Water UK / Environment Agency Storm Overflows Assessment Framework (SOAF)
Invertebrate Impact Assessment using RICT 2

In England, during Asset Management Plan (AMP) 7 between 2020 and 2025, the water industry will be reviewing the impact of storm overflows that discharge frequently to rivers, transitional and coastal waters. There are approximately 750 investigations set out in the Water Industry Environment Programme (WINEP) from the 2019 Price Review (PR19).

These investigations will follow the Storm Overflows Assessment Framework (SOAF). The SOAF involves a 5 stage process. Event duration monitoring data (EDM) is used to identify storm overflows that discharge frequently. The reasons for frequent spills are identified under Stage 1. These reasons could include operational problems such as partial blockages, exceptional rainfall or a general hydraulic incapacity. If discharges are due to a lack of hydraulic capacity, then the investigations proceed to Stage 2. This stage attempts to quantify the environmental impact of the discharge through aesthetic surveys, and an estimation of water quality impact through either invertebrate surveys or water quality modelling. The impact data is used to inform Stage 3, which considers the costs and monetised benefits of potential improvement schemes. Any cost beneficial schemes identified (Stage 4) will be delivered subject to funding under Stage 5.

For the Stage 2 environmental impact assessment, where it is possible to collect representative benthic invertebrate samples immediately upstream and downstream of the overflow, impact will be assessed using abundance weighted Whalley Hawkes Paisley Trigg (WHPT) indices with the River Invertebrate Classification Tool (RICT 2). This is the method used for WFD assessments (UKTAG, 2014). The method is designed to detect impacts due to organic pollution and is also sensitive to toxic pollutants.

RICT 2 is a web application that implements the RIVPACS IV predictive model. This tool is maintained by the UK's environment agencies; Scottish Environment Protection Agency (SEPA), Environment Agency (EA), Natural Resources Wales (NRW) and Northern Ireland Environment Agency (NIEA). RICT2 replaces RICT, which was a web based application hosted by SEPA.

Invertebrate sampling is only appropriate in simple scenarios where there is a single storm overflow discharging to that reach of the river. Where there are multiple outfalls in close proximity, or other sources of pollution which could account for differences in invertebrate quality between sampling sites upstream and downstream of the outfall, then this method should not be used. In degraded urban watercourses where background / upstream invertebrate quality is already poor status then this method should also not be used.

Invertebrate sampling and analysis should be carried out according to Environment Agency operational instructions 024_08 and 018_08 (Environment Agency 2014, 2017). A minimum of two separate seasonal samples are required – one taken in the spring (March – May), and one taken in the autumn (September – November). The number of abundance weighted WHPT scoring families found during sampling (WHPT NTAXA), and their individual abundance weighted scores for sensitivity to organic pollution are recorded. An average score per taxon

(ASPT) for the sample is then calculated. The observed abundance weighted WHPT NTAXA and ASPT values are compared to the values that might be expected under undisturbed or reference conditions for that site. These undisturbed or reference scores are predicted by statistical models in the RICT 2 software (RIVPACS IV). The observed values of WHPT ASPT and WHPT NTAXA are compared to the predicted values to generate an Environmental Quality Ratio (EQR). EQRs close to 1.0 indicate that invertebrate communities are close to their natural state. The EQR ratios for different WFD invertebrate status classes are shown in Table 1 below:

Table 1. Environmental quality ratios for invertebrate status

EQR Values		Invertebrate Status Class
WHPT NTAXA	**WHPT ASPT**	
>=0.8	>=0.97	High
>=0.68	>=0.86	Good
>=0.56	>=0.72	Moderate
>=0.47	>=0.53	Poor
<0.47	<0.53	Bad

During WFD assessments prediction and classification of invertebrate quality is carried out for each of the individual spring and autumn samples. A mean EQR is then calculated for the two seasons. Overall classification is based on the worst status class assigned for the multi – season mean WHPT NTAXA and WHPT ASPT. RICT2 uses Monte Carlo processes to simulate uncertainty in observed and expected EQRs due to factors such as sampling variation, error in measuring environmental variables, and laboratory processing errors (bias). The software typically uses 10,000 ‘shots’ to build up a distribution of potential EQRs in order to estimate confidence of status class. To assess the impact of high frequency spillers, the RICT 2 Compare Experiment will be used to compare the quality of the upstream and downstream sampling sites. The outputs show the probability, or percentage number of simulations where the downstream sample is one or more status classes worse than the upstream sample for both WHPT NTAXA and ASPT. The scoring system in Tables 2a and 2b below will be used for both indices (WHPT NTAXA & ASPT):

Table 2a. Invertebrate impact scoring for WHPT NTAXA & ASPT.

% of simulations the downstream sample is one or more classes worse than upstream	Score	Class Multiplier
1 – 4	1	× 1.0 if the downstream sample is one class worse than upstream, × 2.0 if the downstream sample is more than one class worse than upstream
5 – 9	2	
10 – 29	4	
30 – 49	6	
50 – 70	8	
71 – 90	10	
>90	12	

Table 2b. Invertebrate impact classification for WHPT NTAXA & ASPT.

Total score	Overall classification
1	No impact
2 – 3	Very low
4 – 5	Low
6 – 7	Moderate
8 – 9	High
10 – 11	Very high
12 – 15	Severe
16 – 19	Very severe
20 or more	Extremely severe

The worst score for WHPT NTAXA and ASPT should be used to assign impact. The scoring process will be repeated for each of the individual spring and autumn samples, and the overall mean of the seasons in order to produce a short – term and long – term impact assessment (Table 2c).

Table 2c. Overall short and long – term invertebrate impact classification

Type	Description	Value
Short – term	Worst single season classification result for WHPT NTAXA and ASPT	No impact – extremely severe
Long – term	Worst of WHPT NTAXA and ASPT for the overall multi season (spring & autumn) classification	No impact – extremely severe

Worked example:

The following hypothetical example is based on data for sites on the River Blithe. It shows how WHPT invertebrate indices are classified using RICT2, how the upstream results are compared with the downstream site using the Compare Experiment, and how impact is scored and classified under the SOAF.

Table 3 shows the results for WHPT NTAXA and ASPT for invertebrate samples collected in spring and autumn at the upstream site. Table 4 summarises the environmental characteristics of the upstream sampling site. Average environmental quality ratios (EQRs) simulated by RICT2, along with their status and confidence of class for the spring, autumn and combined season samples are shown in Table 5.

Table 3. WHPT NTAXA & ASPT results for upstream spring and autumn samples.

Season	WHPT NTAXA	WHPT ASPT
Spring	16	5.125
Autumn	16	5.125

Table 4. Environmental variables for the upstream sample site.

Environmental variable		Value
Grid reference		SK 04800 25900
Altitude (mAOD)		97
Slope (m/km)		1.8
Discharge category (1 – 10)		3
Distance from source (km)		27
Mean width (m)		10
Mean depth (cm)		8.7
Mean alkalinity (mg $CaCO_3$/l)		164
Substrate composition (% cover):		
	Boulder / cobbles	25
	Pebbles / gravel	53
	Sand	15
	Silt/clay	7

Table 5. Upstream sample classification results.

Season	Index	Average Face Value EQR	Class	Probability (%)
Spring	WHPT NTAXA	0.650	Moderate	42.0
	WHPT ASPT	0.852	Moderate	52.46
Autumn	WHPT NTAXA	0.634	Moderate	46.63
	WHPT ASPT	0.880	Good	52.25
Spring & autumn	WHPT NTAXA	0.642	Moderate	55.81
	WHPT ASPT	0.866	Good	53.46

Tables 6 and 7 show the results of the WHPT indices and environmental variables respectively for the downstream sample site. The downstream sample point is approximately 100m downstream of the upstream site, is narrower, deeper, and has a higher proportion of sand, silt & clay. Lower values of WHPT NTAXA and ASPT were recorded for both the spring and autumn samples compared to upstream. The average environmental quality ratios (EQRs) simulated by RICT2 for the downstream samples, along with their quality class and confidence of class for the spring, autumn and combined seasons are shown in Table 8.

Table 6. WHPT NTAXA & ASPT results for downstream spring and autumn samples.

Season	WHPT NTAXA	WHPT ASPT
Spring	14	4.82
Autumn	13	4.77

Table 7. Environmental variables for the downstream sample site.

Environmental variable		Value
Grid reference		SK 04745 25728
Altitude (mAOD)		96
Slope (m/km)		1.8
Discharge category (1 – 10)		3
Distance from source (km)		27.1
Mean width (m)		5
Mean depth (cm)		17
Mean alkalinity (mg $CaCO_3$/l)		162
Substrate composition (% cover):		
	Boulder / cobbles	22
	Pebbles / gravel	48
	Sand	20
	Silt/clay	10

Table 8. Downstream sample classification results.

Season	Index	Average Face Value EQR	Class	Probability (%)
Spring	WHPT NTAXA	0.578	Moderate	39.76
	WHPT ASPT	0.808	Moderate	68.26
Autumn	WHPT NTAXA	0.531	Poor	36.09
	WHPT ASPT	0.823	Moderate	63.56
Spring & autumn	WHPT NTAXA	0.554	Poor	43.21
	WHPT ASPT	0.816	Moderate	79.15

Tables 9, 10 and 11 show the results of the comparison experiment between the upstream and downstream samples for the individual spring and autumn seasons, and for the overall

combined spring & autumn classification. The tables show the probability/percentage number of the 10,000 simulations where the downstream sample was in the same or a different class to the upstream sample. For example, in Table 11 which shows the comparison for the overall classification, 40.41% of the simulations for downstream WHPT ASPT were one status class worse than the upstream site.

Table 9. RICT2 outputs for comparison of upstream and downstream samples collected in spring.

WHPT Index	% of simulations where the downstream sample is in the same or a different WFD status class compared to upstream				
	More than 1 class worse	1 class worse	Same	1 class better	More than 1 class better
NTAXA	0	62.96	37.04	0	0
ASPT	0	33.2	66.8	0	0

Table 10. RICT2 outputs for comparison of upstream and downstream samples collected in autumn.

WHPT Index	% of simulations where the downstream sample is in the same or a different WFD status class compared to upstream				
	More than 1 class worse	1 class worse	Same	1 class better	More than 1 class better
NTAXA	2.9	86.16	10.94	0	0
ASPT	0	45.7	54.3	0	0

Table 11. RICT2 outputs for comparison of upstream and downstream following multi – season classification (spring & autumn).

WHPT Index	% of simulations where the downstream sample is in the same or a different WFD status class compared to upstream				
	More than 1 class worse	1 class worse	Same	1 class better	More than 1 class better
NTAXA	0	80.27	19.73	0	0
ASPT	0	40.41	59.59	0	0

The scoring method for estimating impact is summarised in Tables 12a – 12c. The method involves a 'worst of' approach for WHPT NTAXA and WHPT ASPT, and is repeated for the individual spring and autumn season samples, as well as the overall multi – season classification in order to estimate both short – term (single season) as well as longer – term (overall) impacts.

Table 12a. Invertebrate impact scoring for WHPT NTAXA & ASPT.

% of simulations the downstream sample is one or more classes worse than upstream	Score	Class Multiplier
1 – 4	1	× 1.0 if the downstream sample is one class worse than upstream, × 2.0 if the downstream sample is more than one class worse than upstream
5 – 9	2	
10 – 29	4	
30 – 49	6	
50 – 70	8	
71 – 90	10	
>90	12	

Table 12b. Invertebrate impact classification for WHPT NTAXA & ASPT.

Total score	Overall classification
1	No impact
2 – 3	Very low
4 – 5	Low
6 – 7	Moderate
8 – 9	High
10 – 11	Very high
12 – 15	Severe
16 – 19	Very severe
20 or more	Extremely severe

Table 12c. Overall short and long – term invertebrate impact classification.

Type	Description	Value
Short – term	Worst single season classification result for WHPT NTAXA and ASPT	No impact – extremely severe
Long – term	Worst of WHPT NTAXA and ASPT for the overall multi season (spring & autumn) classification	No impact – extremely severe

Tables 13a – 13d summarise the results of the SOAF scoring assessment for this hypothetical example. For the spring scoring assessment the worst result was for NTAXA – 62.96% of the simulations gave downstream NTAXA values one WFD status class worse than upstream. From table 12a this gives a score of 8 which is classified as 'High' impact (Table 12b). For the autumn assessment, the worst result was seen again for NTAXA. In this case the percentage of simulations where the downstream sample was one class worse than upstream was higher

(86.16%), and 2.9% were two classes worse. From Tables 12a and 12b this gives a total score of 12 and an impact classification of 'Severe'. The overall multi – season (spring & autumn) WFD assessment gave a 'Very high' impact classification based on NTAXA, which was again worse than ASPT. Since the worst single season result was 'Severe' impact for NTAXA in autumn, this gives a SOAF short – term impact classification of 'Severe'. Impact was 'Very high' for the SOAF long – term classification.

Table 13a. Spring scoring assessment.

WHPT Index	One class worse than upstream				>1 classes worse than upstream				Overall score	Impact
	% sims	Score	× plier	Total score	% sims	Score	× plier	Total score		
NTAXA	62.96	8	1	8	0	0	2	0	8	High
ASPT	33.2	6	1	6	0	0	2	0	6	Moderate

Table 13b. Autumn scoring assessment.

WHPT Index	One class worse than upstream				>1 classes worse than upstream				Overall score	Impact
	% sims	Score	× plier	Total score	% sims	Score	× plier	Total score		
NTAXA	86.16	10	1	10	2.9	1	2	2	12	Severe
ASPT	45.7	6	1	6	0	0	2	0	6	Moderate

Table 13c. Spring & autumn scoring assessment.

WHPT Index	One class worse than upstream				>1 classes worse than upstream				Overall score	Impact
	% sims	Score	× plier	Total score	% sims	Score	× plier	Total score		
NTAXA	80.27	10	1	10	0	0	2	0	10	Very high
ASPT	40.41	6	1	6	0	0	2	0	6	Moderate

Table 13d. Short (single season) and long – term (spring & autumn) impact classification.

Assessment type	Impact
Short – term	Severe
Long – term	Very high

References

Environment Agency, 2014. Freshwater macroinvertebrate analysis of riverine samples: Operational Instruction 024_08. Issued 28/01/2014 Environment Agency, Bristol.

Environment Agency, 2017. Freshwater macroinvertebrate sampling in rivers: Operational Instruction 018_08. Issued 01/03/2017 Environment Agency, Bristol.