A9.5 Water Quality – Road Drainage Assessment

1 Introduction

1.1.1 This appendix contains additional information to inform the water quality assessment of the proposed scheme and should be read in conjunction with Chapter 9 (Water Environment). The methodologies and supporting calculations are presented in this appendix, whilst the assessment of the magnitude and significance of impacts and any subsequent requirements for mitigation are presented in Chapter 9.

1.1.2 The approach and methods for calculating routine runoff and accidental spillage risk to waterbodies as a result of road drainage, during the longer-term operational phase of the scheme are explained in Section 3 (Impact Assessment Methodology) of this appendix. For watercourses proposed to receive road drainage, these assessments follow guidance within the DMRB HA 216/06 (Highways Agency et al., 2006). The spillage risk assessment for the Firth of Forth is also based on the DMRB HA 216/06 methodology. The purpose of the assessments is to determine whether mitigation in the form of Sustainable Drainage Systems (SUDS) or spillage containment is required, in accordance with the DMRB HA 216/06.

1.1.3 The DMRB HA 216/06 does not provide a method for calculating the potential impacts of routine road runoff to estuarine or coastal waters as it is recognised that such bodies of water normally provide much greater available dilution and dispersion than inland rivers, and experience more complex flow and mixing patterns not easily replicated by simple calculations.

1.1.4 However, a modification of the DMRB routine runoff calculation has been undertaken to provide an assessment of potential localised impacts from the proposed through-deck drainage to the Firth of Forth in the immediate area where the runoff will mix with the ambient water beneath the Main Crossing, as agreed with SEPA in March 2009.

1.1.5 This modified routine runoff assessment, as well as the accidental spillage risk assessment, are also referred to within the Reports to Inform an Appropriate Assessment for the Firth of Forth SPA, the Forth Islands SPA, Imperial Dock Lock, Leith SPA and the River Teith SAC. These reports are required by Article 6 of the Habitats Directive 92/43/EEC.

1.1.6 The waterbodies and existing drainage systems proposed to receive road drainage from the proposed scheme, as well as outfall locations and drainage areas are presented in Section 4 (Proposed Drainage Design). The calculation sheets for calculating routine runoff and accidental spillage risk to each waterbody are supplied in Section 5 (Routine Runoff Assessment Calculations) and Section 6 (Accidental Spillage Risk Assessment Calculations) respectively. These are based on the methodologies detailed below, and have informed the assessment of water quality as detailed in Section 9.4 (Potential Impacts) of Chapter 9 (Water Environment).

1.1.7 SEPA's water quality classification scheme tables are presented in Section 7 (SEPA Classification Schemes for Scotland) and have been used to inform the water quality baseline (Section 9.3: Baseline Conditions) of waterbodies within Chapter 9 (Water Environment).

1.1.8 The sediment plume modelling assessment methodology and results are detailed within Appendix A9.1 (Hydrodynamic Modelling).

2 Background to Potential Pollutants

2.1.1 Potential sources of road runoff contamination are diverse and may be generated from road construction works, traffic, maintenance (including the application of de-icing salts), accidental spillage and from other sources such as atmospheric deposition. Road-associated contaminants that are considered to have the greatest potential impact on receiving waters include suspended solids, hydrocarbons, metals, pesticides and herbicides, de-icing agents, nutrients and those arising from accidental spills. Some of the constituents in road drainage are toxic, persistent or bioaccumulative, as defined under the Water Framework Directive (WFD) (European Community, 2006a) and Dangerous Substances Directive (DSD) (European Community, 2006b).

2.1.2 The DSD introduced the concept of List I and List II substances, which were identified as substances to be eliminated and reduced, respectively, from discharges to the water environment. The WFD will fully supersede the DSD in 2013, and will include new measures to protect the water environment. Most of the substances identified in List I for the DSD will be 'Priority Substances' or 'Priority Hazardous Substances' under the WFD. The WFD also identifies 'Specific Pollutants' considered being discharged in significant quantities, which will include certain List II substances (SEPA, 2008). Monitoring of these substances against statutory Environmental Quality Standards (EQS) that exist for known constituents of road runoff will identify the measures and controls required to meet the WFD, i.e. that natural waterbodies must attain at least 'good ecological status' by 2015. Certain waterbodies may be designated as artificial/heavily modified and will have less stringent targets to meet, however these will still need to demonstrate 'good ecological potential' by 2015 (SEPA, 2002).

2.1.3 Although the pollutants present in road runoff are very diverse in form and origin, they can be grouped into categories (DMRB HA 216/06) as follows:

- insoluble (particulate contaminants likely to settle on the bed of the waterbody or become suspended within the water column);
- soluble (dissolved contaminants affecting water quality); and
- those arising from accidental spillage (which are concentrated).

2.1.4 The insoluble pollutants include vehicle oil and other hydrocarbons, and suspended solids (the solid fraction of the road runoff). Suspended solids are the main road runoff constituents requiring treatment due to the harmful physical effects they can have on aquatic habitats. Pollutants often attach to suspended solids leading to chronic pollution within a watercourse. Therefore by removing coarse solids and a significant proportion of the fine (insoluble) solids from the road discharge, it is understood to remove much of the potentially polluting load (Highways Agency et al., 2006).

2.1.5 The soluble pollutants group comprises dissolved metals, organic toxic substances such as most herbicides and pesticides, de-icing salt and alternative de-icing agents and nutrients. Some of these may enter the watercourse in relatively high concentrations, potentially causing localised acute impacts on the aquatic environment or could accumulate in the freshwater habitats and potentially cause long-term chronic damage to the organisms living in the river (e.g. heavy metals entering the watercourse through road drainage discharge).

2.1.6 Dissolved copper and total zinc are used as indicators of the level of impact as they are generally the main metal pollutants associated with road drainage and can be toxic to aquatic life in certain concentrations. Lead is not included as it has low solubility, and, when in its insoluble form, its low bioavailability means that biological impacts would not be anticipated. There is little information available on background levels of other pollutants in watercourses against which the effects of routine runoff can be assessed (Highways Agency et al., 2006).

2.1.7 The impacts of road drainage on the quality of the receiving waters were quantified by assessing the build up of dissolved copper, total zinc (freshwater) and dissolved zinc (marine) in routine runoff and the risk of accidental spillage in design year 2032 of the proposed scheme (assumed to be 15 years after scheme opening).

3 Impact Assessment Methodology

3.1 Introduction

3.1.1 The water quality impact assessment was carried out in accordance with the methods set out in the DMRB HA 216/06 (Highways Agency et al., 2006), taking cognisance of more recent research such as 'Pollutant Build up and Runoff on Highways; Expanding the Current Methodology for Additional Determinants' (Patel & Drieu, 2005).

3.1.2 Two separate calculations have been undertaken, as detailed below:

- pollution calculations (routine runoff assessment for all waterbodies apart from the Firth of Forth); and
- a spillage resulting in a serious pollution incident (accidental spillage risk assessment for all waterbodies).

3.1.3 The DMRB methodology for routine runoff calculations sets out assessment of the potential pollution in the receiving watercourse assuming a high rainfall event coinciding with a low flow event, i.e. 95-percentile flow (Q95) in the receiving watercourse (the flow that is expected to be exceeded 95% of the time). This calculation is based on the Environment Agency River Ecosystem classification system which uses 95-percentile EQS values for dissolved copper and total zinc. The DMRB states that for trunk road schemes in Scotland, the Scottish classification systems should be considered in such assessments. Consultation was undertaken with SEPA in October 2008, who advised that EQS relevant to Scotland were annual averages. Consequently, the routine runoff methodology has been modified to use a moderate flow – the Q50 (i.e. the flow that is expected to be exceeded 50% of the time) in the receiving watercourse which is more appropriate for considering potential exceedances of annual average EQS.

3.1.4 In addition, a routine runoff assessment is provided for assessment of the Main Crossing through-deck drainage to the Firth of Forth, which is partially based on the DMRB assessment, as detailed below.

3.1.5 The results of the assessments are provided in Section 5 (Routine Runoff Assessment Calculations) and Section 6 (Accidental Spillage Risk Assessment Calculations).

3.2 Routine Runoff Assessment Methodology (Operational Impacts) – Watercourses

3.2.1 Routine runoff is surface water collected as a result of rain falling on the road and draining into the highway drainage system. The resultant highway drainage water contains some of the pollutants deposited on the road surface. This does not include major pollution events resulting from spillages from vehicular collision, which is addressed in the accidental spillage risk assessment below.

3.2.2 The calculations assume that the pollutants are allowed to accumulate on the road surface for five days, with the build up rate being dependent on traffic flow. A proportion of the pollutants are then assumed to be washed off the road and into the receiving water during a 24 hour storm. The potential pollution in the receiving watercourse is calculated assuming a high rainfall event as per Figure A.1 in DMRB HA 216/06 (Highways Agency et al., 2006) coinciding with the Q50 flow in the receiving watercourse. The DMRB states that this calculated downstream concentration can then be compared to the statutory EQS that exist for known constituents of road runoff, such as dissolved copper and total zinc. These standards are in place to protect freshwater and marine aquatic life. The EQS values used are annual average concentrations as provided by SEPA in October 2008, in line with the DSD, and are listed in Table 3.1.

3.2.3 The assessment of routine runoff requires the following inputs:

- the upstream concentrations of dissolved copper and total zinc in each watercourse;
- an indication of receiving water's hardness;
- an estimate of the total impermeable area of road surface to be drained to each outfall;
- the runoff coefficient of the proposed scheme;
- traffic flow data;
- rainfall data;
- the Q50 flow of the receiving watercourse; and
- the relevant statutory EQS values for the receiving watercourse in order to protect freshwater and marine life (Table 3.1).

3.2.4 Where there was an absence of long-term monitoring data specific to the watercourses in the study area, the following approach was adopted, as prescribed in the DMRB guidance (and/or agreed with SEPA as indicated below).

- The upstream concentrations of dissolved copper and total zinc in each watercourse are assumed to be half the EQS (Highways Agency et al., 2006).
- Receiving water hardness for watercourses is assumed to be within the range of 50mg/l – 100mg/l as confirmed by SEPA in March 2009.
- The total impermeable area of road surface is calculated from the proposed scheme design (Table 4.1).
- The runoff coefficient of the proposed scheme is 0.75, which is a conservative value that takes into account losses such as ponding on the road surface (Maidment, 1993).
- Traffic flow data for design year 2032, provided by Jacobs Arup traffic modellers.
- Rainfall data were obtained from the DMRB HA 216/06 Figure A.1 Depth of Rain for Assessing Pollutant Runoff (Highways Agency et al., 2006).
- The Q50 in the receiving watercourses were estimated using methods detailed in the Flood Risk and Hydrology methodology (Appendix A9.2: Surface Water Hydrology for derivation of flows).
- Relevant EQS for dissolved copper and total zinc are provided in Table 3.1, taken from statutory guidance.

Table 3.1: Environmental Quality Standards for the Protection of all Freshwater and Marine Life

Parameter	Hardness Range (mg/l $CaCO_3$)	Freshwater EQS (µg/l) (annual average)	Marine EQS (µg/l) (annual average)
Dissolved Copper	0-50 50-100 100-250 >250	1 6 10 28	5
Total Zinc (freshwater) Dissolved Zinc (marine)	0-50 50-100 100-250 >250	8 50 75 125	40

SEPA (2004) Annex G - Environmental Quality Standards (EQS) List, Issue No. 1, October 2004

3.3 Routine Runoff Assessment Methodology (Operational Impacts) – Firth of Forth

3.3.1 For long span bridges crossing waterways, it is typical to drain surface water runoff directly through the deck to outfall from a high level to the waterbody below. Examples of this type of drainage system on crossings in the UK include the existing Forth Road Bridge and the Second Severn Crossing. Road runoff from the Main Crossing length of approximately 1,880m (ch4920 – ch6800) over the main Firth of Forth channel (from low water mark on the south shore to low water mark on the north shore) is proposed to discharge via through-deck drainage from a number of outfalls, on either side of the deck, similar to the existing drainage arrangements from the existing Forth Road Bridge.

3.3.2 An assessment has been undertaken to consider the potentially very localised impacts in the immediate area where the runoff will mix with the ambient water beneath the Main Crossing. The assessment has been undertaken for the current proposed design of outfall spacings at 15m; resulting in approximately 125 outfalls on either side of the bridge to drain runoff from the deck. In addition, a sensitivity assessment of outfall spacings at 20m, 25m and 30m along each side of the Main Crossing deck has also been carried out.

3.3.3 Diagram 3.1 shows the relative position of 15m mixing zones for six pipes spaced at 15m intervals along the deck. It is assumed that the mixing zones do not overlap and therefore all resultant pollutant concentrations within the Firth of Forth are independent to each zone.

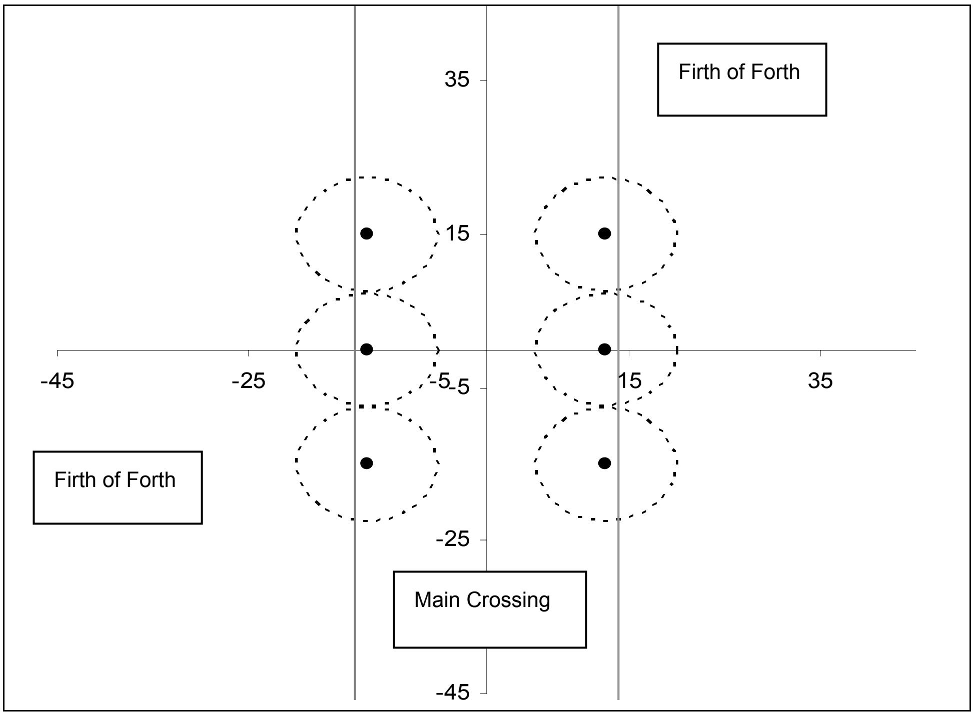

Diagram 3.1: Position of 15m mixing zones within the Firth of Forth for six pipes spaced at 15m

3.3.4 This assessment has limited the area of available dilution to the immediate surface layers of the Firth of Forth and surface current speeds in the location of the Main Crossing. To show the effects of available dilution, the resulting concentrations of dissolved copper and dissolved zinc are calculated within a 15m mixing zone of 0.5m depth. This assessment therefore uses onerous conditions to assess the potential localised impacts of road runoff prior to mixing in the wider Firth of Forth. As the mixing zone area increases, the available dilution is also expected to increase.

3.3.5 In line with the DMRB routine runoff assessment, the calculation assumes that the pollutants are allowed to accumulate on the road surface for five days, with the build up rate being dependent on traffic flow.

3.3.6 The assessment of routine runoff to the Firth of Forth requires the following inputs, as prescribed in the DMRB guidance (and/or agreed with SEPA as indicated below):

- The upstream concentrations of dissolved copper and dissolved zinc in the Firth of Forth were taken as 1.2µg/l and 3.1µg/l respectively using the annual average of several years of monthly chemical data provided in September 2008 by SEPA at Dog Rock upstream monitoring location (2000-2008).
- The total impermeable area of road surface is calculated from the proposed scheme design (Table 4.1).
- The runoff coefficient of the proposed scheme is 1.0 on the Main Crossing deck as it is generally assumed that nearly all rainfall that falls onto a bridge deck will become storm water runoff with only minor losses (NCHRP, 2002).
- It is assumed that the 5-day build up of pollutants are completely flushed off the deck after five minutes into the storm and therefore after five minutes, the runoff is free from pollutants. This is considered to be an onerous case scenario.
- Traffic flow data for design year 2032 (Chapter 4: The Proposed Scheme).
- Rainfall data were obtained from the DMRB HA 216/06 Figure A.1 Depth of Rain for Assessing Pollutant Runoff (Highways Agency et al., 2006).
- Relevant EQS for dissolved copper and dissolved zinc are provided in Table 3.1, taken from statutory guidance.

3.3.7 In addition, the following inputs or assumptions were used to assess the resultant dissolved copper and dissolved zinc concentrations in the immediate area where the runoff will mix with the ambient water beneath the Main Crossing:

- An initial localised mixing zone directly below each drainage outfall with a diameter of 15m (for 15m pipe spacing) and a depth of 0.5m in the surface layers of the Firth of Forth. The resulting concentrations of dissolved copper and zinc within the surface layers were calculated. It is assumed that the freshwater from the runoff will float and therefore be confined to the top 0.5m of the more saline (and hence denser) estuary water of the Firth of Forth.
- A gravity outfall pipe diameter of 150mm.
- A pipe flow velocity of 1.5m/s.
- Based on the modelling software (UKHO TOTALTIDE [UKHO] SN023F tidal diamond), the water current underneath the proposed bridge is moving principally in an east-west direction, almost perpendicular to the alignment of the bridge deck. During slack water periods, the current speed can be considered to be zero. The current speeds in the six hours before and after high water range from 0.15-1.13m/s during a spring tide and from 0.10-0.70m/s during a neap tide (Table 3.2). As slow moving water is unfavourable for dilution, only the neap tide currents were considered in the assessment. For the concentration calculations, the effects of the moving current on the dilution of the pollutants at 0.1m/s, 0.3m/s and 0.5m/s were therefore chosen. As the stationary estuary water would represent the least amount of water available for dilution, this has also been considered in the assessment. However, it should be noted that the EQS are based on annual average concentrations and therefore even if there were short-term exceedances during rainfall events (following dry periods of weather) at slack tide, the annual average EQS is unlikely to be exceeded.

Table 3.2: Current Speed under the Main Crossing at Spring and Neap Tide High Water

Time	Spring Tide Speed m/s	Neap Tide Speed m/s
-06h	0.154	0.103
-05h	0.206	0.103
-04h	1.029	0.514
-03h	1.337	0.669
-02h	0.874	0.463
-01h	0.257	0.154
High Water	0.206	0.103
+01h	0.669	0.360
+02h	0.926	0.463
+03h	1.132	0.566
+04h	0.977	0.514
+05h	0.514	0.257
+06h	0.206	0.103

3.3.8 The resultant concentrations of dissolved copper or dissolved zinc have been estimated using the following formula:

$$\boxed{Conc_{resul\tan t} = Conc_{background} + \frac{M_{runoff}}{V_{mixing}}}$$

3.3.9 Where:

- V_{mixing} = assumed mixing zone volume per downpipe; and
- M_{runoff} = mass of the metal in the runoff per downpipe.
- $Conc_{background}$ = Background concentration of metal in mixing zone.

3.3.10 The mass of metal contained within it (M_{runoff}) per pipe have been estimated according to the following formula:

$$\boxed{M_{runoff} = \frac{5}{365} R_{metal} A}$$

3.3.11 Where:

- A is the area of road surface per downpipe; and
- Rmetal is the annual rate of metal accumulation per m2 of road surface per year.

3.3.12 The volume of the assumed mixing zone (Vmixing) has been estimated according to the following formula:

$$\boxed{V_{mixing} = (\frac{\pi}{4} D^2 + STD)d}$$

3.3.13 Where:

- D is the diameter of the assumed still water mixing zone;
- d is the assumed water depth on the top of the receiving water (0.5m in this case);
- S is the assumed current speed in the mixing zone; and
- T is the duration of mixing.

3.3.14 Table 5.2 summarises the estimated dissolved copper and zinc concentrations for 15m – 30m drainage outfall spacings and current speeds ranging from 0-0.5m/s. Figures 1.2 and 1.3 illustrate the estimated dissolved copper and zinc concentrations for the different outfall spacings and current speeds.

3.4 Risk of Accidental Spillage Methodology (Operational Impacts)

3.4.1 Along any road, there is a risk of vehicular collision that could result in the spillage of fuels, oils or chemicals, particularly if tankers are involved. A risk assessment of a serious spillage causing a pollution incident was undertaken using the methodology outlined in the DMRB HA 216/06 (Highways Agency et al., 2006).

3.4.2 The risk was calculated assuming that an accident involving spillage of pollutants onto the carriageway would occur at an assumed frequency, based on the potential traffic volumes for the design year (2032) and the type of road/junction (Table 3.3). It is also assumed that pollutants spilled on the carriageway would subsequently pass through the road drains and cause a pollution incident in the receiving watercourse without mitigation measures in place. The probability of a serious accidental spillage leading to a serious pollution incident also depends upon the emergency services response time. A risk factor is applied depending on the response time and the quality of the receiving watercourse (Table 3.4).

Table 3.3: Serious Accidental Spillages per Billion HGV (km/year)

Junction Type	Motorways	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	5.35
Cross Road *		0.88	1.46
Side Road *		0.93	1.81
Total	0.37	0.45	0.85

Source: DMRB HA 216/06 (Highways Agency et al., 2006).

Note: * Risk factor applies to all road lengths within 100m of these junction types.

Table 3.4: Probability of a Serious Accidental Spillage Leading to a Serious Pollution Incident

Receiving Watercourse	Urban (response time to site < 20 minutes)	Rural (response time to site < 1 hour)	Remote (response time to site > 1 hour)
High Quality Watercourse	0.45	0.6	0.75
Moderate Quality Watercourse	0.3	0.4	0.5
Groundwater	0.3	0.3	0.5

Source: DMRB HA 216/06 (Highways Agency et al., 2006).

3.4.3 The probability of a serious accidental spillage was calculated as follows:

$$\mathbf{P_{acc} = RL \times SS \times (AADT \times 365 \times 10^{-9}) \times (\%HGV \div 100)}$$

3.4.4 Where:

- Pacc = probability of a serious accidental spillage in 1 year over a given road length.
- RL = road length in kilometres.
- SS = serious spillage rates from Table 1.3 (or local data if available).
- AADT = Annual Average Daily Traffic (in design year 2032).

- %HGV = percentage of Heavy Goods Vehicles (in design year 2032).

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

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

3.4.6 Where, P_{pol} = the risk reduction factor, dependent upon emergency services response times, which determines the probability of a serious spillage leading to a serious pollution incident. The value is to be selected from Table 3.4, dependent on the quality and location of the reach proposed to receive the discharge.

3.4.7 In line with the DMRB HA 216/06 (Highways Agency et al., 2006), where spillage risk is calculated as less than 1% Annual Exceedance Probability (AEP) or less frequent than 1 in 100 years, the spillage falls within acceptable limits and no further spillage prevention measures will be required to reduce the risk of a serious pollution incident. Where assessed to be greater than 1% AEP (more frequent than 1 in 100 years), mitigation will be required to reduce the risk of an impact occurring.

3.4.8 The DMRB HA 216/06 (Highways Agency et al., 2006) states that 'In exceptional cases, where for example, road runoff discharges to a natural wetland or designated wetlands, such as SSSI, SAC, SPA and Ramsar Sites, or discharges less than 1km upstream of an abstraction point for potable water, it will be appropriate to specify a lower probability'. For particularly sensitive waterbodies (Niddry Burn, the River Almond and the Firth of Forth), it has been considered more appropriate to achieve a spillage risk of less than 0.5% AEP (less frequent than 1 in 200 years). Where assessed to be greater than 0.5% AEP (more frequent than 1 in 200 years), mitigation will be required to reduce the risk of an impact occurring.

3.5 Limitations to Assessment

3.5.1 There are certain limitations within these water quality assessment methodologies, as outlined in the following paragraphs.

3.5.2 Firth of Forth through-deck drainage routine runoff assessment – an advection/dispersion of the routine runoff discharge to the estuary has not been carried out. The assessment was based on average dilution of the pollutants by the available receiving water in the Firth of Forth. It is known that, in reality, the concentration will be highest directly under the downpipe and become more diluted towards the edge of the mixing zone, possibly showing the characteristics of an exponential decay curve. The average concentration estimated from the assessment will nevertheless always be higher than those at the mixing zone edge computed by a dispersion calculation and therefore this assessment presents a worst-case scenario.

4 Proposed Drainage Design

4.1.1 Table 4.1 identifies the waterbodies proposed to receive road drainage, including outfall locations, road drainage lengths and new road drainage areas. This information informs the DMRB calculations in Sections 5 (Routine Runoff Assessment Calculations) and 6 (Accidental Spillage Risk Assessment Calculations). Drainage runs are shown on Figure 9.3 (Surface Water Mitigation).

Table 4.1: Waterbodies Proposed to Receive Road Drainage

Road Name/Description (chainages)	Receiving Watercourse	Drainage Run	Outfall Location (NGR)	Road Drainage Length (m)	Approximate Road Drainage Area (m^2)
Existing M9 (ch2500 – ch2200) + new section of taper for northbound diverge to M9 spur.	Swine Burn	Run A	NT 1106 7472	300	3,870
Widened existing M9 Spur (ch0 – ch780). New slip road for Interchange Link.		Run E	NT 1144 7464	1,440	33,228
Existing M9 (ch2500 – ch2180) + new section of taper for westbound diverge from M9 spur.	Tributary of Swine Burn	Run B	NT 1071 7471	320	6,592
Existing M9 to be upgraded and widened (ch2200 – ch1290). New slip roads for Interchange Link.	Niddry Burn	Run C	NT 1175 7406	2,760	44,196
Existing M9 to be widened (ch1290 – ch610).	River Almond	Run D	NT 1209 7354	680	25,718
New A90 (ch2980 – ch1810) and bus link (ch1600 – ch1430).	Ferry Burn	Run J	NT 1260 7745	1,340	39,798
New A90 (ch2980 – ch4920), Queensferry Junction and maintenance access side road (ch0 – ch620)	Firth of Forth	Runs M + P	NT 1144 7873	5,180	84,934
Main Crossing over sub-tidal estuary channel	Firth of Forth	n/a	n/a	1,880	51,700
Existing and new A90 (ch6800 – ch8840), Ferry Toll Junction and B981 realignment	Firth of Forth	Run Q	NT 1224 8125	7,850	113,032

4.1.2 In addition to new outfalls, connection to existing drainage systems is proposed at a number of locations, primarily for the realignment of short sections of existing side roads (Table 4.2). Drainage to existing systems would replicate the existing drainage or include additional SUDS treatment as agreed with SEPA and pipe storage would be included to restrict discharge to pre-development flows, where required. Drainage runs to tie into the existing network are shown on Figure 9.3 (Surface Water Mitigation).

Table 4.2: Scheme to Tie into Existing Drainage Systems

Road Name/Description (chainages)	Drainage Run	Road drainage length (m)
Existing A90, public transport links and A8000 realignment (ch290 – ch130)	Runs GA + GB	1,130
A8000 realignment (ch290 – ch660)	Run HA	370
Farm access to A8000	Run HB	150
A904 realignment (ch0 – ch190)	Run K	190
B924 realignment	Run L	130
Society Road (ch0 – ch290)	Run MA	290
A904 realignment (ch0 – ch180)	Run N	180
Ferry Toll Road, B981 roundabout and Castlandhill Road realignment	Run R	705
Ferry Toll Park and Ride	Run S	220
Existing A90 and slip road to Admiralty Junction	Run T	360
Ferry Toll Road	Run U	140

5 Routine Runoff Assessment Calculations

5.1.1 This section provides the calculation spreadsheets (Table 5.1 and Table 5.2) to determine the impact of routine runoff to waterbodies proposed to receive road drainage (Table 4.1), based on the methodologies described above. The results of these calculations have been used to inform the assessment and are summarised in Table 9.14 of Chapter 9 (Water Environment).

5.1.2 The purpose of the DMRB calculations is to assess the impact of new road runoff to watercourses from the proposed scheme and determine if mitigation is required. In practice, mitigation is normally determined through liaison with SEPA as has been the case for the proposed scheme. Consequently, even where calculations suggest there is no need for mitigation of discharges to watercourses, pollution control measures in the form of SUDS have been proposed. Connection of new drainage to the existing drainage network (Table 4.2) has not been included in this assessment as mitigation for the proposed scheme as a whole has been agreed with SEPA.

Table 5.1: Routine Runoff Assessment Calculations (without mitigation)

Annual Average EQS (Using DMRB Method based on Annual Average (Q50) river flow conditions)		Units	Swine Burn		Trib of Swine Burn	Niddry Burn	River Almond	Ferry Burn
			Run E	Run A	Run B	Run C	Run D	Run J
Input Data								
Q50 i.e. 50-percentile flow (flow exceeded 50% of the time)		m^3/sec	0.044	0.044	0.006	0.134	2.45	0.008
Hardness	Hardness of watercourse - assumed (affects solubility of metals)	mg/l	50-100	50-100	50-100	50-100	50-100	50-100
Cu_b	Upstream dissolved copper data as mg/l (assume half of EQS)	mg/l	0.005	0.005	0.005	0.005	0.005	0.005
Zn_b	Upstream total zinc as mg/l (assume half of EQS)	mg/l	0.038	0.038	0.038	0.038	0.038	0.038
EQS Cu	Environmental Quality Standard for copper Annual Average)	mg/l	0.010	0.010	0.010	0.010	0.010	0.010
EQS Zn	Environmental Quality Standard for zinc (Annual Average)	mg/l	0.075	0.075	0.075	0.075	0.075	0.075
AADT	Annual average daily traffic (design year 2032)		52871	23987	21998	91201	91201	91439
RL	Road length (m)	m	1440	300	320	2760	680	1340
RC	Runoff coefficient		0.75	0.75	0.75	0.75	0.75	0.75
Rain	Rainfall depth (from HA216/06 Vol 11, Annex 1, pg AI/2, Fig A.1)	mm	12.5	12.5	12.5	12.5	12.5	12.5
PBUR (pollutant build up rate)	HA216/06 Vol 11, Annex 1, page AI/4, Table B.1 Cu (dissolved)	kg/ha/annum	1.2	0.4	0.4	1.2	1.2	1.2
	Zn (total)	kg/ha/annum	5.0	2.0	2.0	5.0	5.0	5.0
Calculations								
1. Total impermeable area (TIA)	= RL x RW (m^2)	m^2	33228	3870	6592	44196	25718	39798
2. Runoff volume (V)	= TIA x RC x (rain / 1000)	m^3	311.51	36.28	61.80	414.34	241.11	373.11
3. Q50 in m^3/day	= Q_{50} flow x 3600 x 24	m^3/day	3801.6	3801.6	518.4	11577.6	211680	691.2
4. Cu build up rate	5 day build up (M_{Cu}) = ($PBUR_{Cu}$ /365) x 5 x (TIA / 10000)	kg	0.0546	0.0021	0.0036	0.0727	0.0423	0.0654
5. Zn build up rate	5 day build up (M_{Zn}) = ($PBUR_{Zn}$ /365) x 5 x (TIA / 10000)	kg	0.2276	0.0106	0.0181	0.3027	0.1762	0.2726
Resulting dissolved copper concentration in the water course downstream (Cu_r) $Cu_r = \{(Cu_b \times Q50) + (1000 \times M_{Cu})\} / (Q50 + V)$		mg/l	0.018	0.006	0.011	0.011	0.005	0.065
Resulting total zinc concentration in the watercourse (Zn_r) $Zn_r = \{Zn_b \times Q50) + \{(1000 \times M_{Zn})\} / (Q50 + V)$		mg/l	0.090	0.040	0.065	0.062	0.039	0.281
Does predicted dissolved copper concentration comply with the EQS?			N	Y	N	N	Y	N
Does predicted total zinc concentration comply with the EQS?			N	Y	Y	Y	Y	N
Is mitigation required in accordance with DMRB HA 216/06?			Y	N	Y	Y	N	Y

Table 5.2: Routine Runoff Assessment Calculations (without mitigation) – Main Crossing Through-deck Drainage to Firth of Forth Main Channel

Annual Average EQS - Localised mixing zone in surface layers of Firth of Forth		**Units**	**Main Crossing through-deck drainage**			
Cu_b	Background dissolved copper concentration (SEPA monitoring data)	µg/l	1.2			
Zn_b	Background dissolved zinc concentration (SEPA monitoring data)	µg/l	3.1			
EQS Cu (dissolved)	Environmental Quality Standard for copper (Annual Average)	µg/l	5			
EQS Zn (dissolved)	Environmental Quality Standard for zinc (Annual Average)	µg/l	40			
AADT	Annual average daily traffic (design year 2032)		103383			
RC	Runoff coefficient		1.0			
Rain	Rainfall depth (from HA216/06 Vol 11, Annex 1, pg AI/2, Fig A.1)	mm	12			
PBUR (pollutant build up rate)	DMRB Vol 11, Section 3, Part 10 (Nov 2002) Cu (dissolved)	kg/ha/annum	1.2			
	Zn (dissolved)	kg/ha/annum	2.5			
1. Total impermeable area (TIA)	= RL x RW (RW=13m)	m^2	195 (assuming outfall spacings of 15m)			
2. Runoff volume (V)	= TIA x RC x (rain) over 5 mins	m^3	0.0081			
4. Cu concentration on carriageway	5 day build up (M_{cu}) / runoff volume	g/m^3	39.4521			
5. Zn concentration on carriageway	5 day build up (M_{zn}) / runoff volume	g/m^3	82.1918			
6. Volume of mixing zone	V_{mixing}	m^3	88.357			
Current speed		m/s	0.0 (slack water)	0.1	0.3	0.5
Resulting localised dissolved copper concentration at 15m spacing ($Conc_{resultant}$)		µg/l	4.8	2.2	1.6	1.5
Resulting localised dissolved copper concentration at 20m spacing ($Conc_{resultant}$)			3.9	2.1	1.6	1.5
Resulting localised dissolved copper concentration at 25m spacing ($Conc_{resultant}$)			3.4	2.1	1.6	1.5
Resulting localised dissolved copper concentration at 30m spacing ($Conc_{resultant}$)			3.0	2.0	1.6	1.4
Resulting localised dissolved zinc concentration at 15m spacing ($Conc_{resultant}$)			10.7	5.2	4.0	3.7
Resulting localised dissolved zinc concentration at 20m spacing ($Conc_{resultant}$)			8.8	5.0	3.9	3.6
Resulting localised dissolved zinc concentration at 25m spacing ($Conc_{resultant}$)			7.6	4.9	3.9	3.6
Resulting localised dissolved zinc concentration at 30m spacing ($Conc_{resultant}$)			6.9	4.8	3.9	3.6
Does predicted dissolved copper and zinc concentration comply with the EQS?			Y	Y	Y	Y
Is mitigation required in accordance with DMRB HA 216/06?			N	N	N	N

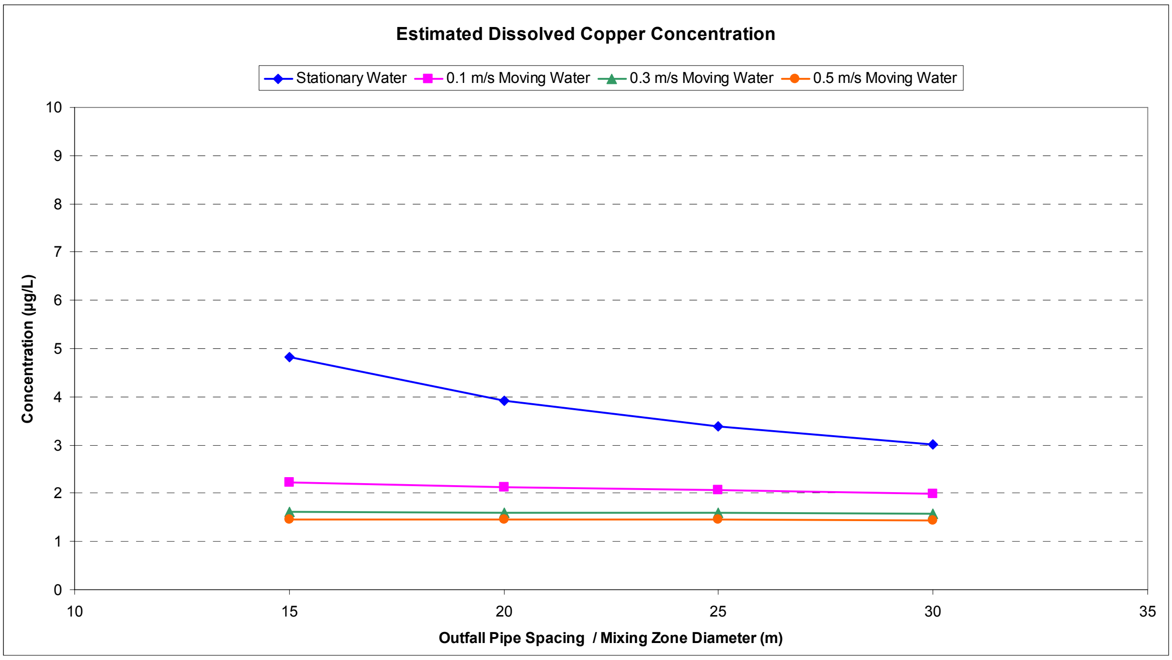

Diagram 5.1: Estimated dissolved copper concentrations within various mixing zone diameters, based on a range of tidal currents

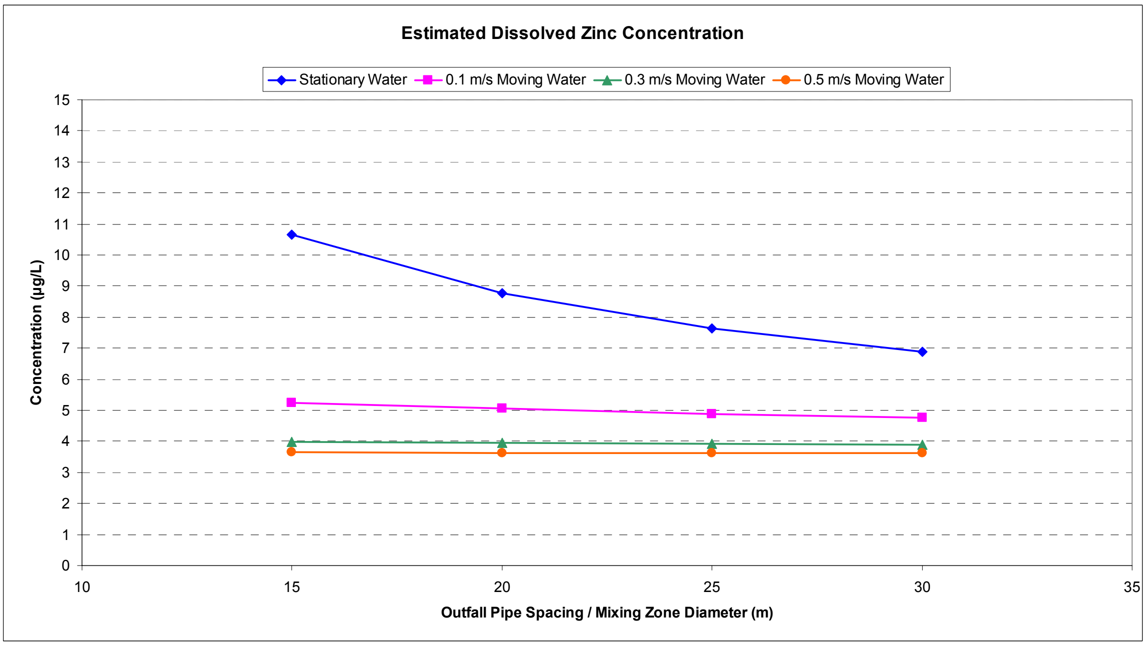

Diagram 5.2: Estimated dissolved zinc concentrations within various mixing zone diameters, based on a range of tidal currents

6 Accidental Spillage Risk Assessment Calculations

6.1.1 This section provides the calculation spreadsheets (Table 6.1) to determine the risk of accidental spillages to waterbodies proposed to receive road drainage, based on the methodology described above in Section 3. The results of these calculations have been used to inform the assessment and are summarised in Tables 9.15 (Watercourses) and 9.19 (Firth of Forth) of Chapter 9 (Water Environment).

6.1.2 The following abbreviations have been used in the calculation spreadsheet:

- RL: road length in km;
- SS: serious accidental spillage rate (from HA 216/06 DMRB Vol 11, Part 10, Annex I, Table D.1);
- AADT: annual average daily traffic;
- %HGV: percentage of heavy goods vehicles;
- Pacc: annual probability of a serious accidental spillage with the potential to cause a serious pollution incident over a given road length;
- Ppol: the probability, given an accident, that a serious pollution incident will result (from HA 216/06 DMRB Vol. 11, Part 10, Annex I, Table D.2); and
- PINC: probability of a spillage accident with an associated risk of a serious pollution incident occurring.

6.1.3 The acceptable risk of a pollution incident (above which mitigation will be required) is:

- 1 in 200 years for discharges to aquifers and sensitive waterbodies; and
- 1 in 100 years for discharges to all other waterbodies.

Table 6.1: HA 216/06 Accidental Spillage Risk Assessment Calculations (without mitigation)

Component	Swine Burn (Run E)				Swine Burn (Run A)				Trib of Swine Burn (Run B)			
	Mainline	Roundabout	Slip Rds	Side Rds	Mainline	Roundabout	Slip Rds	Side Rds	Mainline	Roundabout	Slip Rds	Side Rds
RL	1.03		0.31		0.3				0.22			
SS	0.36		0.43		0.36				0.36			
AADT (2-way flow)	52871		1491		23987				21998			
%HGV	4.2		0.1		6.2				7.9			
P_{acc} *	0.00030054	0	7.254E-08	0	5.9E-05	0	0	0	5.024E-05	0	0	0
P_{INC} **	0.000135275				2.63813E-05				2.26069E-05			
P_{INC} (%)	0.013527475				0.002638133				0.002260689			
Return Period (1 in X)	7392				37906				44234			
Is Mitigation Required in accordance with DMRB HA 216/06?	**N**				**N**				**N**			

Component	Niddry Burn (Run C)				River Almond (Run D)				Ferry Burn (Run J)			
	Mainline	Roundabout	Slip Rds	Side Rds	Mainline	Roundabout	Slip Rds	Side Rds	Mainline	Roundabout	Slip Rds	Side Rds
RL	0.61		2.35		0.68				1.17			0.17
SS	0.36		0.43		0.36				0.36			0.43
AADT (2-way flow)	91201		26279		91201				91439			133
%HGV	6.5		4.5		6.5				4.9			0
P_{acc} *	0.00047516	0	0.00043616	0	0.0005297	0	0	0	0.00069	0	0	0
P_{INC} **	0.000410095				0.000238358				0.000309971			
P_{INC} (%)	0.041009528				0.023835801				0.030997116			
Return Period (1 in X)	2438				4195				3226			
Is mitigation required in accordance with DMRB HA 216/06?	**N**				**N**				**N**			

* $P_{acc} = RL \times SS \times (AADT \times 365 \times 10^{-9}) \times (\%HGV/100)$

** $P_{INC} = \Sigma P_{acc} \times P_{pol}$

Component	Firth of Forth											
	South section (Runs M and P)				North section (Ferry Toll Junction) (Run Q)				Main Crossing – through deck drainage			
	Mainline	Roundabout	Slip Rds	Side Rds	Mainline	Roundabout	Slip Rds	Side Rds	Mainline	Roundabout	Slip Rds	Side Rds
RL	1.54	1.02	1.47	1.15	1.54	1.32	2.95	2.04	0.94			
SS	0.36	5.35	0.43	1.81	0.36	5.35	0.43	1.81	0.36			
AADT (2-way flow)	103383	17369	11400	21200	103383	6427	3095	3233	103383			
%HGV	6.1	17.6	15.9	16.2	6.1	14.3	7.7	9.2	6.1			
P_{acc} *	0.001276	0.006088836	0.000418197	0.002609277	0.00128	0.002369	0.0001103	0.0004009	0.000779	0	0	0
P_{INC} **	0.004676598				0.00187035				0.000350522			
P_{INC} (%)	0.467659812				0.187034952				0.035052153			
Return Period (1 in X)	214				535				2853			
Is mitigation required in accordance with DMRB HA 216/06?	**N**				**N**				**N**			

* P_{acc} = RL x SS x (AADT x 365 x 10^{-9}) x (%HGV/100)
** $P_{INC} = \Sigma P_{acc} \times P_{pol}$

7 Water Classification Schemes for Scotland

7.1.1 Results from SEPA's new WFD classification scheme have been used to inform baseline water quality conditions and assign sensitivities for waterbodies to be impacted by the proposed scheme (refer to Section 9.3: Baseline Conditions of Chapter 9: Water Environment). As the new WFD scheme and associated monitoring programmes have only recently been introduced, the water quality classification systems that it replaced have also been used to provide the best current understanding of the baseline water environment. SEPA's previous water quality classification schemes are provided within Table 7.1 (River Classification Scheme), Table 7.2 (Estuarine Classification Scheme) and Table 7.3 (Coastal Classification Scheme) to allow reference to classification details provided in the baseline assessment. The classification schemes should be read in conjunction with supplementary notes available on SEPA's website (SEPA, 2009a).

7.1.2 Where information is available on pressures and impacts on waterbodies for the new WFD classification system, this has also been provided in the baseline assessment. Information on the SEPA's new WFD classification scheme is available from SEPA's website (SEPA, 2009b).

Table 7.1: SEPA River Classification Scheme (recently superseded by WFD classification)

Class/ Description	Water Chemistry					Biology				Nutrients	Aesthetic Condition (Contaminate)	Toxic Substances	Comments
	DO	BOD	NH4-N	Fe	pH	Lab Analysed		Bankside		SRP			
	(%sat) 10%ile	(mg/l) 90%ile	(mg/l) 90%ile	(mg/l) Mean	%ile	ASPT EQI	TAXA EQI	ASPT	Field Score	(μg/l) Mean			
A1 Excellent	> 80	< 2.5	0.25	<1	5%ile>6 95%ile <9	> 1.0	> 0.85	> 6.0	> 85	< 20	No A Minor B (see SEPA website notes)	Complies with Dangerous Substances EQSs.	Sustainable salmonid fish population. Natural Ecosystem.
A2 Good	> 70	< 4	0.6	<1	10%ile >5.2	> 0.9	> 0.70	> 5.0	> 70	< 100	Trace / Occasional A or B (see SEPA website notes)	Complies with Dangerous Substances EQSs.	Sustainable salmonid fish population. Ecosystem may be modified by human activity.
B Fair	> 60	< 6	1.3	< 2	10%ile <5.2	> 0.77	> 0.55	> 4.2	> 50	> 100	-	Complies with Dangerous Substances EQSs.	Sustainable coarse fish population. Salmonids may be present. Impacted ecosystem.
C Poor	> 20	< 15	9.0	> 2	-	> 0.50	> 0.30	> 3.0	> 15	-	Gross A or B (see SEPA website notes)	> EQS for dangerous substance.	Fish sporadically present. Impoverished ecosystem.
D Seriously Polluted	> 20	> 15	> 9.0	-	-	< 0.50	< 0.30	< 3.0	< 15	-	-	> 10 x EQS for dangerous substance.	Cause of nuisance. Fauna absent or seriously restricted.

Source: http://www.sepa.org.uk/water/river_basin_planning.aspx

Table 7.2: SEPA Estuarine Classification Scheme (recently superseded by WFD classification)

Class	Description	Aesthetic Condition	Fish Migration	Benthic Community and/or Bioassay	Resident Fish	Persistent Substances (Biota)	Water Chemistry	
							Dissolved Oxygen (DO)	EC Red List and Dangerous Substances
A	Excellent	Unpolluted	Water quality allows free passage.	Normal	Resident fish community normal.	< 2X National background	Minimum DO > 6mg/l	100% compliance of samples.
B	Good	May show signs of contamination.	Water quality allows free passage.	Normal	Resident fish community normal.	> or = 2X National background but < substantially elevated	Minimum DO < or = 6 mg/l but > 4 mg/l	Annual compliance of samples.
C	Unsatisfactory	Occasional observations or substantiated complaints of pollution.	Water quality restricts passage.	Modified	Resident fish community modified.	> or = Substantially elevated but < grossly elevated	Minimum DO < or = 4mg/l but > 2mg/l	One or more List II substances fail to comply. List I and Red List all comply.
D	Seriously polluted	Frequent observations or substantiated complaints of pollution.	Water quality allows free passage.	Impoverished or severely modified	Resident fish community impoverished.	> or = Grossly elevated level	DO < 2mg/l	One or more List I or Red List substances fail to comply.

Table 7.3: SEPA Coastal Classification Scheme (recently superseded by WFD classification)

Class/Description	Aesthetic Condition	Biological Condition	Bacteriological Condition	Chemical Condition
A Excellent	Near Pristine	Flora and fauna normal.	Likely to meet quality standards no less stringent than the guideline standards for EC Designated Bathing Waters.	
B Good	Unpolluted, but may show traces of contamination	Flora and fauna normal.	Likely to meet quality standards no less stringent than the mandatory standards for EC Designated bathing waters.	
C Unsatisfactory	Occasional observations or substantiated complaints of sewage solids smell nuisance or oil	Flora and/or fauna modified by effluent discharges.	Likely to occasionally fail to meet quality standards no less stringent than the mandatory standards for EC Designated bathing waters.	Likely to meet all quality standards applied as a consequence of the EC Dangerous Substances Directive.
D Seriously Polluted	Frequent observations or substantiated complaints of sewage solids, smell nuisance or oil	Flora and/or fauna impoverished or absent.	Likely to frequently fail to meet quality standards no less stringent than the mandatory standards for EC Designated bathing waters.	Likely to fail any one or more of quality standards applied as a consequence of the EC Dangerous Substances Directive.

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