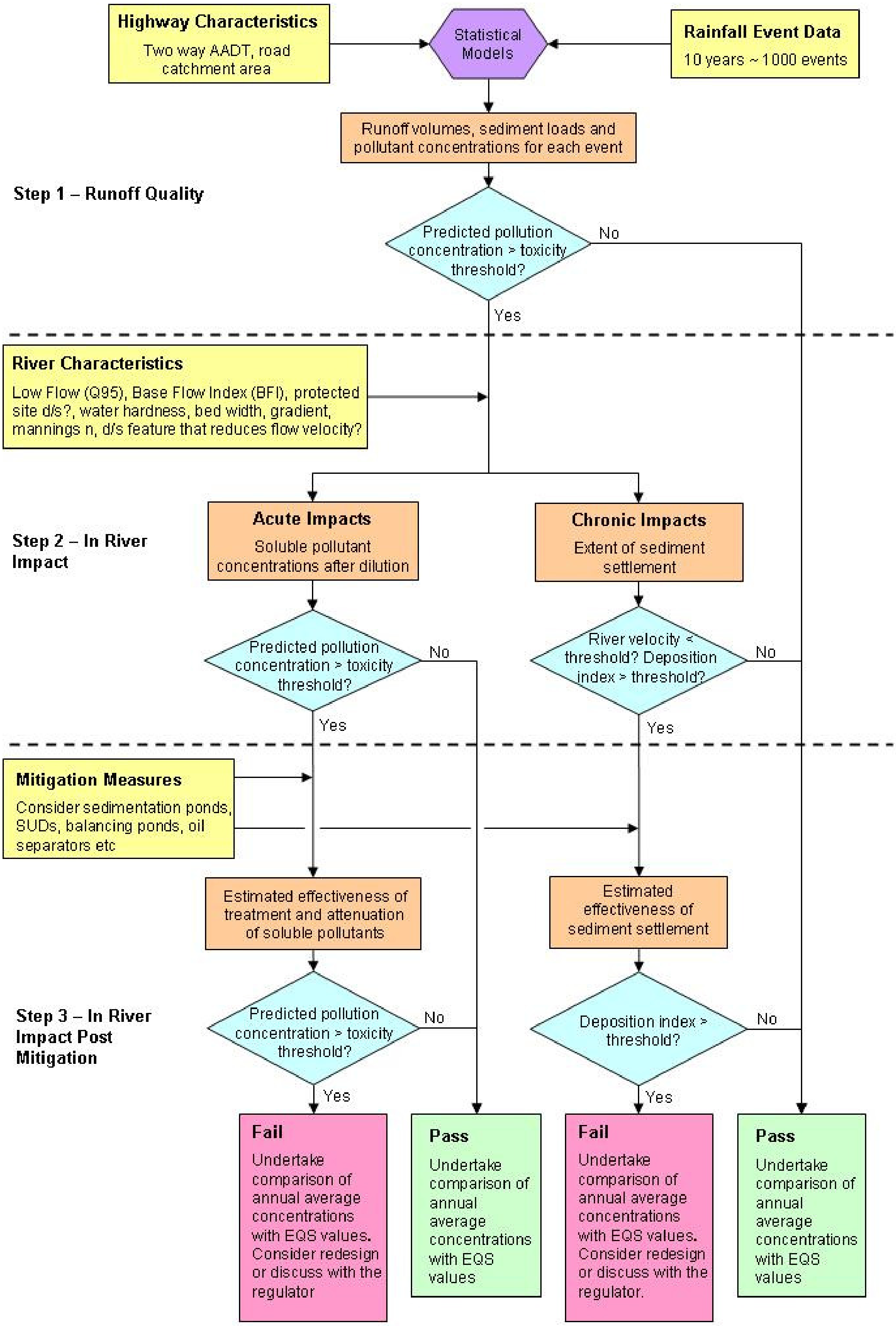
<u>Highways Agency Water Risk Assessment Tool (HAWRAT)</u>

The key features of HAWRAT are:

- it incorporates a tiered consequential approach to assessment whereby unnecessary work is avoided if the impact can be shown to be low.
- it uses a ‘traffic light’ reporting method whereby:
    - Red indicates an unacceptable impact, or a need to carry out further stages of the HAWRAT Assessment
    - Green indicates no marked impact, with no need for any further investigation.
    - Amber indicates no marked sediment impact, but the proximity of a conservation site or downstream structure may cause a problem and the assessor can determine whether further investigation is required.
- The underlying algorithms for assessing pollutant impacts are based on the latest detailed research and data collection carried out by the Highways Agency on runoff quality from non-urban highways under a wide range of traffic and weather conditions. The tool uses recent ecological research to evaluate whether predicted impacts are acceptable or not.

The HAWRAT assessment has been developed as a tiered system and involves up to three assessment stages as shown in Figure 16.9. Step 1 determines pollutant concentrations in raw road runoff prior to any treatment or dilution in the receiving watercourse. Step 2 assesses in river pollutant concentrations after dilution and dispersion but without active mitigation. Step 3 considers the in river pollutant concentrations with active mitigation.

Figure 16.9 HAWRAT Tiered Flow Diagram



Full details on the development and use of HAWRAT can be found in DMRB 11.3.10 HD 45/09 and in the HAWRAT Users Manual, which includes background information on the research programme behind the tool, derivation of the toxicity thresholds used and explanation of the background calculations. The key points are summarised below.

Step 1 – Road Runoff Quality

Rainfall series for 21 reference sites across the UK are built into HAWRAT to represent the different rainfall patterns experienced in the different climatic regions (cold & wet, cold & dry, warm & wet, warm & dry) across England, Scotland, Wales and Northern Ireland. The Carmoney rainfall site (Climatic Region: cold & wet), located approximately 7.5km north-east of Londonderry/Derry, has been used in the A5WTC assessment. For the Carmoney rainfall site 10 years worth of hourly rainfall data has been stochastically generated, resulting in approximately 1000 individual rainfall events over a 10 year period. For each rainfall event data on the total rainfall, event duration, intensity and antecedent dry weather period has been calculated.

The mean concentration of each pollutant in the raw road runoff is calculated for each rainfall event. HAWRAT tests for a suite of pollutants identified through the Highways Agency and Environment Agency research programme as the key contaminants in road runoff either because of their abundance and/or they are the most harmful in terms of species sensitivity in the water environment. These pollutants are:

- Soluble pollutants associated with acute pollution impacts, expressed as Event Mean Concentrations (EMCs in µg/l) for dissolved copper and zinc, and;
- Sediment related pollutants associated with chronic pollution impacts, expressed as Event Mean Sediment Concentrations (EMSCs in mg/kg) for total copper, zinc, cadmium, and (in µg/kg) for pyrene, fluoranthene, anthracene, phenanthrene and total PAH (Polycyclic Aromatic Hydrocarbons).

The models used for calculating the various pollutant concentrations have been developed as part of the underpinning research programme. It has been found that the concentration of any particular pollutant in road runoff from any particular rainfall event is related to the climatic region, traffic volume within the road drainage catchment, month, maximum hourly intensity of the rainfall event and antecedent dry weather period.

The calculated pollutant EMC's and EMSC's for each rainfall event are compared with the toxicity thresholds for each pollutant. The toxicity thresholds have been derived from the HA and EA research programme. For soluble pollutants Runoff Specific Thresholds (RST's), a six hour threshold (RST6hr) and a 24 hour threshold (RST24hr), have been developed for dissolved Copper and Zinc to protect receiving organisms from short-term exposure, as shown in 12. It should be noted that the toxicity of dissolved Zinc is dependant on water hardness, therefore there are three sets of RST's for dissolved zinc built into HAWRAT, which correspond to low, medium or high water hardness.

Table 16B.2 Runoff Specific Toxicity Thresholds for Soluble Pollutants

Runoff Specific Threshold	Copper (µg/l)	Zinc (µg/l)		
		Water Hardness (mg $CaCO_3$/l)		
		Low (<50)	Medium (50-200)	High (>200)
RST24hr	21	60	92	385
RST6hr	42	120	184	770

For sediment bound pollutants Threshold Effects Levels (TEL's) and Probable Effects Levels (PEL's) have been developed for metal and PAH concentrations, as shown in Table16B.3. The TEL is the concentration below which toxic effects are extremely rare. The PEL is the concentration above which toxic effects are observed on most occasions.

Table16B.3 Toxicity Thresholds for Sediment Bound Pollutants.

Thresholds	Metals			Polycyclic Aromatic Hydrocarbons (PAH's)				
	Copper (mg/kg)	Zinc (mg/kg)	Cadmium (mg/kg)	Total PAH (µg/kg)	Pyrene (µg/kg)	Fluoranthene (µg/kg)	Anthracene (µg/kg)	Phenanthrene (µg/kg)
TEL	35.7	123	0.6	1684	53	111	46.9	41.9
PEL	197	315	3.5	16770	875	2355	245	515

In comparing the pollutant concentrations with the relevant toxicity thresholds the number of rainfall events that result in an exceedance can be calculated. At Step 1 the maximum number of exceedances allowed per year has been set at one. If the average number of exceedances per year is one or less HAWRAT will return a 'Pass' result and no further assessment is required for the outfall in question. If the number of exceedances is greater than one HAWRAT will return a 'Fail' result and the assessment should proceed to Step 2.

Step 2 – In River Impact

Step 2 takes the road runoff soluble pollutant concentrations calculated for each of the ~1000 rainfall events, calculates the diluted in-river concentrations and again compares these with the toxicity thresholds to calculate the number of exceedances. To do this HAWRAT must calculate the road runoff flow rate and watercourse flow rate for each event.

To calculate the road runoff flow HAWRAT requires information from the user on the impermeable and permeable areas of the road drainage catchment. These are individually multiplied by the event total rainfall and an appropriate runoff coefficient. The two values are added together to give the total runoff volume, which is then divided by the rainfall event duration to give the mean road runoff flow rate.

To calculate the river flow rate for each event the rainfall series is passed through a soil and groundwater model to attenuate the flows and create a river flow series. To generate an accurate river flow series for the watercourse in question information on the groundwater contribution to river flow must be entered into the model in the form of the catchment base flow index (BFI). At this stage the river flow data is based on an arbitrary catchment area and must be scaled to represent the river flow in the actual watercourse of interest. To do this the 95%ile low flow is calculated for the river flow series (i.e. the flow exceeded 95% of the time), while the user enters the actual 95%ile river flow for the site. The ratio of these two 95%iles provides the factor to scale the river flow series. Finally the actually river flow assigned to a particular rainfall event, and used in the pollutant concentration calculations, is taken as the scaled river flow just before the start of the event.

The in-river soluble pollutant concentrations are then calculated for each event by a simple mass balance of river flow and runoff flow:

In-River Pollutant Concentration = [(road runoff pollutant concentration x road runoff flow rate) + (upstream river pollutant concentration x river flow rate)] / (road runoff flow rate + river flow rate)

It should be noted that, as the river flow rate used in the calculation is taken from the start of the event, it is assumed that the rainfall event itself will not elevate river flows quickly enough to provide additional dilution during the event. Also, the default setting in HAWRAT for the upstream river pollutant concentration is 0µg/l. This enables an assessment of the added risk rather than total risk, i.e. the additional risk to organisms in the receiving water when they are exposed to road runoff.

As with Step 1 the number of events for which the in-river soluble pollutant concentrations exceed the toxicity thresholds are calculated and compared with the exceedance frequency thresholds. At this stage the sensitivity of the watercourse is taken into account. Normally the exceedance frequency thresholds are two per year for the RST24hr and one per year for the RST6hr. However if there is a protected conservation site such as a SAC or ASSI within 1 km downstream stream of the discharge the frequency thresholds are halved, providing a greater level of protection to the most sensitive watercourses. If the average number of exceedances per year is less than the relevant exceedance frequency threshold HAWRAT will return a ‘Pass’ result and no further assessment of soluble pollutants is required for the outfall in question. If the number of exceedances is greater than the relevant exceedance frequency threshold HAWRAT will return a ‘Fail’ result and the assessment of soluble pollutants should proceed to Step 3.

The Step 2 assessment of the sediment bound pollutants is handled differently. The in-river impacts are determined by considering the likelihood and probable extent of sediment deposition, in a two stage process.

Firstly an estimate of whether sediment accumulation is likely or not, based on the low flow (90%ile flow) velocity of the receiving watercourse is carried out. To calculate the flow velocity HAWRAT uses the 90%ile river flow, calculated from the river flow series, and data on the watercourse dimensions, which are inputted by the user. There are two levels (tiers) of sophistication to this calculation. Tier 1 requires only the river width, which can be estimated from mapping or aerial photography, to calculate approximately the flow velocity. Tier 2 requires the watercourse bed width, side slope, longitudinal slope (or gradient) and Manning's roughness coefficient, which are determined from site survey, to iteratively estimate the velocity with greater accuracy. If the calculated flow velocity is greater than 0.1m/s the site is considered to disperse sediment and HAWRAT reports a 'Pass' result for chronic sediment impacts. If the velocity is less than 0.1m/s the site is assessed as accumulating sediments and further assessment of the extent of deposition is required.

The extent of sediment deposition is represented by a Deposition Index (DI), which is 100 times the ratio of the estimated annual volume of sediment in the road runoff to a volume represented by a layer 0.01m thick, spread across the full width of the river at low flow conditions and down a 10m length of the river, i.e.

Deposition Index = 100 x [annual road runoff sediment volume / (0.01 x 10 x low flow river width)]

Where the annual road runoff sediment volume is calculated using the annual road runoff volume calculated earlier, a median suspended solids concentration of 139mg/l derived from the research programme and an assumed sediment density of 2000 kg/m3.

If the calculated DI is less than 100 the sediment accumulation is not considered extensive and HAWRAT returns a 'Pass' result for chronic sediment impacts. If the DI is greater than 100 the accumulation is considered extensive and HAWRAT returns a 'Fail' result and the assessment of chronic impacts from sediment bound pollutants should proceed to Step 3. In addition to the 'Pass' and 'Fail' results HAWRAT can also return an 'Alert' result. In this case the outfall may pass the assessment but the presence of a downstream conservation site that requires greater protection, or a downstream structure, lake, pond or canal that may reduce flow velocity, means that additional care should be given to the design and assessment of the drainage scheme. Information on the downstream considerations is entered into HAWRAT by the user.

A number of the outfall locations in this assessment discharge directly into the River Foyle, which is a transitional water. In these instances the sediment calculations undertaken by HAWRAT are inappropriate as they assume there is no tidal influence. Given the size and flow of the River Foyle it was not anticipated that sediment accumulation would be an issue. However to provide some confidence basic estimations of sediment input from road outfalls compared with natural processes have been carried out for the relevant outfalls and are reported in the Transitional Waters Section of this technical appendix.

Step 3 – In River Impact with Mitigation

Step 3 provides an assessment of the in-river impacts with mitigation in place. HAWRAT is designed to allow different types of treatment to be applied:

- Attenuation of the soluble pollutants through restriction of the road runoff discharge rate;
- Treatment of road runoff to reduce soluble pollutant concentrations. The mitigation effect is quoted as a percentage reduction in pollutant concentration; and
- Settlement of road runoff sediments to reduce the annual sediment volume release into the receiving watercourse. Again, the mitigative effect is quoted as a percentage reduction in sediment load.

All three types of mitigation are likely to be provided by the use of sustainable urban drainage systems (SUDS) within the road drainage network. The mitigation used within the A5WTC scheme is discussed in detail within the Mitigation section.

The calculation for the mitigated in-river concentration of soluble pollutants incorporates the treatment percentage reduction and restricted discharge rate values into the simple mass balance formula as shown:

Mitigated Soluble Pollutant Concentration = {[(road runoff pollutant concentration x road runoff flow rate x {rainfall event duration / restricted discharge duration}) x (1 – {% solubles treatment / 100})] + (upstream river pollutant concentration x river flow rate)} / (restricted discharge rate + river flow rate)

Where the restricted discharge duration is calculated as:

Restricted Discharge Duration = total road runoff / restricted discharge rate / 3600

As with Steps 1 and 2 the mitigated soluble pollutant concentrations are calculated for each rainfall event and the number of toxicity threshold exceedances. The same exceedance thresholds are applied in Step 3 as in Step 2. If HAWRAT returns a 'Pass' result the user should move onto the EQS assessment of chronic impacts from soluble pollutants, as described below. If a 'Fail' result is returned the user should consider re-designing the road drainage network and/or the mitigation measures.

For chronic sediment impacts the DI is recalculated using the annual sediment volume after settlement measures and the sediment risk impact is then re-estimated using the same procedure as in Step 2. A 'Pass' result requires no further assessment, while if a 'Fail' result is returned the user should consider re-designing the road drainage network and/or the mitigation measures.

User Parameters

The HAWRAT parameters that must be entered by the user at each stage of the assessment are summarised in Table 16B.4, with details of the respective data sources.

Table 16B.4 HAWRAT User Parameters.

Parameter	Data Source
Step 1	
AADT	Annual Average Daily Traffic flow data has been provided the A5WTC Traffic Team for each road drainage catchment. One of three broad ranges of AADT must be selected within HAWRAT. The majority of road drainage catchments within the A5WTC scheme have an AADT in the range of >10,000 and < 50,000 vehicles (the lowest band). There are a small number of road drainage catchments which have an AADT of slightly less than 10,000. The HAWRAT manual suggests that the tool may not be suitable for the assessment of such lightly trafficked road drainage catchments. However to ensure a thorough and consistent approach across the entire scheme it was felt that HAWRAT was the most appropriate assessment method for the road catchments, although it may slightly overestimate the pollutant build-up and provide an overly conservative assessment.
Climatic Region	Four options are available to choose from: Colder Wet, Colder Dry, Warmer Wet and Warmer Dry. In this instance the Colder Wet option was selected
Rainfall Site	Having selected a Climatic Region a restricted list of rainfall site are available to choose from. The Carmoney rainfall site was chosen in this instance as it was geographically closest to the road scheme.
Step 2	
Impermeable road area drained (ha)	The A5WTC Drainage Design Team have provided details of the individual road drainage catchment area, at this stage in the scheme design the catchments have not been divided into impermeable and permeable areas, therefore it has been assumed in each instance that the entire road drainage catchment is impermeable. This has resulted in a conservative estimate of the road runoff flow rate etc.
Permeable road area drained (ha)	
Annual 95%ile river flow (m^3/s)	The 95%ile (Q_{95}) river flows have been calculated for each outfall location using the Institute of Hydrology Report No. 108: Low Flow Estimation in the United Kingdom.
Baseflow Index (BFI)	The baseflow index for each receiving watercourse has been taken from the Flood Estimation Handbook (FEH) CD-ROM.
Conservation Area Proximity	The locations of downstream conservation sites has been provided by the A5WTC Ecology Team. This data has been entered into a GIS and the distance from the road drainage outfalls determined. Where a conservation site lies within

Parameter	Data Source
	1km downstream of an outfall the drop down option for this is chosen
Water Hardness	Data on the water hardness of the receiving watercourses, which is required for the assessment of soluble zinc only, has been collated from NIEA WFD classification information. One of three broad ranges must be chosen within HAWRAT.
Downstream Structure Proximity	The location of downstream structures, lakes, pond and canals has been determined from aerial photo interpretation and site survey work undertaken by the Drainage Design and Ecology Teams.
Estimated River Width (m)	Used in the Tier 1 assessment of chronic sediment impacts, this was derived from aerial photo interpretation.
Bed Width (m) / Manning's n / Side Slope (m/m) / Long Slope (m/m)	Used in the Tier 2 assessment of chronic sediment impacts, this information was provided by the Drainage Design Team who have undertaken topographic surveys of all affected watercourses.
Step 3	
Proposed Mitigation Measures	Text description of the proposed mitigation measures. Appropriate mitigation measures have been identified through an iterative design & assessment process undertaken by the Drainage Design and Water Environment teams. Further information on mitigation is provided in the Mitigation section of this report.
Treatment for Solubles (%)	An estimate of the probable effectiveness of the mitigation measures in reducing soluble pollutant concentrations is entered. See the Mitigation section of this report for further details
Restricted Discharge Rate (l/s)	Restriction of the road runoff discharge rate has not been used as a mitigation measure for the A5WTC outfalls. Where the assessment found that mitigation was required, the receiving watercourses were generally very small with very low 95%ile flows. In these instances the discharge rate would have had to be restricted to an impracticably low rate for attenuation to be effective. Treatment of soluble pollutants was considered the only practical solution in these cases.
Settlement of Sediments (%)	An estimate of the probable effectiveness of the mitigation measures in reducing sediment concentrations is entered. See the Mitigation section of this report for further details

Cumulative Assessment

Where more than one outfall discharges into the same reach of a watercourse the combined impacts will be more significant. In these circumstances the outfalls should be aggregated for the purposes of aggregate assessment in HAWRAT.

To aggregate the outfalls the drained areas are simply added together. The location on the watercourse used for the cumulative assessment should be positioned downstream of the last outfall in the reach. For this purpose a reach is defined as a length of watercourse between two confluences, the reason being that the available dilution and stream velocity will naturally change at confluences and influence the assessment.

However watercourse reaches can vary greatly in length. Therefore for the assessment of the impacts of soluble pollutants only outfalls within 1km of each other along the length of a watercourse were aggregated for cumulative assessment. When assessing the combined impact of sediment bound pollutants outfalls within 100m of one another are assessed. Beyond 100m the road runoff sediment, if it settles at all, is likely to be sufficiently diluted with natural sediments so as not to have an adverse impact.

As with the assessment of individual outfalls, if the cumulative assessment fails mitigation should be applied to one or more of the outfalls and the calculations re-run.

EQS Assessment

The EQS Assessment provides an assessment of the long-term risks to receiving water ecology from soluble pollutants. The annual average concentrations for dissolved copper and zinc are calculated and compared with the published Environmental Quality Standards (EQS), shown in Table 16B.5 overleaf to assess whether there is likely to be a long-term impact. It should be noted that at present there are published EQS values for total zinc, but not dissolved zinc. The values quoted for dissolved zinc are proposed and are likely to be adopted before 2013.

The annual average concentrations are calculated within HAWRAT at both Step 2 and Step 3. In calculating the annual average concentrations for dissolved copper and dissolved zinc, HAWRAT assumes that the background/upstream concentrations are zero. This enables an assessment of the added risk rather than the total risk i.e. the additional risk to organisms in the receiving water when they are exposed to road runoff.

Table 16B.5 Environmental Quality Standards for Dissolved Copper and Zinc

Water Hardness Bands (mg/l $CaCO_3$)	EQS for Dissolved Copper (µg/l)	EQS for Dissolved Zinc* (µg/l)
0 – 50	1	7.8
>50 – 100	6	
>100 – 250	10	
> 250	28	
* Proposed value		

Assessment of Pollution Impacts from Routine Runoff on Groundwaters – Method C

The road drainage system of the A5WTC has been designed to primarily discharge to surface waters. However, wetlands are proposed as part of the mitigation measures at a number of outfalls. At the present time it is not known whether these wetlands will be designed to interact with the local groundwater or not, as this will depend on the results of detailed ground investigations.

Taking a precautionary approach each of these wetland locations has been assessed for pollution impacts from routine runoff on groundwaters. It should be noted that there are a large number of attenuation ponds also proposed throughout the scheme. Although these will hold road runoff that is to be attenuated, the period of time that the water will be held in the ponds will be a matter of hours. It is felt that there will be insufficient time for significant infiltration to groundwater and therefore it is not proposed to assess these for groundwater impacts.

Impacts of infiltration of routine road runoff on the quality of the underlying groundwater have been assessed in accordance with the assessment method set out Method C of DMRB Vol. 11, Section 3, Part 10 Road Drainage and the Water Environment.

The DMRB sets out a matrix that has been designed to assess the potential overall risk to groundwater and to highlight any sites at high risk, where additional measures may be required. The risk assessment matrix uses the Source-Pathway-Receptor (S-P-R) protocol developed for use in risk assessment procedures for contaminated land evaluation. For road systems, the road drainage provides the source term. The pathway is represented by the processes by which road drainage is transported and discharged. The receptor is the groundwater. The parameters used in the risk assessment matrix are shown in Table 16B.6.

Each parameter is considered in turn and assigned a risk category. The corresponding risk score (low risk – 1, medium risk – 2, high risk – 3) is multiplied by the weighting factor for each parameter, then summed. The overall risk of impact to groundwater is determined as:

- Overall risk score <150 – Low Risk of Impact;
- Overall risk score 150 - 250 – Medium Risk of Impact; and
- **Overall risk score >250 – High Risk of Impact.**

Table 16B.6 Pathway and Source Descriptions

S-P-R	Weighting Factor	Parameter	Low Risk (Score 1)	Medium Risk (Score 2)	High Risk (Score 3)
SOURCE	15	Traffic Density	< 50,000 AADT	50,000 to <100,000 AADT	> 100,000 AADT
	15	Annual Average Rainfall	< 740mm rainfall	740 – 1060 mm rainfall	> 1060 mm rainfall
		Rainfall Intensity	Even (<35mm FEH 1hr rainfall)	Uneven (35-47 mm FEH 1hr rainfall)	Concentrated (>47mm FEH 1hr rainfall)
PATHWAY	15	Soakaway Geometry	Continuous Linear (e.g. ditch, grassed channel)	Single point, or shallow soakaway (e.g. lagoon) serving low road area	Single point, deep serving high road area (>5,000m^2)
	20	Unsaturated zone	Depth to water table >15m and unproductive strata	Depth to water table 5-15m	Depth to water table <5m
	20	Flow type	Unconsolidated or non-fractured consolidated deposits (i.e. dominantly intergranular flow)	Consolidated deposits (i.e. mixed fracture and intergranular flow)	Heavily consolidated sedimentary deposits, igneous and metamorphic rocks (dominated by fracture porosity)
	7.5	Effective grain size	Fine sand and below	Coarse sand	Very coarse sand and above
	7.5	Lithology	>15% clay minerals	1-5% clay minerals	<1% clay minerals

Assessment of Pollution Impacts from Accidental Spillages – Method D

Spillages resulting from road traffic accidents or other causes could occur anywhere along the A5WTC road network. Although the A5WTC has been designed to minimise the risk of collision, it is important to assess the risk of serious pollution incident occurring. This assessment has carried out in accordance with Method D as detailed in DMRB.

The accidental spillage assessment determines, for each road drainage catchment, the overall probability of a serious pollution incident as a result of a spillage accident. This is done in two stages, which can be carried out within HAWRAT.

- Firstly the method estimates the probability that there will be a collision involving a spillage of potentially polluting substance somewhere within the road drainage catchment being assessed.
- It then calculates the probability, assuming a spillage has occurred, that the pollutant will reach and impact on the receiving watercourse.

These two probabilities are multiplied together to give the overall annual probability of such an event occurring. Factors which influence the overall probability within a road catchment area are:

- the type of road i.e. motorway, rural trunk road or urban trunk road. In this case the A5WTC route has been assessed as rural trunk road;
- the road components within each road catchment area i.e. no junction , slip road, roundabout, crossroad and side road. This data has been provided by the A5WTC Highways Team;
- the length of each road component within the road drainage catchment, again provided by the A5WTC Highways Team;
- the AADT (annual average daily traffic) two way flow, provided by the A5WTC Traffic Team;
- the percentage of the AADT flow that comprises Heavy Goods Vehicles (HGV's), also provided by the A5WTC Traffic Team;
- the response time of the emergency services. The method of determination is discussed below; and
- the receiving waterbody. In this case all outfalls are designed to discharge to surface watercourses.

The annual probability of a spillage occurring on any road component within the drainage catchment is calculated as:

Spillage Probability = road length x spillage rate x (AADT x 365 x 10-9) x (percentage HGV's / 100)

Where the spillage rate is determined from Table 16B.7 below.

Surface Water and Ground Water

Table 16B.7 Spillage Rates for Serious Spillages (Billion HGV km/year)

Road Component	Road Type		
	Motorway	Rural Trunk Roads	Urban Trunk Roads
No Junction	0.36	0.29	0.31
Slip Road	0.43	0.83	0.36
Roundabout	3.09	3.09	5.35
Crossroad	-	0.88	1.46
Side Road	-	0.93	1.81

The spillage probabilities for each road component type within the road drainage catchment are summed to give the overall spillage probability for the road drainage catchment under assessment.

The probability of a serious pollution incident occurring as a result of a serious spillage is determined from Table 16B.8 below.

Table 16B.8 Probability of a Pollution Incident Occurring as a Result of a Serious Spillage

Receiving Waterbody	Urban (response time to site < 20 mins)	Rural (response time to site < 1 hour)	Remote (response time to site > 1 hour)
Surface Water	0.45	0.6	0.75
Groundwater	0.3	0.3	0.5

Using data from the A5WTC Traffic Team on the travel time for each section of the road, the travel times from the fire stations in the vicinity to the furthest reaches of the proposed road have been estimated. In each case the maximum travel time was less than 20 minutes, indicating an 'Urban' response time throughout the scheme. However, it was felt that a more conservative approach may be advisable, as the first priority of the emergency services will be ensuring human safety, which may delay the containment and clean-up of any pollutants. Therefore a 'Rural' response time has been used throughout the scheme.

Finally the overall annual probability of a serious pollution incident as a result of accidental spillage is calculated by multiplying the spillage probability and response time probability together. Within

HAWRAT this probability is expressed as a return period such as 1 in 50 years i.e. there is a 1 in 50 (2%) probability of such an event occurring in any one year.

The DMRB guidance recommends that the receiving watercourses are protected such that the risk of a serious pollution incident has an annual probability of less than 1% (or 1 in 100 year return period). However, where outfalls are to discharge within 1km of a protected site a higher level of protection will be required such that the annual probability is less than 0.5% (or a 1 in 200 year return period).

If any outfalls are found to fail these criteria then mitigation, such as oil separators, penstocks or ponds, should be designed into the drainage network, which will capture and contain any potential pollutant before it reaches the watercourse. The accidental spillage calculations should be re-run applying the appropriate risk reduction factors from Table 16B.9.

Table 16B.9 Risk Reduction Factors for Drainage Systems

Drainage System	Optimum Risk Reduction Factor
Filter Drain	0.6
Grassed Ditch / Swale	0.6
Pond	0.5
Wetland	0.4
Soakaway / Infiltration Basin	0.6
Sediment Trap	0.6
Unlined Ditch	0.7
Penstock / Valve	0.4
Notched Weir	0.6
Oil Separator	0.5

8.1 Transitional Waterbodies

The northernmost part of the Proposed Scheme runs approximately parallel with the River Foyle and River Finn from New Buildings to just South of Strabane. A number of the A5WTC road drainage outfalls will discharge directly into these rivers where there is a tidal influence. They are therefore classified as Transitional Waters under the Water Framework Directive

There are three outfalls discharging directly into the Foyle in and around New Buildings and four discharges directly into the Finn immediately south of Strabane.

In November 2009 the DMRB guidance on Road Drainage and the Water Environment was updated and a new assessment tool for road drainage outfalls introduced. HAWRAT (Highways Agency Water Risk Assessment Tool) assesses the acute pollution impacts associated with soluble pollutants and the chronic pollution impacts associated with sediment related pollutants. For soluble pollutants HAWRAT calculates the available dilution in the receiving watercourse under low flow conditions. For the sediment bound pollutants the ability of the receiving watercourse to disperse sediments is considered and, if sediment is expected to accumulate, the potential extent of sediment coverage is also considered. HAWRAT estimates the river velocity under low flow conditions and assumes that sediment arriving in the river when the velocity is less than 0.1 m/s accumulates. A basic estimation of velocity is calculated iteratively using the cross sectional area of the river channel and the flow volume at low flow conditions.

The HAWRAT method has been used to assess the impact of the road drainage outfalls throughout the A5WTC corridor. However, the DMRB guidance highlights that the HAWRAT tool may not be suitable for assessing outfalls where the receiving watercourse is tidal, particularly in relation to the assessment of sediment bound pollutant impacts. Under tidal conditions the river flow velocity calculation outlined above is not appropriate as the river flow may be stratified with water at different depths flowing at different velocities and even in different directions. To fully assess the sediment impacts under these conditions detailed sediment transportation modelling would be required. This can be a difficult and time-consuming process which, given the size of the Foyle and the Finn and the low probability of significant impacts, is likely to be inappropriate and unnecessary.

However, to provide some comfort that this is the case the HAWRAT methodology has been supplemented with basic estimations of sediment input from road outfalls compared with natural processes, as detailed below.

The annual sediment volume discharged from each outfall can be calculated as:

$$Annual\ \ Sediment\ \ Volume\ (m^3)\ =\ \frac{SS\ \ Conc\ \ (mg/l)\ \times\ Annual\ \ Runoff\ \ Volume\ (m^3)}{Sediment\ \ Density\ (kg/m^3)\ \times\ 1000}$$

Research has shown that the median suspended solids concentration of highway runoff is 139 mg/l. While a typical sediment density for highway runoff is 2000 kg/m3. (Note these figures and equation are also used in the HAWRAT sediment calculations). The annual runoff volume for each outfall can be calculated as:

$$Annual\ Runoff\ Voulme\ (m^3) = \frac{SAAR\ (mm) \times Road\ Catchment\ Area\ (m^2)}{1000}$$

Where SAAR is the standard annual average rainfall as derived from the Flood Estimation Handbook (FEH) CD-ROM and Road Catchment Area is the area of the road draining to the outfall in question.

As with the road outfalls, the annual natural sediment volume passing through the rivers at the outfall locations can be estimated as above. Unlike the road drainage runoff volume the calculation for annual natural runoff volume in the rivers must also take account of evapotranspiration effects. Annual natural river runoff volume is calculated as:

$$Annual\ River\ Runoff\ Voulme\ (m^3) = \frac{[SAAR\ (mm) - pe\ (mm)] \times Catchment\ Area\ (m^2)}{1000}$$

Where SAAR is the standard annual average rainfall as derived from the FEH CD-ROM, potential evapotranspiration for the area is 493 mm as quoted by the Meteorological Office Rainfall and Evapotranspiration Calculation System (MORECS) and catchment area is the river catchment area upstream of the road outfall locations.

Method of Assessment Water Crossing Assessment

Data on the existing baseline conditions and the proposed crossing structures has been collated through consultation, desk study and field surveys as detailed below:

- A review of published maps and information;
- Information provided by the Rivers Agency, NIEA Water Management Unit and other branches of the NIEA;
- Information from and discussions with the A5WTC highways and environment teams, particularly the Drainage, Structures and Ecology disciplines;
- Desk based and field based geomorphological assessments; and
- Water quality monitoring.

This data has subsequently been entered into a GIS and individual datasheets produced for each watercourse crossing location, which are presented later in this report. The data sources for each field in the datasheets are discussed in Section 4.1 below.

Also included in each datasheet is a summary of the mitigation measures which are required at that crossing location.

Datasheet Data Sources

Details of the information presented in the Watercourse Crossing Datasheets, and the sources of this information, are given in Table 16B.10 below

Table 16B.10 Datasheet Fields and Data Sources

Datasheet Field	Data Source
Crossing ID	Naming convention as used by the A5 Drainage Design team for cross-referencing purposes
Grid Reference	Irish grid reference for the centre point of the watercourse at the crossing location
Chainage	Approximate road chainage at the crossing location, as defined by the A5 Drainage Design team
Watercourse ID	Both naming conventions used by the A5 Drainage Design and Ecology teams are used for cross-referencing purposes
WFD Waterbody ID	Unique ID assigned by NIEA under the Water Framework Directive, taken from the NIEA River Basin Plan Interactive Map at: http://maps.ehsni.gov.uk/wmuviewer/. The WFD classification system has been applied by waterbody rather than individual river reach. A waterbody in the A5 study area typically consists of a significant reach of major river and its minor tributaries; therefore there may be multiple watercourse crossings within a single waterbody area.
Designations	Details of protected area designations taken from NIEA website at: http://www.ni-environment.gov.uk/protected_areas_home.html
WFD Class / Objectives	Current WFD Classification and objectives for 2015, 2021 and 2027 as published in December 2009, are taken from the NIEA River Basin Management Plan (RBMP) Interactive Map at: http://maps.ehsni.gov.uk/wmuviewer/. The RBMP map viewer shows only the rivers visible on the 1:50K OSNI base mapping as having been classified. For the purposes of this assessment it has been assumed that the classification of a river can be extrapolated and applied to all its tributary streams and drains. The status of heavily modified rivers is quoted in terms of ecological potential, in line with the WFD classifications systems used by the NIEA.
FFD Category	Details of Freshwater Fisheries Directive Designations (Salmonid / Cyprinid) taken from the NIEA River Basin Plan Interactive Map at: http://maps.ehsni.gov.uk/wmuviewer/. The description of the size of population supported has been derived by the A5 Ecology team, based on desk study and field survey work as discussed below.

<table>
<tr><th>Datasheet Field</th><th>Data Source</th></tr>
<tr><td>Significant Species</td><td rowspan="3">Ecology data has been provided by the A5 Ecology team and has been gathered from both desk study and field survey work. Full details of the freshwater ecology work undertaken for the A5WTC scheme can be found in the Ecology Chapter of the Environmental Statement and the supporting Stage 3 Technical Appendix: Fish Fauna. A brief summary of the studies undertaken is given below:

• Desk studies including collation of historical survey records from the Loughs Agency (LA), NIEA and the Agri-Food and Biosciences Institute (AFBI);
• River Habitat Surveys (RHS) and Fish Habitat Surveys (FHS);
• Riverine Plants/Aquatic Macrophytes Survey;
• Aquatic Macro-Invertebrate Surveys;
• Electrofishing & Netting Surveys; and
• Freshwater Pearl Mussel and White-Clawed Crayfish Surveys.

Watercourses were selected for Stage 2 field survey following analysis of the desk study data. Those rivers receiving European protection as an SAC and/or identified as being a classified watercourse, either under the WFD or the FFD, were selected for RHS assessment as these rivers have been identified as being of significance for salmonid species. Further to this, any significant tributaries to these watercourses were also subject to RHS as these could have still contained significant habitat for salmonids despite not being classified. At Stage 2 a total of 47 watercourses were identified for RHS assessment; all other significant watercourses, with the exception of field drains, were subject to rapid assessment from “drive by” surveys and the presence of any notable culvert, weir or any other potential barrier to fish migration was noted. Following the Stage 2 assessment a subset of 16 watercourse sites were identified for more detailed Stage 3 fish fauna survey and assessment.

The ecology information presented in the datasheets within this report has been selected to provide a summary and broad overview of the baseline ecological condition of the affected watercourses.</td></tr>
<tr><td>River Habitat Survey</td></tr>
<tr><td>Biodiversity Value</td></tr>
</table>

<table>
<tr><th>Datasheet Field</th><th>Data Source</th></tr>
<tr><td></td><td>
The Significant Species information has been derived from both the desk study and field surveys.
The River Habitat Survey is a method designed to characterise and assess, in broad terms, the physical structure of freshwater rivers, which has been developed in collaboration by the Environment Agency (EA), Scottish Environmental Protection Agency (SEPA) and NIEA. RHS is undertaken along 500m lengths of river channel, with observations / target notes on flow structure, physical features in the channel and on the banks, substrates, vegetation characteristics and land use in the river channel made at ten equally spaced spot-checks along the channel. An overall assessment of the reach, with valley form, artificial structures, etc., is also made. The information gathered from the RHS can be used to identify the diversity and naturalness of the riverine habitat through completion of a Habitat Quality Assessment (HQA) and the level of modification identified through completion of a Habitat Modification Score (HMS), which can identify the corresponding Habitat Modification Class.
HQA – the HQA scores do not have a specific grading as per the HMS (see below), rather the score indicates the geomorphological quality and diversity of the habitat. The higher the score, the more diverse the watercourse with more habitat ‘pockets’ (i.e. a variety of substrates, flow and bank conditions), the lower the score the more uniform the channel, with flow structure dominated by one flow type and one substrate with uniform bank structure (e.g. slope and vegetation type).
HMS – the HMS scoring system is graded dependent upon the level of modification ranging from ‘Pristine / Semi-natural’ through to ‘Severely Modified’ as shown below.
<table>
<tr><th>HMS Score</th><th>HMS Modification Class</th></tr>
<tr><td>0 – 16</td><td>Pristine / semi-natural</td></tr>
<tr><td>17 – 199</td><td>Predominantly unmodified</td></tr>
<tr><td>200 – 499</td><td>Obviously modified</td></tr>
<tr><td>500 – 1399</td><td>Significantly modified</td></tr>
<tr><td>1400 +</td><td>Severely modified</td></tr>
</table>
</td></tr>
</table>

<table>
<tr><th>Datasheet Field</th><th>Data Source</th></tr>
<tr><td></td><td>The Biodiversity Value has been based on the evaluation guidelines published by the Institute of Ecology and Environmental Management (IEEM) which provide information on how the relative value and importance of a species can be determined and states that the value of a species should be measured against published selection criteria where available. In addition, when valuing a species reference should also be made to UK and Local BAPs and subsequent Species Action Plans (SAPs). The evaluation criteria distinguish between the biodiversity value of a receptor and its legal status. For the purposes of the ecology assessment each population has been assessed as valuable, or potentially valuable, based on the following geographic frame of reference:

<table>
<tr><th>Biodiversity Value</th><th>Description</th></tr>
<tr><td>International</td><td>a population warranting designation as a SAC and/or of significant conservation status for Europe</td></tr>
<tr><td>National</td><td>a population warranting designation as an Area of Special Scientific Interest (ASSI) and/or of significant conservation status for NI</td></tr>
<tr><td>County</td><td>a population warranting designation as a Site of Local Nature Conservation Importance (SLNCI) of county significance e.g. of significance for County Tyrone</td></tr>
<tr><td>District</td><td>a population of significant conservation status for the local districts</td></tr>
<tr><td>Local</td><td>a population of significant conservation status within a local context (i.e. within ~5 km of the proposed works areas)</td></tr>
<tr><td>Less than local</td><td>a population of significance for the immediate survey site only</td></tr>
</table>
</td></tr>
<tr><td>Temp / Cond / pH / DO / TSS</td><td>Water quality data on the following parameters are presented in the datasheets: temperature, conductivity, pH, dissolved oxygen and total suspended solids.

Water quality data has been derived from a number of sources. Long term monitoring data for the major rivers within the study area has been provided by NIEA. This data has been supplemented with monthly monitoring carried out by Mouchel between November 2009 and May 2010 at 28 locations. These locations were selected to ‘fill in the gaps’ in the NIEA coverage, and are concentrated on the larger tributary streams that the A5WTC route crosses. Details of the monitoring programme, the water quality results and a</td></tr>
</table>

Datasheet Field	Data Source
	comparison with the NIEA long term monitoring data are provided in the Technical Appendix16G: Water Quality Monitoring. In addition in-situ one-off monitoring was carried out by the ecologists whilst undertaking the various freshwater ecology surveys. The water quality data quoted in the individual datasheets is generally taken from the closest monitoring location to the crossing under consideration and average figures have been derived from the dataset used i.e. NIEA or Mouchel data. In some instances there is no monitoring data available for the particular watercourse or reach being crossed. In these cases the water quality data has been extrapolated from nearby monitoring locations, taking into consideration the relative catchment sizes and ground conditions.
Low / Mean / High Flow	Low and mean flow figures have been calculated for each crossing point using the Institute of Hydrology Report No. 108: Low Flow Estimation in the United Kingdom. Using this method the derived annual low flow, Q_{95}, is the flow exceeded 95% of the year. The high flow figures quoted have been provided by the Drainage Design team. They represent the Q_{100} flow i.e. a high flow with a return period of 1 in 100 years, which has been calculated using either the Poots & Cochrane or Flood Estimation Handbook (FEH) method, dependent on catchment size and characteristics.
Bed Width / Channel Depth / Top of Bank Width **Bed Gradient**	Details of the channel dimensions have been provided by the Drainage Design team, who have undertaken topographic surveys of all affected watercourses. In addition to measuring the channel cross-section and gradient the survey teams photographed each watercourse and recorded basic information on watercourse type (field drain / minor / main / major), flow type (dead / slow / medium / fast / rapid) and nature of the channel (clean, no weeds / weeds and grass / stones / sand, mud, silt). Although some of this information is not presented within the datasheets it has been added to the GIS and used in the evaluation of impact significance.
Bed Material	Information on the bed material has come from a variety of sources and is therefore of varying detail. Where ecological or geomorphological surveys have been carried out information on the percentage composition of boulders / cobbles/ gravel / sand / silt & clay are presented. For the remaining watercourses (mainly minor drains and streams) broad estimates of the bed material have been made based on site photographs and the information gathered on channel nature during the drainage design topographic surveys.

Datasheet Field	Data Source
In-Channel / Bankside Vegetation	Information on the in-channel and bankside vegetation has come from a variety of sources and therefore is of varying detail. Where ecological surveys have been carried out more detailed information is presented. For the remaining watercourses (mainly minor drains and streams) broad estimates of the vegetation have been made based on site photographs and the information gathered on channel nature during the drainage design topographic surveys. The bankside vegetation descriptions have been broadly based on the RHS nomenclature.
Flood Risk	Flood risk modelling has been undertaken by the Drainage Design Team for a number of the larger rivers within the A5WTC study area. Mapping of the 1 in 100 year plus climate change floodplains has been produced from this modelling work. The floodplain mapping produced has been used to determine whether the proposed crossings are in a flood risk area. Where flood modelling has not been carried out data has been taken from the Rivers Agency Strategic Flood Mapping at: http://www.riversagencyni.gov.uk/index/stategic-flood-maps.htm
Fluvial Geomorphology	A phased fluvial geomorphology assessment has been carried out in the A5WTC study area. Firstly, a desk based review of the affected watercourses was undertaken, using the available mapping, aerial photography and site photos from the Drainage topographic survey work. Based on this review, watercourses that were unlikely to have any geomorphological / ecological interest, i.e. minor field drains, were screened out. The remaining watercourses were divided into two catergories: those requiring a site walkover and qualitative fluvial assessment by a geomorphologist, primarily the larger rivers and streams with significant fish interest, and those requiring qualitative assessment from site photographs collected by the Drainage Design survey team. Where applicable the desk study and field survey has been supplemented with information from the ecology River Habitat Survey. Further details of the locations assessed, the assessment methods and the results are provided in Technical Appendix 16C. A brief summary of the primary findings of the geomorphology assessment at each crossing location are presented in the individual datasheets.
Proposed Crossing Type	Information on culverts and bridges has been supplied by the Drainage Design and Structures teams respectively. Bridge information includes whether the structures will be constructed perpendicular or skewed to the watercourse channel, whether

Datasheet Field	Data Source
	the proposed structure is clear span, or where piers are proposed, the location of the piers in relation to the channel or floodplain. In the case of the culverts this includes whether they are circular pipe or box culverts, and also whether the structures will be constructed perpendicular or skewed to the watercourse channel.
Crossing Structure Dimensions	The Drainage Design team has provided details of the diameter of the pipe culverts and height and width of the box culverts. The Structures team has provided information on the span of the bridges, positions of any piers and clearance of the bridges above the 1 in 100 year plus climate change flood level.
Crossing Structure Length	The Drainage Design team has provided details on the length of each proposed culvert. This field does not apply to the bridge structures.
Aerial View	Each datasheet has an aerial image of the relevant crossing. Superimposed on the aerial image are the V3.1 Rev B highways alignment, V3.1 Rev B drainage design and watercourse centrelines.
Site Photograph	Each datasheet has a site photograph of the watercourse under consideration. The photographs were taken by the Drainage Design Team and are generally of the specific watercourse reach in question. In some instances where access was difficult the site photograph may be for a reach a short distance upstream or downstream. The photographs have been included to provide some basic information and context to the assessment

Watercourse Diversions

Data on the existing baseline conditions and the proposed diversions has been collated through consultation, desk study and field surveys as detailed below:

- A review of published maps and information;
- information provided by the Rivers Agency, NIEA Water Management Unit and other branches of the NIEA;
- information from and discussions with the A5WTC highways and environment teams, particularly the Drainage and Ecology disciplines;
- desk based and field based geomorphological assessments; and
- water quality monitoring.

This data has subsequently been entered into a GIS and individual datasheets produced for each watercourse diversion, which are presented later in this report. The data sources for each field in the datasheets are discussed in Section 4.1 below.

Also included in each datasheet is a summary of the mitigation measures which are required at that diversion location.

Datasheet Data Sources

Details of the information presented in the Watercourse Diversion Datasheets, and the sources of this information are given in Table 16B.11 below.

Table 16B.11 Datasheet Fields and Data Sources

Datasheet Field	Data Source
Diversion ID	
Grid Reference	National grid reference for the proposed diversion centroid
Watercourse ID	
WFD Waterbody ID	Unique ID assigned by NIEA under the Water Framework Directive, taken from the NIEA River Basin Plan Interactive Map at: http://maps.ehsni.gov.uk/wmuviewer.
Designations	Details of protected area designations taken from NIEA website at: http://www.ni-environment.gov.uk/protected_areas_home.html
WFD Class / Objectives	Current WFD Classification and objectives for 2015, 2021 and 2027 as published in December 2009, are taken from the NIEA River Basin Management Plan (RBMP) Interactive Map at: http://maps.ehsni.gov.uk/wmuviewer/. The RBMP map viewer shows only the rivers visible on the 1:50K OSNI base mapping as having been classified. For the purposes of this assessment it has been assumed that the classification of a river can be extrapolated and applied to all its tributary streams and drains. The status of heavily modified rivers is quoted in terms of ecological potential, in line with the WFD classifications systems used by the NIEA. Where the WFD class has been extrapolated the classification is annotated as shown: (e)
FFD Category	Details of Freshwater Fisheries Directive Designations (Salmonid / Cyprinid) taken from the NIEA River Basin Plan Interactive Map at: http://maps.ehsni.gov.uk/wmuviewer/. The description of the size of population supported has been derived by the A5 Ecology team, based on desk study and field survey work as discussed below.
Significant Species	Ecology data has been provided by the A5 Ecology team and has been gathered from both desk study and field survey work. Full details of the freshwater ecology work undertaken for the A5WTC scheme can be found in the Ecology Chapter of the Environmental

Datasheet Field	Data Source
River Habitat Survey	Statement and the supporting Technical Appendix 11B:Freshwater Fish Fauna. A brief summary of the studies undertaken is given below:
Biodiversity Value	• Desk studies including collation of historical survey records from the Loughs Agency (LA), NIEA and the Agri-Food and Biosciences Institute (AFBI); • River Habitat Surveys (RHS) and Fish Habitat Surveys (FHS); • Riverine Plants/Aquatic Macrophytes Survey; • Aquatic Macro-Invertebrate Surveys; • Electrofishing & Netting Surveys; and • Freshwater Pearl Mussel and White-Clawed Crayfish Surveys. Watercourses were selected for Stage 2 field survey following analysis of the desk study data. Those rivers receiving European protection as a SAC and/or identified as being a classified watercourse, either under the WFD or the FFD, were selected for RHS assessment as these rivers have been identified as being of significance for salmonids species. Further to this, any significant tributaries to these watercourses were also subject to RHS as these could have still contained significant habitat for salmonids despite not being classified. At Stage 2 a total of 47 watercourses were identified for RHS assessment, all other significant watercourses, with the exception of field drains, were subject to rapid assessment from “drive by” surveys and the presence of any notable culvert, weir or any other potential barrier to fish migration was noted. Following the Stage 2 assessment a subset of 16 watercourse sites were identified for more detailed Stage 3 fish fauna survey and assessment. The ecology information presented in the datasheets within this report has been selected to provide a summary and broad overview of the baseline ecological condition of the affected watercourses. The **Significant Species** information has been derived from both the desk study and field surveys.

Datasheet Field	Data Source
	The **River Habitat Survey** is a method designed to characterise and assess, in broad terms, the physical structure of freshwater rivers, which has been developed in collaboration by the Environment Agency (EA), Scottish Environmental Protection Agency (SEPA) and NIEA. RHS is undertaken along 500m lengths of river channel, with observations / target notes on flow structure, physical features in the channel and on the banks, substrates, vegetation characteristics and land use in the river channel made at ten equally spaced spot-checks along the channel. An overall assessment of the reach, with valley form, artificial structures, etc. is also made. The information gathered from the RHS can be used to identify the diversity and naturalness of the riverine habitat through completion of a Habitat Quality Assessment (HQA) and the level of modification identified through completion of a Habitat Modification Score (HMS), which can identify the corresponding Habitat Modification Class. **HQA** – the HQA scores do not have a specific grading as per the HMS (see below), rather the score indicates the geomorphological quality and diversity of the habitat. The higher the score, the more diverse the watercourse with more habitat 'pockets' (i.e. a variety of substrates, flow and bank conditions), the lower the score the more uniform the channel, with flow structure dominated by one flow type and one substrate with uniform bank structure (e.g. slope and vegetation type). **HMS** – the HMS scoring system is graded dependant upon the level of modification ranging from 'Pristine / Semi-natural' through to 'Severely Modified' as shown below.

HMS Score	HMS Modification Class
0 – 16	Pristine / semi-natural
17 – 199	Predominantly unmodified
200 – 499	Obviously modified
500 – 1399	Significantly modified
1400 +	Severely modified

The **Biodiversity Value** has been based on the evaluation guidelines published by the Institute of Ecology and Environmental Management (IEEM) which provide information on how the relative value and importance of a species can be determined and states

<table>
<tr><th>Datasheet Field</th><th>Data Source</th></tr>
<tr><td></td><td>that the value of a species should be measured against published selection criteria where available. In addition, when valuing a species reference should also be made to UK and Local BAPs and subsequent Species Action Plans (SAPs). The evaluation criteria distinguishes between the biodiversity value of a receptor and it's legal status. For the purposes of the ecology assessment each population has been assessed as valuable, or potentially valuable, based on the following geographic frame of reference:

<table>
<tr><th>Biodiversity Value</th><th>Description</th></tr>
<tr><td>International</td><td>a population warranting designation as a SAC and/or of significant conservation status for Europe</td></tr>
<tr><td>National</td><td>a population warranting designation as a Site of Special Scientific Interest (ASSIs) and/or of significant conservation status for NI</td></tr>
<tr><td>County</td><td>a population warranting designation as a Site of Local Nature Conservation Importance (SLNCI) of county significance e.g. of significance for County Tyrone</td></tr>
<tr><td>District</td><td>a population of significant conservation status for the local districts</td></tr>
<tr><td>Local</td><td>a population of significant conservation status within a local context (i.e. within ~5 km of the proposed works areas)</td></tr>
<tr><td>Less than local</td><td>a population of significance for the immediate survey site only</td></tr>
</table>
</td></tr>
<tr><td>Temp / Cond / pH / DO / TSS</td><td>Water quality data on the following parameters are presented in the datasheets: temperature, conductivity, pH, dissolved oxygen and total suspended solids.

Water quality data has been derived from a number of sources. Long term monitoring data for the major rivers within the study area has been provided by NIEA. This data has been supplemented with monthly monitoring carried out by Mouchel between November 2009 and May 2010 at 28 locations. These locations were selected to 'fill in the gaps' in the NIEA coverage, and are concentrated on the larger tributary streams that the A5WTC route crosses. Details of the monitoring programme, the water quality results and a comparison with the NIEA long term monitoring data are provided in the Technical Appendix 16G: Water Quality Monitoring. In</td></tr>
</table>

Datasheet Field	Data Source
	addition in-situ one-off monitoring was carried out by the ecologists whilst undertaking the various freshwater ecology surveys. The water quality data quoted in the individual datasheets is generally taken from the closest monitoring location to the diversion under consideration and average figures have been derived from the dataset used i.e. NIEA or Mouchel data. In some instances there are no monitoring data available for the particular watercourse or reach being crossed. In these cases the water quality data has been extrapolated from nearby monitoring locations, taking into consideration the relative catchment sizes and ground conditions.
In-Channel / Bankside Vegetation	Information on the in-channel and bankside vegetation has come from a variety of sources and therefore is of varying detail. Where ecological surveys have been carried out more detailed information is presented. For the remaining watercourses (mainly minor drains and streams) broad estimates of the vegetation have been made based on site photographs and the information gathered on channel nature during the drainage design topographic surveys. The bankside vegetation descriptions have been broadly based on the RHS nomenclature.
Bed Material	Information on the bed material has come from a variety of sources and is therefore of varying detail. Where ecological or geomorphological surveys have been carried out information on the percentage composition of boulders / cobbles/ gravel / sand / silt & clay are presented. For the remaining watercourses (mainly minor drains and streams) broad estimates of the bed material have been made based on site photographs and the information gathered on channel nature during the drainage design topographic surveys.
Low / Mean / High Flow	Low and mean flow figures have been calculated for each diversion location using the Institute of Hydrology Report No. 108: Low Flow Estimation in the United Kingdom. Using this method the derived annual low flow, Q_{95}, is the flow exceeded 95% of the year. The high flow figures quoted have been provided by the Drainage Design team. They represent the Q_{100} flow i.e. a high flow with a return period of 1 in 100 years, which has been calculated using either the Poots & Cochrane or Flood Estimation Handbook (FEH) method, dependant on catchment size and characteristics.
Flood Risk	Flood risk modelling has been undertaken by the Drainage Design Team for a number of the larger rivers within the A5WTC study area. Mapping of the 1 in 100 year plus climate change floodplains has been produced from this modelling work. . The floodplain

Datasheet Field	Data Source
	mapping produced has been used to determine whether the proposed diversions are in a flood risk area. Where flood modelling has not been carried out data has been taken from the River's Agency Strategic Flood Mapping at: http://www.riversagencyni.gov.uk/index/stategic-flood-maps.htm
Fluvial Geomorphology	A phased fluvial geomorphology assessment has been carried out in the A5WTC study area. Firstly, a desk based review of the affected watercourses was undertaken, using the available mapping, aerial photography and site photos from the Drainage topographic survey work. Based on this review, watercourses that were unlikely to have any geomorphological / ecological interest i.e. minor field drains were screened out. The remaining watercourses were divided into two catergories: those requiring a site walkover and qualitative fluvial assessment by a geomorphologist, primarily the larger rivers and streams with significant fish interest, and those requiring qualitative assessment from site photographs collected by the Drainage Design survey team. Where applicable the desk study and field survey has been supplemented with information from the ecology River Habitat Survey. Further details of the locations assessed, the assessment methods and the results are provided in Technical Appendix: Geomorphology Assessment. A brief summary of the primary findings of the geomorphology assessment at each diversion location are presented in the individual datasheets.
Current Reach Length / Bed Gradient / Top of Bank Width / Bed Width / Channel Depth	Details of the existing channel dimensions have been provided by the Drainage Design team, who have undertaken topographic surveys of all affected watercourses. In addition to measuring the channel cross-section and gradient the survey teams photographed each watercourse and recorded basic information on watercourse type (field drain / minor / main / major), flow type (dead / slow / medium / fast / rapid) and nature of the channel (clean, no weeds / weeds and grass / stones / sand, mud, silt). Although some of this information is not presented within the datasheets it has been added to the GIS and used in the evaluation of impact significance.
Proposed Diversion Reach Length / Bed Gradient /	Information on the proposed diversion channel design has been provided by the Drainage Design Team. The channel cross-sectional information is a representative average for the whole diversion. Multiple bed gradients have been provided for diversion channels where significant changes in gradient occur along the diversion reach. These are typically where a culvert is incorporated

Datasheet Field	Data Source
Top of Bank Width / Bed Width / Channel Depth	into the diversion.
Comment	Short discussion on the planform design of the proposed channel, differences in existing and channel dimensions and potential impacts as a consequence of changes.
Aerial View	Each datasheet has an aerial image of the relevant diversion. Superimposed on the aerial image are the V3.1 Rev B highways alignment, V3.1 Rev B drainage design and watercourse centrelines.
Site Photograph	Each datasheet has a site photograph of the watercourse under consideration. The photographs were taken by the Drainage Design Team and are generally of the specific watercourse reach in question. In some instances where access was difficult the site photograph may be for a reach a short distance upstream or downstream. The photographs have been included to provide some basic information and context to the assessment

Fluvial Geomorphological Assessment

An initial desk-based fluvial geomorphological assessment of all watercourse crossings, discharge points and diversions affected by the proposed A5 route was undertaken by looking at aerial and ground-based photographs and maps to assess the potential impact to the morphology of the watercourses and the geomorphological processes operating within them. This exercise was undertaken to reduce the number of sites to be visited in the field. Sites where it was assessed that there would be no significant impact to the fluvial geomorphology of the watercourses and no impact to the scheme, such as small field drains with minimal flow and no evidence of instability were ruled out from further investigation.

This resulted in a total of 46 sites which showed evidence of instability or where it was not possible to make a definite conclusion from the desk-based studies to be assessed in the field, 23 of these were to be visited by an experienced geomorphologist to assess the geomorphological sensitivity of these watercourses. The watercourses tended to show planimetric evidence of instability or evidence of erosion and deposition and were considered to be more geomorphologically sensitive than the remaining sites. These watercourses tended to be the larger watercourses or watercourses in steeper environments where they would have more energy and be potentially more unstable. Extensive and detailed photographs of the remaining sites were taken and the photographs reviewed by the experienced geomorphologist. These sites were ones where they showed some instability, but tended to be small watercourses or on low gradient ground where they would not be as dynamic.

At each of the 23 sites, the watercourses were walked upstream and downstream from the potential point of impact. The distance walked being dependent on the size of the watercourse, its geomorphological sensitivity and the nature of the potential impact. Typically, a distance of 100 metres up and downstream was walked for small watercourses with low geomorphological sensitivity, while for larger watercourses, with greater geomorphological sensitivity, a distance of 500 metres up and downstream was walked. Investigation up and downstream of the point of interest allowed it to be put in context in relation to the whole watercourse.

A detailed digital photographic library was taken at each site and the nature of the watercourse and surrounding land recorded including the channel morphology, bed and bank material, degree of vegetation, sinuosity, braiding, evidence of erosion and deposition and land use. Any evidence of historic channel change was recorded including palaeochannels, terraces and raised bars. These features provide an indication of the sensitivity and dynamism of the watercourse.

In the case of diversions, the area in which the new diversion channel is to be created was investigated to determine if the slope is similar to the existing channel and how the local topography and material may respond to the presence of a watercourse. Any slight change to the nature of the watercourse could result in erosion or deposition, which could have significant impacts on how the watercourse may behave in proximity to the road and impact downstream.

The field assessment was undertaken from the 14th to 18th of June 2010 and the site visits where only photographs were taken was conducted on the 28th and 29th of June. Both trips occurred during a prolonged warm dry spell when flow in all of the watercourses investigated, was very low. The qualitative survey identified that no further information relevant to this geomorphological investigation would be gleaned from quantitative investigations.

Many of the watercourses were only walked along one bank due to access restrictions and the high density of the vegetation. It was not possible to view the bed of a small number of the watercourses due to the depth of flow. The diversion areas were investigated closely to determine how re-routing the watercourses will affect these areas and how the characteristics of these areas will impact the watercourses.

Abstractions Survey

The information collected from the desk study regarding private abstractions (surface and groundwater) in the vicinity of the route required validation. In order to do so, a questionnaire was sent to all land owners whose parcels of land were potentially at risk of being impacted should they contain a private water abstraction. The area of interest within which questionnaires was issued was defined based on the available information on the hydrogeology of the route and road construction (principally cuttings). Information was requested from landowners on the type of abstraction they had, if any, water volumes, quality and uses.

785 survey questionnaires were issued in April 2010 and responses were collated until 6th August 2010. This information was supplemented by information gathered during mitigation meetings during the same period. Where the information in the returned survey forms was unclear or incomplete follow-up phonecalls were made.

In total, the information received from the survey forms, follow-up phonecalls and mitigation meetings gave 40% coverage of the original area of interest. This data was then used to update the historical abstraction information in the GIS to make the information available for the assessments. Further information on the abstractions is expected to be received by future mitigation meetings, further ground investigation and groundwater monitoring. This will be taken into account for the detailed design of the road.

Assessment of Impact of Road Cuttings

The road cuttings have the potential to affect groundwater flow and aquifer vulnerability. An assessment was therefore undertaken on each cutting in the proposed route to assess the potential impacts.

The location of each road cutting along the route was identified and the maximum depth, geology and depth to groundwater of each was established using GIS, GI and monitoring data. The receptors in the vicinity of each cutting which could potentially be impacted. The primary concern being groundwater and aquifer vulnerability but also groundwater fed wetlands, streams, rivers, springs and wells were identified.

In order to determine the likely impact of the cuttings on groundwater receptors, a distance/area of influence was estimated for each cutting. Permeability of the superficial geology and bedrock geology was estimated using a combination of field test data, information from logs and generic hydrogeological properties of rock types. Where a cutting penetrated both drift and bedrock, the more permeable stratum was used for the assessment.

There is no published formula to calculate a distance of influence of road cuttings. The method for estimating the distance of influence of individual road cuttings was based on the empirical formula for calculating the radius of influence of groundwater abstractions from CIRIA guidance 515, Sichardt equation (Powers, 1992):

$$L = \sqrt{}K*(H-h)*x$$

Where:

L – distance/radius of influence, K = permeability, H-h = groundwater table draw-down, i.e. penetration of cutting beneath water table, x = 2000

Only approximate distance of influence, and not predicted input of flow, has been calculated as detailed ground investigation has not been undertaken to estimate this.

To assess the potential risks to groundwater a DMRB significance rating was assigned to each cutting. This significance rating relates the importance of the groundwater receptors against the magnitude of the change of groundwater flow conditions (Section 4.5).

The impact of the cuttings on the groundwater abstractions identified from the abstractions survey was then determined. In order to be conservative, or where no hydrogeological information was available for a cutting, a buffer zone was defined for each cutting based on location specific professional judgement using conservative distances of possible impacts, also taking into account that road cuttings may have the effect of cutting off parts of the catchment of groundwater receptors (wells, wetlands, pond), which could lead to a reduced or a more variable water supply.

Flood Risk

The A5WTC flood risk assessment has been carried out in accordance with the following legislation and guidance:

- Planning Policy Statement 15 (PPS 15) – Planning and Flood Risk
- DMRB Vol. 11 Section 3, Part 10 Road Drainage and the Water Environment
    - Method E – Hydrological Assessment of Design Floods
    - Method F – Hydraulic Assessment
- Rivers Agency guidance and documents:
    - Guidelines for Road Schemes
    - Guidance on Flood Risk Assessment
    - Guidance on Floodplain Storage Compensation
- CIRIA Report C624 - Development and Flood Risk – Guidance for the Construction Industry

A phased approach has been taken to the assessment of flood risk impacts. A preliminary assessment was undertaken to determine where there was a potential for impact from flooding. The following data has been collated from consultation with the statutory consultees and from desk study and has informed the preliminary assessment:

- Strategic Flood Mapping – published by the Rivers Agency
- Historic flooding data – historic flood mapping provided by the Rivers Agency and data from newspaper and library archives
- Flood defence data – data on existing flood defences has been provided by the Rivers Agency
- Alluvium mapping – the location and extent of alluvial deposits were extracted from GSNI drift geology mapping. Alluvium deposits depict the extent of flood plains arising from long-term historical flooding.
- Existing flood risk assessment reports and models
- Historic river flow and tidal data
- Topographic data – high resolution DTM and LIDAR data has been utilised

- Detailed aerial photography
- Hydrological catchment boundaries and descriptors - taken from the Flood Estimation Handbook

Using this data potential floodplains that will be crossed or impinged upon by the proposed route have been identified. The A5 WTC study area incorporates both fluvial and tidal systems; therefore, this assessment considers those areas at risk of flooding during a 100 year return period event (Q100) for rivers, and during a 200 year return period event for tidal extents.

Where potential flood risk impacts have been identified further assessment of these areas was then carried out through hydraulic modelling. Flooding mechanisms and impacts are specific to each individual floodplain location and thus the application of a variety of hydraulic modelling techniques has been used. Hydraulic models may be one, two or three dimensional with steady or unsteady flows and built using software packages such as HEC-RAS, ISIS or MIKE 11. In general the hydraulic modelling has involved:

- Site inspections of all proposed modelling locations were undertaken to confirm the location and nature of the various watercourses, gain an appreciation of catchment characteristics (steepness, land use, etc), confirm model extents and determine the appropriate channel and floodplain roughness (Manning's n) coefficients to be applied to the hydraulic model.
- detailed topographical survey of model cross sections and any hydraulic control (bridges, culverts, etc).
- catchment analysis and design flow estimation
- model build, calibration and sensitivity analysis

The hydraulic models have been used to identify the flood plains and flood water levels for a range of return periods up to and including the 100 year (plus climate change allowance) event for the existing site conditions and with the proposed road scheme in place. Through comparison of these results the following potential impacts can be identified:

- Afflux – Afflux is the increase in upstream water level caused by a restriction in flow
- Loss of Floodplain Storage - In relation to the location of a road within a floodplain,
- Impediment of Water Flows - The construction of a new road forms a barrier that may cross existing drainage routes, causing potential blockage and altering local catchment areas and boundaries.
- Potential Increase in Flood Risk – it is identified that there is a potential to impact flood water levels, thus increasing flood risk both within the vicinity of the development and elsewhere in the catchment.

Where these impacts are identified mitigation measures have been devised, such ensuring appropriate sizing of bridges and culverts, the introduction of flood relief culverts and flood plain storage compensation areas. The hydraulic modelling is re-run with these mitigation measures incorporated and a further set of flood plain extents and flood water levels calculated to ensure that the proposed mitigation is effective and appropriate, in reducing the flood risk to pre-development levels. Finally the overall significance of flood impact is evaluated in accordance with the DMRB guidance. The tables below illustrate the method adopted for estimating the importance of the floodplain attributes and the magnitude of impact on flood risk.

Assessment of Significance

The predicted significance of impacts in relation to surface waters, groundwater, abstractions and peatlands has been based on the importance of the relevant attribute and the magnitude of the impact.

Groundwater and Surface Water Attributes and indicators of quality

Groundwater and surface water (rivers/streams) attributes and indicators of quality are summarised in Table A4.1 in the DMRB, Volume 11, Section 3, Part 10; this is replicated in Table 16B.12.

Table 16B.12 Groundwater and Surface Water: Attributes and Indicators of Quality

Attribute	Indicator of Quality	Possible Measure
Groundwater		
Water Supply/Quality	Amount used for water supply (potable/industrial/agricultural)	Location and number of abstraction points Volume abstracted daily Location and grade of source protection zone WFD groundwater quantitative and chemical status
Soakaway	Presence of soakaways or other discharges to the ground	Location and number of discharge points Daily volume discharged
Vulnerability	Groundwater vulnerability	Classification of aquifer vulnerability
Economic Value	Extent of use for abstractions	Number of people employed
Conveyance of Flow	Presence of groundwater supported water courses Potential for groundwater flooding Groundwater interception by road structures or drainage	Changes to groundwater recharge, levels or flows Number and size of water courses

Attribute	Indicator of Quality	Possible Measure
Biodiversity	Presence of groundwater supported wetlands	Changes to groundwater recharge, levels or flows Status or classification of wetland
River/Stream		
Water Supply/Quality	Amount used for water supply (potable/industrial/agricultural) (potable)	Location and number of abstraction points Volume abstracted daily WFD chemical status class
Dilution and Removal of Waste Products	Presence of surface water discharges Effluent discharges	Daily volume of discharge (treated/untreated)
Recreation	Access to river Use of river for recreation	Length of river used for recreation (fishing, water sports) Number of clubs
Value to Economy	Value of use of river	Length of river used for recreation commercially Number of people employed Length of river bank developed / fished commercially
Conveyance of Flow	Presence of water courses	Number and size of water courses
Biodiversity	Biological Water Quality Fisheries quality	WFD ecological status class Fisheries Status as defined in the Freshwater Fish Directive

Significance Criteria

The predicted significance of impacts in relation to surface and groundwater has been based on the importance of the relevant watercourse and its attributes and the magnitude of the impact from the proposed discharge diversion.

Importance has been evaluated taking into account quality, rarity, scale and sustainability of the attribute. Table A4.3 in the DMRB, Volume 11, Section 3, Part 10 provides guidance relating to the estimation of importance, this guidance is replicated in Table 16B.13.

Table 16B.13 Estimating the Importance of Water Environment Attributes

Importance	Criteria	Examples
Very High	Attribute with a high quality and rarity on a national or regional scale	- WFD High Class river - EC designated Salmonid / Cyprinid fishery - Site protected under EU or UK wildlife legislation (SAC, SPA, ASSI, Ramsar sites) - Principal aquifer providing regionally important resource or supporting a site protected under habitat legislation - Floodplain or defence protecting more than 100 residential properties from flooding
High	Attribute with a high quality and rarity on a local scale	- WFD Good Class river - EC designated Cyprinid fishery - Principal aquifer providing locally important resource - Floodplain or defence protecting between 1 and 100 residential or industrial properties from flooding
Medium	Attribute with a medium quality and rarity on a local scale	- WFD Moderate Class river - Aquifer providing abstraction water for agricultural or industrial use - Floodplain or defence protecting 10 or fewer industrial properties from flooding
Low	Attribute with a low quality and rarity on a local scale	- WFD Poor Class river - Non aquifer - Floodplain with limited development and a low probability of flooding residential and industrial properties

Impact Magnitude has been evaluated taking into account the quality, rarity, scale and sustainability of the attribute. Table A4.4 in the DBRB, Volume 11, Section 3, Part 10 provides guidance relating to the estimation of importance, this guidance is replicated in Table 16B.14.

Table 16B.14 Estimating the Magnitude of an Impact on a Water Environment Attribute

Magnitude	Criteria	Examples
Major Adverse	Results in loss of attribute and/or quality and integrity of the attribute	- Failure of both soluble and sediment bound pollutants in HAWRAT and compliance failure with EQS values - Risk of pollution from accidental spillage >2% annually - High risk of pollution to groundwater from routine runoff - Loss or extensive change to a fishery - Increase in peak flood level (1% annual probability) >100mm
Moderate Adverse	Results in loss of part of attribute, or effect on quality and integrity of the attribute	- Failure of both soluble and sediment bound pollutants in HAWRAT but compliance with EQS values - Risk of pollution from accidental spillage >1% annually - Partial loss in productivity of a fishery - Medium risk of pollution to groundwater from routine runoff - Increase in peak flood level (1% annual probability) >50mm
Minor Adverse	Results in some measurable change in attributes quality or vulnerability	- Failure of either soluble or sediment bound pollutants in HAWRAT - Risk of pollution from accidental spillage >0.5% annually - Low risk of pollution to groundwater from routine runoff - Increase in peak flood level (1% annual probability) >10mm
Negligible Adverse	Results in effect on attribute, but of insufficient magnitude to affect the use or integrity	- No risk identified by HAWRAT - Risk of pollution from accidental spillage <0.5% annually

Magnitude	Criteria	Examples
		- No measurable impact upon an aquifer - Negligible effect in peak flood level (1% annual probability) +/- 10mm

The prediction of the significance of the identified impacts has been arrived at by combining the estimated importance of the affected attributes and the magnitude of the impacts using the matrix recommended in Table A4.5 of the DBRB, Volume 11, Section 3, Part 10, which is replicated in Table 16B.15. Where the significance is shown as being one of two alternatives a single description is provided based upon reasoned judgement.

Table 16B.15 Estimating the Significance of Potential Effects

Importance of Attribute	Magnitude of the Impact			
	Major	**Moderate**	**Minor**	**Negligible**
Very High	Very Large	Large / Very Large	Moderate / Large	Neutral
High	Large / Very Large	Moderate / Large	Slight / Moderate	Neutral
Medium	Large	Moderate	Slight	Neutral
Low	Slight / Moderate	Slight	Neutral	Neutral

Typical examples of potential beneficial/adverse effects are described in Table 16B.16. This table is based upon Table 4.6 taken from the DMRB Volume 11, Section 3, Part 10 Annex IV and indicates the qualifying conditions for overall assessment scores.

Table 16B.16 Re-produced Table A4.6 From DMRB Volume 11, Section 3, Part 10, Annex IV 'Qualifying Conditions for Overall Assessment Scores'

Score	Comment
Very Large Adverse	Where the proposal would result in degradation of the water environment because it results in predicted very significant adverse impacts on at least one water attribute. More than one attribute may be affected by a single project and each should be assessed and reported separately. for example: **Surface water** • potential failure of both soluble and sediment-bound pollutants in a high or good watercourse or in an EC designated salmonid fishery, for both short-term and long-term assessment (methods a and b); • loss or extensive change to a site/habitat protected under EC or UK legislation (SAC, SPA, RAMSAR SITE, SSSI, WPZ salmonid water); and • calculated risk of pollution from spillages is >2% when discharging into a good watercourse, >1% for a high watercourse. **Groundwater** • potential high risk (risk score >250) of pollution in the groundwater assessment (method c, annex I) to a principal aquifer providing a regionally important resource or supporting a site protected under habitat legislation or a medium to high risk (risk score >150) to a spz1; • calculated risk of pollution from spillages is >1% when discharging into a spz1 or principal aquifer; • potential loss or extensive change to a site/habitat protected under EC or UK legislation (s SAC, SPA, RAMSAR SITE, SSSI, WPZ salmonid water) through interception of groundwater flow or significant change to groundwater level flood risk; and • an increase in peak flood levels (1% annual probability) >100 mm increasing the risk of flooding to >100 residential properties
Large Adverse	Where the proposal would result in a degradation of the water environment because it results in predicted highly significant adverse impacts on a water attribute. More than one attribute may be affected by a single project and each should be assessed and reported separately. for example: **Surface water** • potential short-term (HAWRAT) failure of both soluble and sediment-bound pollutants in a high or good watercourse or in an EC designated salmonid fishery; • calculated risk of pollution from spillages is >1% for a good watercourse (or one of lower ecological class) and >0.5% for a

<table>
<tr><th>Score</th><th>Comment</th></tr>
<tr><td></td><td>high watercourse;

• loss or extensive change to a cyprinid fishery; and

• loss or extensive change to a local nature reserve;

Groundwater

• potential high risk (risk score >250) of pollution to a secondary aquifer providing water for a small number of dwellings, agricultural or industrial use and/or supporting local nature reserves aquifer or medium risk (risk score 150-250) of pollution of a principal aquifer providing a locally important resource or supporting a site protected under habitat legislation, or medium to high risk (score >150) to a spz2, or potential low risk (score <150) to a spz1:

• calculated risk of pollution from spillages is >0.5% when discharging to a principal

aquifer or spz1; and

• loss or extensive change to a local nature reserve through interception of groundwater flow or change to groundwater level.

Flood risk

• an increase in peak flood levels (1% annual probability) >50 mm increasing the risk of flooding to >100 residential properties or an increase of >100 mm increasing the risk of flooding to 1-100 residential properties</td></tr>
<tr><td>Moderate Adverse</td><td>Where the proposal may result in the degradation of the water environment because it results in predicted moderate adverse impacts on at least one attribute. More than one attribute may be affected by a single project and each should be assessed and reported separately. for example:

Surface water

• potential short-term (HAWRAT) failure of either soluble or sediment-bound pollutants in a high or good watercourse;

• calculated risk of pollution from spillages is >0.5% for a good watercourse or >1% for a moderate or poor watercourse;

• partial loss or change to a fishery; and

• effect on the integrity of the existing flora and fauna.

Groundwater

• potential medium risk (score 150-250) to a secondary aquifer providing water for a small number of dwellings, agricultural or industrial use and/or supporting local nature reserves or potential low risk (score <150) of pollution to a principal aquifer providing a regionally important resource or supporting a river ecosystem or medium to high risk (score >150) to a spz3, or</td></tr>
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Score	Comment
	potential low risk (score <150) to a spz2, or high risk (score >250) for a discharge to unproductive strata: • calculated risk of pollution from spillages is >1% for an aquifer or spz3; and • effect on the integrity of the existing flora and flora through interception of groundwater flow or change to groundwater level. **Flood risk** • an increase in peak flood level (1% annual probability) >10 mm resulting in an increased risk of flooding to >100 residential properties or an increase of >50 mm resulting in an increased risk of flooding to 1-100 residential properties.
Slight Adverse	Where the proposal may result in a degradation of the water environment because it results in a predicted slight impact on one or more attributes. More than one attribute may be affected by a single project and each should be assessed and reported separately. for example: **Surface water** • potential short-term (HAWRAT) failure of either soluble or sediment-bound pollutants in a moderate or poor watercourse; • calculated risk of pollution from spillages is >0.5% for a moderate or poor watercourse; and • temporary loss to, or loss in productivity of, a fishery. **Groundwater** • potential low risk of pollution (score <150) to a secondary aquifer with limited agricultural use and connectivity to surface waters and local ecology or low to medium risk (score <250) for a discharge to unproductive strata, or low risk (score <150) to a spz3; and • calculated risk of pollution from spillages is >0.5% for an aquifer or spz3. **Flood risk** • an increase in peak flood level (1% annual probability) >10 mm resulting in a increased risk of flooding to fewer than 10 industrial properties.
Neutral	Where the net impact of the proposals is neutral, because it results in no appreciable effect, either positive or negative, on the identified attribute. More than one attribute may be affected by a single project and each should be assessed and reported separately. for example:

Score	Comment
	Surface water • no risk identified by method a or method b assessment (pass both soluble and sediment-bound pollutants); and • calculated risk of pollution from spillages <0.5% annually. **Groundwater** • no predicted change in quality of any type of aquifer and/or its use as a resource; and • calculated risk of pollution from spillages <0.5% annually. **Flood risk** • negligible change in peak flood (1% annual probability) <+/- 10 mm
Slight Beneficial	All other situations where the proposal provides an opportunity to enhance the water environment or provide an improved level of protection to an attribute. More than one attribute may be affected by a single project and each should be assessed and reported separately. for example: **Surface water** • method a assessment of either soluble or sediment-bound pollutants becomes pass from previous fail condition for **existing** discharges; and

Score	Comment
	• reduction by 50% or more in **existing** pollution risk from spillages into high to poor watercourses (when existing spillage risk is <1%). **Groundwater** • reduction by 50% or more in **existing** pollution risk from spillages into an aquifer (when existing spillage risk is <1%) **Flood risk** • a reduction in peak flood level (1% annual probability) >10 mm resulting in a reduced risk of flooding to 1-100 residential properties
Moderate Beneficial	Where the proposal provides an opportunity to enhance the water environment because it results in a moderate improvement for an attribute. More than one attribute may be affected by a single project and each should be assessed and reported separately. for example: **Surface water** • method a assessment of both soluble and sediment-bound pollutants becomes pass from previous refer or fail condition for **existing** discharges • reduction by 50% or more in likelihood of pollution to watercourses from spillages from **existing** discharges through retrofitting of pollution control to outfalls into a high to poor watercourse (existing risk >1%); and • recharge of aquifer through provision of treated discharges to ground resulting in measurable improvements to a connected site/habitat of local nature conservation value i.e. local nature reserve.

Score	Comment
	Groundwater • reduction by 50% or more in **existing** likelihood of pollution arising from a spillage to an aquifer through retrofitting of pollution control (existing risk >1%). **Flood risk** • a reduction in peak flood level (1% annual probability) >10 mm resulting in a reduced risk of flooding to >100 residential properties or a reduction of >50 mm resulting in a reduced risk of flooding to 1-100 residential properties.
Large Beneficial	it is extremely unlikely that any proposal incorporating the construction of a new or improved trunk road would fit into this category. However, proposals could have a large positive impact if it is predicted that it will result in a 'very' or 'highly' significant improvement to a water attribute(s), with insignificant adverse impacts on other water attributes. more than one attribute may be affected by a single project and each should be assessed and reported separately. for example: **Surface water** • removal of an existing polluting discharge through provision of pollution prevention measures, or any other measure, affecting a site/habitat protected under EC or UK legislation (SAC, SPA, RAMSAR SITE, SSSI, WPZ salmonid water); and • reduction by 50% or more in the existing likelihood of pollution arising from a spillage affecting a site/habitat protected under EC or UK legislation (SAC, SPA, RAMSAR SITE, SSSI, WPZ, salmonid water) where existing risk >1% **Groundwater** • removal of an existing polluting discharge within zone 1 and 2 of a SPZ and/or a principal aquifer; • reduction by 50% or more in the existing likelihood of pollution arising from a spillage at discharge points within zone 1 or 2 of a SPZ principal aquifer and/or a site supporting a habitat protected under habitat legislation (existing risk >1%); and • recharge of aquifer through provision of treated discharges to ground resulting in measurable improvements to a connected site/habitat protected under EC or UK legislation (SAC, SPA, RAMSAR SITE, SSSI, WPZ, salmonid water). **Flood risk** • a reduction in peak flood levels (1% annual probability) >50 mm reducing the risk of flooding to >100 residential properties or a reduction of >100 mm resulting in a reduced risk of flooding to 1-100 residential properties.