Welsh Government

# M4 Corridor around Newport

## December 2016 Environmental Statement Supplement

## Appendix SS16.1 Revised Water Treatment Area DMRB Risk Assessment

M4CaN-DJV-EWE-ZG_GEN-AX-EN-0003

At Issue | December 2016

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# 1 Introduction

## 1.1 Background

1.1.1 An assessment of the potential impact of the proposed Water Treatment Area (WTA) discharges on surface water quality was undertaken and reported in the Water Treatment Area Design Manual for Roads and Bridges (DMRB) Risk Assessments (Appendix 16.3 of the March 2016 Environmental Statement (ES)).

1.1.2 Following comments from NRW on the March 2016 ES and a subsequent meeting held with their water quality and conservation experts, it was agreed to reassess the proposed Water Treatment Area water environment risk assessments. This was principally in light of updated NRW water quality trigger levels for the Gwent Levels SSSI but also to take account of any limitations of the HAWRAT methodology due to very low or non-flow within reens proposed to receive WTA discharges.

1.1.3 It was agreed that the risk assessment would be reappraised to increase the conservatism of the original work by identifying areas where the dependence on reen flow in the prediction of worst case impacts on water quality could be further constrained.

1.1.4 NRW stated given the very high sensitivity of the Gwent Levels SSSI, high confidence was required that reen water quality would be preserved following discharge of the proposed treated motorway drainage.

## 1.2 Methodology

1.2.1 As previously undertaken, this assessment was undertaken to DMRB methodology including use of the bespoke Highways Agency Water Risk Assessment Tool (HAWRAT). HAWRAT is approved by the Highways Agency and Environment Agency for the assessment of pollution impacts from routine runoff to surface waters to inform Environmental Impact Assessment (EIA).

1.2.2 Part of the DMRB assessment methodology requires delineation of mitigation measures present within the proposed road drainage design to reduce impact from pollution to within scientifically judged acceptable limits. As described in the Drainage Strategy Report and Supplementary Drainage Strategy Report (Appendices 2.2 and S2.2 to the March 2016 ES and September 2016 ES Supplement respectively), such mitigation measures included:

- extensive roadside grass lined channels totalling approximately 14km, including 80% of the motorway within the Gwent Levels SSSI;
- a pollution control lagoon (also known as a bypass interceptor or forebay);
- a permanently wet attenuation lagoon (also known as a wet sedimentation pond) ; and
- a reed bed (also known as a wetland) (averaging approximately 800 m2 for every hectare of drained motorway).

1.2.3 For clarity of terminology the following terms will be adopted for describing the above pollution attenuation features individually referred to stages of a treatment train.

- Stage 1: Grass Lined Channels.
- Stage 2: Pollution Control Lagoon.
- Stage 3: Attenuation Lagoon .
- Stage 4: Reed Bed

**1.2.4** Due to road drainage design requirements, it is not possible to include road side grass lined channels for a section of the proposed new section of motorway within the Gwent Levels Site of Special Scientific Interest (SSSI). Concrete channels have therefore been proposed. This section drains to WTA10 and consequently, WTA10 comprises a three-stage rather than four-stage treatment train.

**1.2.5** Additionally, WTAs located outside of the Gwent Levels SSSI where lower elevation embankments are not possible due to vertical alignment considerations, grass lined channels are also not proposed. Accordingly WTA1, WTA2, WTA8a, WTA11b, WTC11c, WTA12a and WTA12b comprise three stage treatment trains.

**1.2.6** Annex 2 summarises the WTA drainage design parameters and chainage within the Gwent Levels SSSI and grass lined channel provisions.

## 1.3 Previous Assessment

### Quantitative Assessment of Proposed Mitigation Measures

**1.3.1** An assessment of the pollution reduction potential of three and four stage treatment trains was undertaken within Appendix 16.3 to the March 2016 ES. This approach utilised guidance within CIRIA C609 Sustainable Drainage Systems. This guidance provides approaches to conservatively judge expected combined pollution reduction efficiencies for multi train treatment systems for chemically similar groups of contaminants.

**1.3.2** For clarity the combined pollution reduction efficiencies calculated following CIRIA guidance are summarised in Table 1.1.

**Table 1.1: Cumulative Treatment Efficiencies of Proposed 4 and 3 Stage Treatment Train**

| Pollutant Group | 4 Stage | 3 stage |
|---|---|---|
| TSS / suspended heavy metals | 95.6% | 91.9% |
| Heavy metals - dissolved | 94.8% | 82.2% |
| Hydrocarbons / PAH | 93.7% | 83.7% |
| Nutrients | 57.2% | 50.3% |

TSS = Total Suspended Solids. PAH = Polynuclear Aromatic Hydrocarbons.

#### Results of HAWRAT Assessment

**1.3.3** The results of the HAWRAT assessment reported in Appendix 16.3 found that all proposed attenuated WTA discharges at the proposed maximum design discharge rates as defined within the Drainage Strategy Report (Appendix 2.2 of the March 2016 ES) did not exceed strict HAWRAT water quality and sediment compliance criteria for both 6 and 24 hour periods for dissolved copper and zinc - termed Run-off Specific Thresholds (RST) and annual accumulation potential of sediment bound copper, zinc, cadmium and PAH - termed Threshold Effect Levels (TEL) and Probable Effect Levels (PEL).

**1.3.4** The HAWRAT criteria RST, TEL and PEL concentrations were developed by collaborative research undertaken by the Environment Agency and the Highways Agency. This utilised short term toxicity studies for 13 algal, invertebrate and fish species along with literature data for other relevant species all chosen as representative of UK resident species with a representative range of sensitivities to significant pollutants found in road run-off. In this way the concentrations are protective against possible short term effects on tested and untested but sensitive species. Higher standards of compliance are required for discharges within 1km of protected sites including SSSI and Special Areas of Conservation (SAC).

**1.3.5** This approach is consistent with that adopted for the derivation of Environmental Quality Standards (EQS) under the Water Framework Directive (WFD). The HAWRAT user guide provides a complete description of the methodology and underlying science and principals of operation of the assessment.

**1.3.6** A further assessment was undertaken in Appendix 16.3 to the March 2016 ES to determine the likelihood that baseline water quality as measured over 4 quarterly monitoring rounds at or near proposed locations of WTA discharges to reens, could be preserved.

**1.3.7** This assessment defined current representative Ambient Background Concentrations (ABC) for the contaminants of concern within reens at the location of each proposed WTA discharge and calculated the attenuation factors required to reduce HAWRAT predicted discharge concentration - post treatment - back to these ambient concentrations.

**1.3.8** This assessment found that owing to the very low levels of pollutants at some locations within the Gwent Levels SSSI, not all discharged water would be at a reen ABC prior to entry into the watercourse for all ruin-off events predicted by HAWRAT over a ten year period.

**1.3.9** However, it was found that for both 3 and 4 treatment train WTAs, treated discharges prior to entry into a reen were below the appropriate WFD EQS for every contaminant of concern with the exception of fluoranthene owing to its extremely low EQS concentration and chloride during winter thaws following salt treatment of the carriageway. Many of the contaminants prior to discharge to a reen were below half the WFD EQS.

## Quantitative Approach to Reed Bed Sizing

**1.3.10** The preliminary design of reed bed sizes is based on literature guidance (Ellis et al., 2003) on critical performance criteria to ensure these features are capable of operating at expected pollutant removal efficiencies. This guidance was produced for use by the Environment Agency operational staff and others involved in the control and management of surface water runoff from development, and those who are seeking advice on the construction and operation of constructed wetlands (reed beds) to treat road runoff.

**1.3.11** Such performance criteria optimised for the individual reed bed areas within WTA include the recommended residence time for water within the wetland prior to discharge and the recommended hydraulic loading rates; that is the ratio of the flow through a wetland to its total area.

**1.3.12** Such a design approach is considered a robust methodology from which to size reed beds to deliver the optimum performance for the removal of residual pollutants within water emerging from the attenuation lagoon of the WTA, prior to discharge to a receiving watercourse.

**1.3.13** Reed bed sizing has been approached solely from the standpoint of providing high confidence of water quality protection. No other sizing constraints have been considered, i.e. reducing land take and associated impacts.

**1.3.14** Annex 2 presents the reed bed sizing parameters and calculations.

## NRW Response to the Environmental Statement

**1.3.15** With respect to the proposed motorway drainage discharges to tidal waters of the Rivers Usk and Ebbw, in their comments of 4th May 2016 on Chapter 16 Road Drainage and the Water Environment of the March 2016 ES, NRW stated that:

*"we are satisfied that discharges to the Rivers Usk and Ebbw have lesser requirements for attenuation and treatment and, provided these requirements are adequately covered to our satisfaction within the Statement of Commitments, we advise that that the proposals presented into these tidal waters are adequate."*

**1.3.16** With regard to the treatment of data in Appendix 16.3, NRW stated:

*"We also note that 'average levels' and 'ranges' are provided. This data is of limited use in interpreting water quality data trends with respect to the SSSIs. All data from samples must be viewed independently as this is the only way to ensure exceedances of contaminants can be identified. In particular, when considered in conjunction with the proposals and the potential for adverse impact on water quality during both construction and operation phases."*

## Water Quality Meeting with NRW

**1.3.17** Following a meeting with NRW water quality and conservation specialists, a set of revised water quality trigger levels were presented. These are intended to replace the former Countryside Council for Wales (CCW) trigger levels provided by NRW at the time of assessment for, and publication of, the March 2016 Environmental Statement. The new trigger levels are based principally on Water Framework Directive (WFD) Environmental Quality Standards (EQS) and thus afford a predominantly higher standard of protection to the watercourses of the Gwent Levels SSSI.

**1.3.18** At this meeting the HAWRAT assessments provided to support the Water Environment and Drainage chapter of the Environmental Statement was discussed. It was accepted that HAWRAT was an appropriate tool to assess likely risks on water quality from the proposed WTA, however caution was expressed on the validity of reliance on flow within reens accepting drainage discharges. On this basis, revised HAWRAT calculations will be undertaken within this revised assessment to explore sensitivity to low flow conditions on soluble and sediment discharges from WTA on water quality.

**1.3.19** Reed bed sizing methodology was discussed and the approach based on residence time analysis, as described in Ellis et al., 2003 and used to inform the March 2016 Environmental Statement, was considered an appropriate approach.

**1.3.20** Finally, the requirement for the identification of appropriate contingency measures was discussed. To this end, a number of additional practices are identified and described to foresee, avoid and/or mitigate potentially unacceptable deteriorations in long term water quality or aquatic ecological quality within reens accepting WTA discharges.

# 2 Revised HAWRAT Assessment

## 2.1 Soluble Pollutants

**2.1.1** Annex 1 to this report presents the average Ambient Background Concentrations recorded in each reen where WTA discharges are proposed. The table also records the Probable No Effect Concentration (PNEC) calculated for each location for both dissolved copper and zinc using the M-BAT tool based on average concentrations of calcium, pH and dissolved organic carbon. Site specific PNECs are required to determine compliance under the Water Framework Directive. They replace Environmental Quality Standards (EQS) concentrations based on water hardness alone.

**2.1.2** HAWRAT utilises a large database of real monitored 'events' being a rainfall driven flush of pollutants from a road surface for a number of rural sites throughout England and Wales. Site monitoring involved continuous rainfall and run-off flow monitoring (depth and velocity) and automatic sampling triggered by predetermined flow thresholds in a highway drain. Event selection was based on a minimum antecedent dry weather period (ADWP) of 24 hours. Samples were then combined according to the flow regime at the time of each sample to produce a flow weighted event mean concentration (EMC). All EMCs for the principal pollutants of concern from road drainage were statistically treated to find minimum, mean, median and maximum EMCs (Crabtree et al., 2008).

**2.1.3** Below the table at Annex 1 the HAWRAT generated Event Mean Concentrations (EMC) for copper, zinc and cadmium are shown for both the mean and maximum values. WTA specific PNEC values for copper and zinc, which are defined as long term average concentrations, are compared with the relevant mean EMC to derive a 'mean EMC to PNEC' attenuation factor (AF) that is the WTA specific AF that would need to be achieved by any treatment train to reduce the EMC to the PNEC for both dissolved copper and zinc.

**2.1.4** Comparison of the WTA specific mean EMC to PNEC AF values for both copper and zinc show that with the exception of a minor deficiency at WTA1 of 3.6% and 0.1% for copper and zinc respectively, all discharges are attenuated to below the PNEC. A residual value has been shown, that is the difference where positive between the required and the available AF at each WTA as shown under solubles removal efficiency.

**2.1.5** This assessment approach is also undertaken to determine an AF for each WTA to reduce the mean EMC to the mean ABC and the 95th%ile ABC as monitored in each WTA specific reen. A residual value is again presented for both where positive. These residuals are less than 15% and accordingly it is considered that, given the solubles reduction efficiencies for the WTA used are based on a highly conservative approach, such residuals are within the likely performance envelope for the WTA treatment trains, particularly given the large scale and size of the individual treatments stages described in Appendix 16.3 to the March 2016 ES, being far larger than comparable systems in existence currently operating on the Highways estate within the UK.

**2.1.6** Furthermore, the calculations presented in Annex 1 are based on 'event' impacted drainage entering the grass lined channels and WTA. Such events as described previously, follow a duration of dry weather - the antecedent dry weather period (ADWP) - of at least 24 hours and are therefore representative of 'first flush' road drainage. This so called 'first flush' of the road surface whereby maximum pollutants are associated with the washing of the highway pavement following the build-up of pollutants during antecedent periods of dry weather, typically occurs within the first 10 mm of a rainfall event.

**2.1.7** It is the case that the majority of weather events in the UK are of short duration and limited rain depth. It has been estimated that around 50% of rainfall events (probably in excess of 70 events a year in most areas), are less than 5mm (Environment Agency, 2013). HAWRAT predicts an average of 95 ADWP events of any rain depth per year occurring in the Cardiff area, being the nearest to Newport. The Met Office long term daily rainfall data for Usk weather station (being the nearest to Newport) gives an average number of 135 days a year seeing rain of which 25 to 40 days see rainfall in excess of 10 mm.

**2.1.8** It can therefore be appreciated that a sizeable proportion of rainfall will fall after the first flush has been generated, i.e. during first 10 mm of rainfall. Such non-event rainfall, i.e. rainfall following the first 10 mm, received at the WTA via the grass lined channels will be relatively unpolluted and dilute water stored within the grass lined channels, pollution control and attenuation lagoons, and reed bed. Treated water discharged by the WTA will be of a higher quality and require lower attenuation factors than those calculated within the tables at Annex 1.

**2.1.9** Finally, following NRW concerns of impact to low/no flow reens within the Gwent Levels, particularly during summer, no account of in-channel pollutant dilution or dispersion has been allowed for. Under winter penning, such an approach is likely to result in an over estimate of the impact on water quality. Certainly taken over the year as an annual average, dilution and dispersion of pollutants can be expected to occur either as a consequence of mixing or flow resulting in reduced impact.

**2.1.10** Taking the above considerations together, there is high confidence that WTA discharges will be able to preserve existing baseline water quality within reens and very high confidence that water quality will remain within PNEC concentrations, i.e. those considered to have no detectable adverse effect on aquatic life. This is in keeping with the findings of the original HAWRAT assessments - for which an annual Q95 low flow of 1L/s was assumed - where the principal soluble pollutants of concern were not predicted to exceed the more stringent RST6 or RST24 concentrations for protected sites.

**2.1.11** This evidence also supports Commitment Ref. No. 4 and No. 5 concerning meeting of WFD and SSSI requirements with respect to water quality.

## 2.2 Sediment Bound Pollutants

**2.2.1** Following NRW's stated concerns regarding dependence on reen dilution and HAWRAT dependence on a flow regime to predict impact polluted sediment accumulation beyond discharge outfalls, the HAWRAT assessments were revisited to identify how improvements could be made to deliver higher confidence in the risk assessment predictions being attributable to the Gwent Levels SSSI, particularly under summer penning. The following areas were identified:

- Fivefold reduction in the assumed Q95 flow rate of the reen network from 0.0005 to 0.0001 $m^3/s$. This is used by HAWRAT to determine what size of rainfall event needs to be exceeded to prevent sediment from accumulating. This reduction will lead to in many instances to all HAWRAT predicted rainfall events leading to sediment deposition, i.e. no in channel dispersion is predicted due to perennial low flow conditions being imposed.
- WTA specific reen dimensions. Previously a generic reen width was used of 4.2 metres. Reen dimensions based on field measurements are now adopted, as summarised in Table 2.1. The majority of reens are narrower than 4.2 m, by up to 71%, leading to more onerous predicted impacts being made by HAWRAT on sediment accumulation depths within these reens. This leads to a more conservative assessment than that reported in Appendix 16.3 to the Environmental Statement.
- Comparison of baseline flow modelling for individual reens from the Flood Consequence Assessment (Appendix 16.1 of the March 2016 ES) to identify order of magnitude likely annualised flow rates within the Gwent Levels for comparison with the Q95 flow.

**Table 2.1: WTA Specific Reen Widths**

| WTA | Receiving Reen | Reen Width (m) | Change from previous assessment |
|---|---|---|---|
| 1 | Pwll Bargoed Reen | 2.6 | -38% |
| 2 | Tyn-y-Brwyn Reen | 2.5 | -40% |
| 4a<br>4b | Percoed Branch East | 1.3 | -69% |
| 5 | Morfa Gronw Reen | 1.5 | -64% |
| 6 | Lakes Reen | 1.2 | -71% |
| 7 | Julians Reen | 2.7 | -36% |
| 8 | Ellen Reen | 5.9 | 40% |
| 8a | Black Wall Reen | 2.1 | -50% |
| 9 | Middle Road Reen Diversion | 4.2 | 0% |
| 10 | Rush Wall South Reen | 1.5 | -64% |
| 11b<br>11c | Mill Reen | 1.4 | -67% |

WTA discharging to the same reen have been assessed as a single combined discharge.

**2.2.2** The HAWRAT chronic impact assessments were rerun using the above conservative modifications. The results are presented in HAWRAT by a Deposition Index (DI) where a factor of 100% is taken to be the threshold of acceptability of accumulating sediment discharged by a WTA into a reen. The threshold equates to the predicted toxicity of an accumulation of sediment to a depth of 10 mm over a 10 m length of riverbed.

**2.2.3** In this eventuality during a ten year modelling period, HAWRAT calculates the concentration of pollutants within this sediment for comparison with scientifically derived Threshold Effect Levels (TEL) and Probable Effect Levels (PEL). These are risk based thresholds following extensive field measurements within sediment accumulating and non-accumulating watercourses receiving highways drainage within England and Wales (Gaskell et al., 2007).

**2.2.4** HAWRAT also calculates a sediment reduction attenuation factor that would be required to achieve compliance with the TEL and PEL thresholds for the modelled discharge. These can be compared with the WTA specific cumulative treatment efficiencies, i.e. for 3 or 4 stage treatment trains as appropriate.

**2.2.5** A review was undertaken of the lowest predicted pre storm event baseline flows in reens within the study catchment as modelled and reported within the Flood Consequences Assessment (Appendix 16.1 to the March 2016 Environmental Statement). The lowest baseline flow was found to be of the order 0.01 $m^3$/s. The Q95 low flow modelled for the purposes of determining impact from accumulating sediment of 0.0001 $m^3$/s is two orders of magnitude below these modelled baseline flows. This gives confidence that the effective HAWRAT modelled Q95 flow rate is likely to be appropriate for the purposes of the risk assessment.

**2.2.6** The results of the HARWAT assessment for chronic sediment impact are summarised in Table 2.2. Deposition Indices and HAWRAT calculated sediment reduction attenuation factors are presented together with the individual WTA cumulative treatment efficiencies for comparison.

**Table 2.2: WTA Specific Sediment Risk Assessment Results**

| WTA | Receiving Reen | Discharge within 100m of SSSI? | HAWRAT Deposition Index | HAWRAT Sediment Reduction | WTA Cumulative Treatment Efficiency |
|---|---|---|---|---|---|
| 1 | Pwll Bargoed Reen | No | 95 | 92% | 82% |
| 2 | Tyn-y-Brwyn Reen | No | 99 | 94% | 82% |
| 4a<br>4b | Percoed Branch East | Yes | 94 | 96% | 95% |
| 5 | Morfa Gronw Reen | Yes | 70 | 94% | 95% |
| 6 | Lakes Reen | Yes | 57 | 93% | 95% |
| 7 | Julians Reen | Yes | 22 | 80% | 82% |
| 8 | Ellen Reen | Yes | 22 | 80% | 95% |
| 8a | Black Wall Reen | Yes | 13 | 36% | 82% |
| 9 | Middle Road Reen Diversion | Yes | 54 | 92% | 95% |
| 10 | Rush Wall South Reen | Yes | 58 | 87% | 82% |
| 11b<br>11c | Mill Reen | No | 208 | 97% | 82% |

WTA discharging to the same reen have been assessed as a single combined discharge.

**2.2.7** The results of the revised HAWRAT sediment bound pollutant assessment show that, with the exception of WTA 11b/c, all discharges are not predicted to present a risk of accumulation of sediments at levels that are considered to present a toxicity risk to aquatic biology.

**2.2.8** Given the increased levels of conservatism employed within this revised risk assessment, it is concluded that a high level of certainty can be afforded to these results.

**2.2.9** The risk assessment for Mill Reen was reassessed in light of the exceedance of acceptable limits presented above. Notwithstanding that discharges from WTA11 do not occur within the Gwent Levels SSSI, and that the residual treatment efficiency of 15% could be accounted for within the likely performance envelope for the WTA treatment trains as previously discussed, a sensitivity analysis was performed on the Q95 flow rate required to reduce the Deposition Index to below 100. This was found to equal 0.0032 $m^3$/s.

**2.2.10** Examination of the Flood Consequence Assessment baseline flow data for Mill Reen as modelled within the Magor area (Inflow 4), a baseline flow of 0.2 $m^3$/s is predicted, i.e. two orders of magnitude higher than the value input to HAWRAT as was the case for the other reens receiving proposed discharges. This is also supported by field observations of Mill Reen where visible stream flows are reported reflecting the elevated spring fed catchment of this watercourse north of Magor.

**2.2.11** On this basis it is judged that the discharges from WTA11b and WTA11c are not considered to represent a risk of sediment accumulation leading to potential impact on aquatic biology.

**2.2.12** In summary, the revised sediment bound pollutant assessment has shown there is high confidence that the proposed WTA discharges will not lead to unacceptable sediment accumulation within reens.

# 3 Proposed Contingency Measures

**3.1.1** At the meeting held on 8th November 2016, NRW expressed a need to understand what contingency measures could be taken in the event that water quality of reens receiving proposed WTA discharges did not perform as predicted.

**3.1.2** A number of contingency measures have been identified to provide confidence that the Gwent Levels SSSI will be protected as follows. A number of these measures form current commitments as recorded in the Register of Commitments. The relevant commitment reference number is given where applicable.

## 3.2 Grass Lined Channel and WTA Maintenance

**3.2.1** HA103/06 (May 2006) provides suggestions for maintenance and management of vegetative drainage systems recognising the requirement for a more frequent level of inspection compared to conventional drainage systems. Table 3.1 summarises the HA suggested requirements whilst acknowledging these should not be interpreted rigidly.

**Table 3.1: Inspection and Maintenance Requirements for Vegetative Systems**

| | Grass Lined Channel | Attenuation Lagoon | Reed Bed |
|---|---|---|---|
| **INSPECTIONS** | | | |
| Inflow/outfalls Integrity/erosion Debris/rubbish | Quarterly or after each major storm | Monthly | Monthly or after each major storm |
| Build-up of sediment or invasive weeds | Annually | Annually | Annually |
| Vegetation cover/vigour | Monthly or after each major storm | Annually | Annually |
| Check for protected species | Specialist advice to be sought | | |
| **ROUTINE WORKS** | | | |
| Clearance of rubbish/debris | Monthly or after each major storm | Quarterly | Quarterly |
| Cutting vegetation | Monthly or after each major storm | 5-10 year cycle and remove | 1-5 year cycle and remove |
| Removal of plant litter | N/A | N/A | 5-10 year cycle if required |
| Removal of sediment | To be determined annually | To be determined annually | To be determined annually |

**3.2.2** Through these inspections and maintenance, high confidence can be maintained in the design functionality of the water treatment described systems. It is therefore important that responsibilities and maintenance routines are clearly identified at an early stage.

**3.2.3** A Management Plan will be prepared setting out objectives and an annual programme of intended maintenance operations. This supports Commitment No. 161 describing ongoing long term maintenance commitment transferring to Welsh Government's highway maintenance contractor (currently SWTRA) to be documented within a Handover Environmental Management Plan (HEMP).

## 3.3 Post Construction Monitoring

**3.3.1** As stated in the Register of Commitments, a period of 5 years contingency chemical water quality and biological assurance monitoring of reens receiving WTA discharges is proposed. Upstream and downstream monitoring of reen chemical and ecological status will be recorded to allow any measurable impact from the proposed drainage on the SSSI features to be identified. To aid delineation of natural variations unattributable to the new section of motorway, monitoring sites will also be chosen as representative of reen aquatic biology not considered to be in direct or indirect.

**3.3.2** This supports Commitment No. 159 where Water quality would continue to be monitored for 5 years of operational use of the new section of motorway to demonstrate acceptable quality of the water treatment area discharges.

## 3.4 Trigger and Control Levels Reporting

**3.4.1** Trigger levels are useful data management approaches to provide better understanding of WTA performance and to draw the attention of operators and regulators to the development of adverse, or unexpected, trends in the monitoring data.

**3.4.2** Control levels are additional specific concentrations defined as criteria below which a WTA can be considered to be operating within expected and acceptable pollutant reduction efficiency. Additionally, control levels can be set to allow for variation in natural water quality from baseline conditions as well as giving sufficient time to take corrective or remedial action before trigger levels are breached.

**3.4.3** It is therefore proposed to maintain quarterly monitoring during the 5 year aftercare period to demonstrate compliance with the NRW trigger levels but also to identify baseline conditions and trends so that any statistically relevant deviations can be identified and contingencies put into practice before a trigger level is potentially breached. Accordingly a control level will be defined for each pollutant at the $95^{th}$ %ile of the baseline data set or similar in agreement with NRW. In this way, the range of natural variation of baseline conditions can be accounted for.

**3.4.4** A significant control level breach will be considered to have occurred following 3 consecutive exceedances of the control level or other number in agreement with NRW. Such an approach allows for sporadic, non-repeating fluctuations to be observed but discounted as they are not in themselves considered as significant or warranting corrective actions to be implemented.

**3.4.5** Following the identification of a significant control level breach following consecutive exceedances of a control level, corrective action would be started. This would be agreed with NRW within the Surface Water Management Plan but would typically involve the communication of the event to concerned parties, the instigation of further monitoring to verify conditions and further investigations of the drainage catchment to identify likely causes and to propose mitigation. In the first instance, this would likely be the inspection of grass lined channels and the WTA for possible causes potentially leading to the removal of silts from grass lined channels or WTA lagoons or partial regeneration of reed beds.

**3.4.6** It is considered that this methodology will provide the necessary understanding of drainage treatment functionality and provide evidence to NRW of adequate levels of WTA performance and hence protection of surface water quality, whilst allowing for timely identification and intervention should significant deficiencies in WTA performance occur.

**3.4.7** This contingency supports Commitment Ref. No. 102 and No.103 to provide, as part of a general environmental monitoring strategy, trigger levels for ongoing construction and operation monitoring to be agreed and a protocol for reporting any problems quickly.

## 3.5 Reen Flow and Storage Management

**3.5.1** Whilst not accounted for within the risk assessments for proposed water discharges, reen character and flow characteristics may at times be identified as a contributing factor to the rise in concentrations of pollutants derived from motorway run-off.

**3.5.2** Although calculated as a very low risk, for contingency purposes a scenario is identified that, following all necessary WTA and grass lined channel repair and maintenance having being implemented, there remains strong evidence that a WTA discharge is responsible for unacceptable water quality deterioration and trend analysis suggests long term breach of water quality standards, i.e. breach of NRW trigger levels. In this hypertheoretical scenario, it is proposed that the receiving reen be investigated to identify measures in which in-reen dilution and dispersion could be enhanced through increase in channel volume and/or increase in average flow rates.

**3.5.3** Reen channel volume flow rates could be enhanced by widening or deepening during routine dredging. Reen flow rates could be enhanced by the managing of local water level (penning) to promote flow in the vicinity of a WTA discharge. Finally, WTA discharge rates could be adjusted where evidence could be gathered to demonstrate the necessary storm water flows through the drainage system could still be accommodated due to the over pessimistic assumptions utilised during design.

## 3.6 Sediment Monitoring and Recovery

**3.6.1** As a final resort where unacceptable sediment discharge and accumulation was considered to be occurring as a consequence of WTA discharge, sampling would be undertaken for chemical analysis. Early dredging would be considered where concentrations found to exceed HAWRAT chronic toxicity thresholds for heavy metals and PAH were assessed as contributing to unacceptable long term water quality and demonstrably adverse impacts on aquatic ecology. This could be undertaken during routine reen dredging within the Gwent Levels SSSI.

# 4 Conclusions

**4.1.1** Further information has been provided on the HAWRAT methodology to highlight the conservatism of this approach and what further steps have been taken to further limit the dependence on reen flow in the prediction of worst case impacts on water quality. These are as follows

- A review of regional rainfall data to show first flush events - representing the occasion pollutant is actually mobilised from the carriageway – occurs more infrequently than assumed for the risk assessment;
- A five-fold reduction in assumed low flow conditions to 100 times smaller than the summer baseline flows modelled within the Flood Consequences Assessment; and
- Use of actual reen widths which are up to 71% and on average 42% smaller than the generic reen width used by the original HAWRAT assessments based on the Drainage Strategy Report generic width of 4.2m.

**4.1.2** A number of contingency measures have been identified and described to provide further assurances that reen water quality can be managed effectively and be further protected in the albeit ver low risk of deteriorating chemical or ecological conditions as a consequence of treated drainage discharges. These include

- Grass lined channel and Water Treatment Area maintenance;
- Post construction monitoring;
- Trigger and control levels reporting;
- Reen flow and storage management; and
- Sediment monitoring and recovery.

**4.1.3** In summary, the revised risk assessment has shown there is high confidence that the proposed Water Treatment Area discharges will preserve reen baseline water quality within existing baseline conditions. It is concluded that associated potentially adverse effects on the Gwent Levels Sites of Special Scientific Interest as a consequence of operational motorway drainage can be avoided.

# 5 References

Environment Agency, 2003. Report SC030219. Rainfall runoff management for developments.

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# Annex 1 HAWRAT Results

| WTA | Reen | WTA Treatment Stages | Solubles Removal Efficiency | Mean Cu PNEC | Mean Cu EMC to PNEC AF | Residual AF | Mean Cu ABC | Mean Cu EMC to ABC AF | Residual AF | 95th%ile Cu Reen ABC | Mean Cu EMC to 95th%ile ABC AF | Residual AF | Mean Zn PNEC | Mean Zn EMC to PNEC AF | Residual AF | Mean Zn ABC | Mean Zn EMC to ABC AF | Residual AF | 95th%ile Zn Reen ABC | Mean Zn EMC to 95th%ile ABC AF | Residual AF |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Pwll Bargoed Reen | 3 | 82.2% | 4.60 | 85.8% | 3.6% | 1.01 | 96.9% | 14.7% | 2.01 | 93.8% | 11.6% | 18.94 | 82% | 0.1% | 2.69 | 97.5% | 15.3% | 5.30 | 95.1% | 12.9% |
| 2 | Tyn-y-Brwyn Reen | 3 | 82.2% | 22.82 | 29.3% | 0% | 1.66 | 94.9% | 12.7% | 4.33 | 86.6% | 4.4% | 29.34 | 73% | 0% | 2.50 | 97.7% | 15.5% | 6.22 | 94.2% | 12.0% |
| 4a+4b | Percoed Branch East | 4 | 94.8% | 35.36 | 0% | 0% | 1.16 | 96.4% | 1.6% | 2.70 | 91.6% | 0% | 33.81 | 68% | 0% | 5.28 | 95.1% | 0.3% | 15.49 | 85.5% | 0% |
| 5 | Morfa Gronw Reen | 4 | 94.8% | 57.08 | 0% | 0% | 2.10 | 93.5% | 0% | 5.74 | 82.2% | 0% | 58.00 | 46% | 0% | 5.23 | 95.1% | 0.3% | 13.40 | 87.5% | 0% |
| 6 | Lakes Reen | 4 | 94.8% | 59.11 | 0% | 0% | 1.81 | 94.4% | 0% | 5.94 | 81.6% | 0% | 55.00 | 49% | 0% | 5.23 | 95.1% | 0.3% | 16.16 | 84.9% | 0% |
| 7 | Julians Reen | 4 | 94.8% | 56.73 | 0% | 0% | 1.19 | 96.3% | 1.5% | 3.15 | 90.2% | 0% | 47.96 | 55% | 0% | 2.45 | 97.7% | 2.9% | 7.99 | 92.6% | 0% |
| 8 | Ellen Reen | 4 | 94.8% | 54.30 | 0% | 0% | 0.76 | 97.6% | 2.8% | 1.66 | 94.8% | 0% | 45.85 | 57% | 0% | 1.44 | 98.7% | 3.9% | 2.40 | 97.8% | 3.0% |
| 8a | Black Wall Reen | 3 | 82.2% | 49.25 | 0% | 0% | 0.93 | 97.1% | 14.9% | 2.23 | 93.1% | 10.9% | 45.08 | 58% | 0% | 1.34 | 98.8% | 16.6% | 2.91 | 97.3% | 15.1% |
| 9 | Middle Road Reen Diversion | 4 | 94.8% | 36.39 | 0% | 0% | 2.62 | 91.9% | 0% | 6.01 | 81.4% | 0% | 36.35 | 66% | 0% | 4.01 | 96.3% | 1.5% | 15.06 | 86.0% | 0% |
| 10 | Rush Wall Reen | 3 | 82.2% | 61.49 | 0% | 0% | 1.60 | 95.0% | 12.8% | 4.97 | 84.6% | 2.4% | 67.27 | 37% | 0% | 2.72 | 97.5% | 15.3% | 9.68 | 91.0% | 8.8% |
| 11b+11c | Mill Reen | 3 | 82.2% | 8.14 | 74.8% | 0% | 0.75 | 97.7% | 15.5% | 1.69 | 94.8% | 12.6% | 21.77 | 80% | 0% | 1.38 | 98.7% | 16.5% | 2.98 | 97.2% | 15.0% |
| 12a | Prat Reen | 3 | 82.2% | nd | - | - | nd | - | - | nd | - | - | nd | - | - | nd | - | - | nd | - | - |
| 12b | Furlong Reen | 3 | 82.2% | nd | - | - | nd | - | - | nd | - | - | nd | - | - | nd | - | - | nd | - | - |

nd=no data. WTA=Water Treatment Area. PNEC=Probable No Effect Concentration. EMC=Event Mean Concentration. ABC=Ambient Background Concentration. AF=Attenuation Factor.
Values shown in red exceed Solubles Removal Efficiency for WTA based on CIRIA C609 evaluation methodology.

| Soluble COC | Concentration (ug/L) | Required AF | 3 Stage AF | Stage AF |
|---|---|---|---|---|
| Mean Cu EMC | 32.3 | | | |
| 95th%ile Cu EMC | 84.0 | | | |
| Cu RST6 | 42 | 0% | 82.2% | 94.8% |
| Cu RST24 | 21 | 75.0% | | |
| Mean Zn EMC | 107.22 | | | |
| 95th%ile Zn EMC | 325.64 | | | |
| Zn RST6 | 120 | 0% | 82.2% | 94.8% |
| Zn RST24 | 60 | 81.6% | | |
| Mean Cd EMC | 0.26 | | | |
| Max Cd EMC | 3.12 | | | |
| Cd EQS AA | 0.15 | 42.3% | 82.2% | 94.8% |
| Cd EQS MAC | 0.9 | 71.2% | | |
| Mean Cl EMC | 349.5 | 28.5% | | |
| Cl EQS AA | 250 | | | |

# Annex 2: Drainage and WTA Design Information

| Water Treatment Area No. | Drained Chainage Start (m) | Drained Chainage End (m) | Total Drained Chainage (m) | Receiving Watercourse | Reen Width (m) | Estimated Highway Run-off Storage ($m^3$) | Contributing Impermeable Area (Ha) | Discharge Rate (l/s) | Treatment Train Stages | Treatment Train Efficiency (%) | HAWRAT Required Sediment Reduction (%) | HAWRAT DI |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1350 | 2850 | 1500 | Pwll Bargoed Reen | 2.6 | 9,000 | 9.3 | 32.6 | 3 | 82.2 | 92 | 95 |
| 2 | 2850 | 4300 | 1450 | Tyn-y-Brwyn Reen | 2.5 | 10,500 | 11.5 | 40.3 | 3 | 82.2 | 94 | 99 |
| 4a | 4300 | 6550 | 2250 | Percoed Branch East | 1.3 | 4,200 | 4.3 | 15.1 | 4 | 91.4 | 96 | 94 |
| 4b | | | | | | 4,200 | 4.2 | 14.7 | 4 | 91.4 | | |
| 5 | 6550 | 10150 | 3600 | Morfa Gronw Reen | 1.5 | 7,000 | 7.3 | 25.6 | 4 | 91.4 | 94 | 70 |
| 6 | 10150 | 12400 | 2250 | Lakes Reen | 1.2 | 4,000 | 4.8 | 16.8 | 4 | 91.4 | 93 | 57 |
| 7 | 12400 | 13350 | 950 | Julians Reen | 2.7 | 3,600 | 4.1 | 14.4 | 4 | 91.4 | 80 | 22 |
| 8 | 13350 | 15500 | 2150 | Ellen Reen | 5.9 | 8,400 | 9.0 | 31.5 | 4 | 91.4 | 80 | 22 |
| 8a | Glan Llyn junction | | - | Black Wall Reen | 2.1 | 3,500 | 1.0 | 3.5 | 3 | 82.2 | 36 | 13 |
| 9 | 15500 | 19100 | 3600 | Middle Road Reen Diversion | 4.2 | 13,000 | 15.8 | 55.3 | 4 | 91.4 | 92 | 54 |
| 10 | 19100 | 20500 | 1400 | Rush Wall South Reen | 1.5 | 2,700 | 3.3 | 11.6 | 3 | 82.2 | 87 | 58 |
| 11b | 20500 | 21300 | 800 | Mill Reen | 1.4 | 7,950 | 6.0 | 17.7 | 3 | 82.2 | 97 | 208 |
| 11c | 21300 | 22050 | 750 | Mill Reen | 1.4 | 5,100 | 5.0 | 17.5 | 3 | 82.2 | | |
| 12a | 22050 | 23950 | 1900 | Prat Reen North | dry | 18,000 | 14.4 | 50.4 | 3 | 82.2 | nd | nd |
| 12b | M48 junction | | - | Furlong Reen | dry | 675 | 0.73 | 2.6 | 3 | 82.2 | nd | nd |
| **TOTALS** | | | | | | **101,825** | **100.7** | | | | | |

| Water Treatment Area No. | Drained Chainage Start (m) | Drained Chainage End (m) | Total Drained Chainage (m) | Located In SSSI? | SSSI Chainage Start (m) | SSSI Chainage End (m) | SSSI Total Chainage (m) | Grass Lined Channels ? | Grass Lined Channel Chainage Start (m) | Grass lined channel Chainage End (m) | Grass Llined Channel Total Length (m) | %SSSI with Grass Lined Channels |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1350 | 2850 | 1500 | No | - | - | 0 | No | 1,350 | 2,800 | 1,450 | - |
| 2 | 2850 | 4300 | 1450 | No | - | - | 0 | No | 2,800 | 4,300 | 1,500 | - |
| 4a | 4300 | 6550 | 2250 | Yes | 5,000 | 6,550 | 1,550 | Yes | 4,300 | 6,400 | 2,100 | 100% |
| 4b | | | | Yes | | | | | | | | |
| 5 | 6550 | 10150 | 3600 | Yes | 6,550 | 8,450 | 1,900 | Yes | 6,750 | 8,150 | 1,400 | 74% |
| 6 | 10150 | 12400 | 2250 | No | - | - | 0 | E/B only | 11,400 | 12,400 | 1,000 | - |
| 7 | 12400 | 13350 | 950 | Yes | 13,000 | 13,350 | 350 | Yes | 12,650 | 13,350 | 700 | 100% |
| 8 | 13350 | 15500 | 2150 | Yes | 13,350 | 14,900 | 1,550 | Yes | 13,350 | 15,500 | 2,150 | 100% |
| 8a | Glan Llyn junction | | - | No | - | - | 0 | No | - | - | 0 | - |
| 9 | 15500 | 19100 | 3600 | Yes | 16,550 | 19,100 | 2,550 | Yes | 15,500 | 19,100 | 3,600 | 100% |
| 10 | 19100 | 20500 | 1400 | Yes | 19,100 | 20,050 | 950 | Limited | 19,100 | 19,150 | 50 | 5% |
| 11b | 20500 | 21300 | 800 | No | - | - | 0 | No | - | - | 0 | - |
| 11c | 21300 | 22050 | 750 | No | - | - | 0 | No | - | - | 0 | - |
| 12a | 22050 | 23950 | 1900 | No | - | - | 0 | No | - | - | 0 | - |
| 12b | M48 junction | | - | No | - | - | 0 | No | - | - | 0 | - |
| **TOTALS** | | | | | | | **8,850** | | | | **13,950** | **80%** |

| Water Treatment Area No. | Drained Chainage Start (m) | Drained Chainage End (m) | Total Drained Chainage (m) | Water Treatment Area No. | Drained Chainage Start (m) | Drained Chainage End (m) | Total Drained Chainage (m) | Atenuation Lagoon volume ($m^3$) | HRT Volume ($m^3$) | HRT Area ($m^2$) | Proposed Reed Bed Area ($m^2$) | Proposed Area / HRT Area |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1350 | 2850 | 1500 | 1 | 1350 | 2850 | 1500 | 6,680 | 39 | 65 | 7,100 | 109.1% |
| 2 | 2850 | 4300 | 1450 | 2 | 2850 | 4300 | 1450 | 11,180 | 48 | 81 | 7,210 | 89.6% |
| 4a | 4300 | 6550 | 2250 | 4a | 4300 | 6550 | 2250 | 8,068 | 18 | 30 | 3,890 | 129.2% |
| 4b | | | | 4b | | | | 6,509 | 18 | 29 | 3,750 | 127.6% |
| 5 | 6550 | 10150 | 3600 | 5 | 6550 | 10150 | 3600 | 23,079 | 31 | 51 | 6,329 | 123.9% |
| 6 | 10150 | 12400 | 2250 | 6 | 10150 | 12400 | 2250 | 6,465 | 20 | 34 | 3,336 | 99.3% |
| 7 | 12400 | 13350 | 950 | 7 | 12400 | 13350 | 950 | 3,725 | 17 | 29 | 2,859 | 99.6% |
| 8 | 13350 | 15500 | 2150 | 8 | 13350 | 15500 | 2150 | 8,261 | 38 | 63 | 6,379 | 101.3% |
| 8a | Glan Llyn junction | | - | 8a | Glan Llyn junction | | - | 3,590 | 4 | 7 | 3,373 | 481.9% |
| 9 | 15500 | 19100 | 3600 | 9 | 15500 | 19100 | 3600 | 27,255 | 66 | 111 | 10,299 | 93.1% |
| 10 | 19100 | 20500 | 1400 | 10 | 19100 | 20500 | 1400 | 20,439 | 14 | 23 | 8,062 | 349.0% |
| 11b | 20500 | 21300 | 800 | 11b | 20500 | 21300 | 800 | 7,802 | 21 | 35 | 2,770 | 78.2% |
| 11c | 21300 | 22050 | 750 | 11c | 21300 | 22050 | 750 | 2,255 | 21 | 35 | 3,200 | 91.4% |
| 12a | 22050 | 23950 | 1900 | 12a | 22050 | 23950 | 1900 | 20,775 | 60 | 101 | 11,595 | 115.0% |
| 12b | M48 junction | | - | 12b | M48 junction | | - | 354 | 3 | 5 | 450 | 88.1% |
| **TOTALS** | | | | **TOTALS** | | | | **156,437** | | **699** | **80,602** | **115.4%** |

**Reed bed Sizing formula variables**

| **Input Parameter** | **Value** | **Units** | **Notes** |
|---|---|---|---|
| Greenfield Run-off Rate | 3.5 | L/s/Ha | NRW design parameter |
| Wetland depth | 0.6 | m | Drainage design parameter |
| Substrate porosity | 37.5 | % | Reed bed design parameter |
| Hydraulic Rentention Time | 12.5 | hours | 10-15 hrs recommended - mid value used |

| **Calculated Parameter** | **Value** | **Units** | **Optimal Range** |
|---|---|---|---|
| SSF Void Volume / Drained Area | 158 | $m^3$/Ha | Min. 100 $m^3$ for 10 mm first flush recommended by EA |
| Average Reed Bed Area / Drained Area | 800 | $m^2$/Ha | not prescribed |
| Hydraulic Loading Rate (HLR) | 43.20 | ($m^3/m^2/d$) | Recommended <1.0. Optimum = 0.2. Acceptable HLR |