Chapter 16b
Non financial measures
Sewerage service serviceability indicators

Covering:
Sewage treatment works – BOD predicted performance
Sewage treatment works – SS predicted performance
Sewage treatment works – Ammonia predicted performance

Non financial measures
Chapter 16b
Sewerage service serviceability indicators

This table has three blocks and 9 lines.

They call for information concerning the sewage treatment works performance in relation to consent standards for biochemical oxygen demand (BOD), suspended solids (SS) and ammonia (NH_3).

The prediction of several aspects of sewage works performance is required to enable NIAUR to identify trends that may indicate declining asset condition at sewage treatment works. These add to the basket of indicators that together inform an assessment of serviceability to customers.

Guidance

The tables first two blocks cover:

- Sewage treatment works – BOD performance (lines 1 to 3)
- Sewage treatment works – SS performance (lines 4 to 6)
- Sewage treatment works - NH_3 performance (lines 7 to 9)

These 3 blocks cover the performance against the most common consent standards, biochemical oxygen demand (BOD), suspended solids (SS) and ammonia (NH_3). The measures of predicted performance reported are the proportion (percentage) of sewage treatment works which are **predicted to not have** statutory sampled values in each of these three categories, called events where:

a) Maximum value more than twice the consent value;
b) 95 percentile is greater than the consent value; and
c) Mean value is more than half the consent value.

The **not have** phrase means that higher values indicate better performance than lower values.

Rather than report performance for the past calendar year, the company is asked to report a predicted performance for the current calendar year, based on the past three years' performance. This requires a repetitive sequence of offline calculations to predict the proportion of 'no events' and the procedure is set out in Appendix A (methodology and calculations).

The company should report their numbers and those which are excluded from the calculations, recognising that not all sewage treatment works have numeric BOD, SS or NH_3 consents (column 2).

The company must note that the company level statistics (lines 1, 4 and 7) are not the sum of the individual works band values and need to be compiled separately as outlined in Appendix A to this chapter.

Company commentary

- The company should comment on its expectations and influences on performance in particular to the event categories, the use of three years' data and the reporting of predicted performance rather than actual;
- The analysis is normalised on prevailing consent standards applying. The company should report on changes to the standards and whether it has a material impact on the results in their commentary; and
- It is recognised that results are influenced by operational factors. The company is encouraged to position themselves to identify operational costs at works level, and to report such progress in their commentary.

Guidance to Reporters

Sewage treatment works – BOD performance
Sewage treatment works – SS performance
Sewage treatment works – NH_3 performance

Reporters should:

- review the calculations undertaken by the company including adherence to the methodology, assumptions made and calculations produced;
- challenge the results produced by the company to satisfy themselves that they are realistic and justifiable, and that the definitions have been interpreted correctly and adhered to;
- assess whether consent value changes have been applied correctly in the methodology;
- verify that where systems and procedures are in place for the collection and recording of works operating costs at works level they are "fit for purpose";
- comment on the collection and recording of works operating costs; and
- comment on company proposals regarding any other performance indicators proposed for this group of assets.

Appendices A & B
Table 16b
Methodology and calculations

Appendix A
Sewage treatment works BOD, SS & NH_3 performance
Lines 1- 9

Introduction

Three new indicators have been developed to enhance the existing "pass ~ fail" indicator for sewage treatment works by providing a measure of works performance measured in terms of the prevailing works consent values at the time the sample is taken. The requirement is to report the three indicator values for each of three determinands (BOD, SS and NH_3).

Description

Three indicator values are to be reported at company level for works in 4 size bands. The indicators provide a prediction of the proportion of sewage treatment works for which a defined "event" will not occur in the current calendar year based on their performance over the previous 3 years. Three "events" are specified:

Event	Distribution characteristic of m / c
A	Maximum value > 2.0
B	95%tile (Normal) > 1.0
C	Mean value > 0.5

where 'm' is a determinand measurement and 'c' is the prevailing consent for that determinand. Using the ratio m/c enables changes in the consent to be taken into account, so that we have an analysis 'normalised' to prevailing consents.

Data recording – sewage treatment works

1. It is suggested that the total asset stock of sewage treatment works is segregated into 6 bands according to the population equivalent served. Record the number of works in each band:

Population equivalent served	**Band 1**	**Band 2**	**Band 3**	**Band 4**	**Band 5**	**Band 6**
	< 250	250 to 500	500 to 2,000	2,000 to 10,000	10,000 to 25,000	> 25,000
Kg load BOD_5/day	<=15	>15 <=30	>30 <=120	>120 <=600	>600 <=1,500	>1,500

2. Record the legal consent value for each works and any changes throughout the year.

3. Record sanitary determinand compliance data (BOD, SS and NH_3) for all works in bands 3-6.

4. For the purposes of future analysis it is suggested that an accounting system should be put in place (where none currently exists) and data collection progressed to record the operating costs associated with the management of each of the company's works.

5. Reporting is at company level only (size band 3 and above). The company however may find it useful to collect individual band performance data for their own benefit and information.

Procedure for calculating sewage treatment works performance statistics

The off-line calculations are repetitive to generate data for each block (BOD, SS and NH_3), each line (population banding) and each works to report on event categories a, b, c.

For each works the following procedure generates in a series of steps to:

- Calculate maximum value, 95 percentile and mean values for each of the past three years' results, normalised to the prevailing consents (step 5);
- Whether the works is in either of the three event categories for each year (step 6);
- The average number of times it was in each category over last three years; and
- The probability of the works not being in each category (that is, predicted to have zero events) in the next year (that is, the current calendar year) based on the last three years, and based on an assumed poisson distribution.

The probability results for all the works in the relevant reporting cell are added and converted to a percentage for reporting in columns 2, 3 and 4.

It is suggested that the calculations are made as follows:

In the calculations the following convention for identifying years is:

Current year:	**y + 1**
Calendar year just ended:	**y**
2 years ago:	**y-1**
3 years ago	**y-2**

The forecast is being made for the current calendar year, ignoring any results in the current year.

Step 1: Repeat steps 2 to 9 then 10, 11, and 12 for each sewage treatment works in size bands 3 and above.

Step 2: Repeat steps 3 to 9 for each determinand D (≡ BOD, SS, NH_3) and for each treatment works within the company level works-band 'B'

Step 3: For each of the years y, y-1, and y-2: assemble the set of yearly measurements (typically monthly) made of each determinand D. Exclude works with five or less measurements in the year.

This gives three sets of '(n>=6)' values $\{m_1..m_n\}$.

Step 4: Divide each sample value by its prevailing **consent** value to give $\{m_1^*..m_n^*\}$. This normalises the analysis.

Step 5: For the set of values $\{m_1^*..m_n^*\}$ calculate for each year:

- **Sample maximum: max** = $\max\left(m_1^*..m_n^*\right)$
- **Sample mean:** $\overline{m} = \frac{1}{n}\sum_{i=1}^{n} m_i^*$
- **Sample standard deviation**: $s = \sqrt{\frac{1}{n-1}\sum_{i=1}^{n}\left(m_i^* - \overline{m}\right)^2}$
- **Sample 95%tile** = $\overline{m} + 1.64485 \times s$

Step 6: For current year (y) data,
let V1(y) = 1 if sample max > 2.0 and V1(y) = 0 otherwise; (category 'a' event)
let V2(y) = 1 if sample 95%tile > 1.0 and V2(y) = 0 otherwise; (category 'b' event)
let V3(y) = 1 if sample > 0.5 and V3(y) = 0 otherwise; (category 'c' event)

Similarly calculate V1(y-1), V1 (y-2),
Similarly calculate V2(y-1), V2(y-2),
Similarly calculate V3(y-1), V3(y-2),

Step 7: Calculate $r_{V_1} = \frac{V_1(y)+V_1(y-1)+V_1(y-2)}{3}$

and probability, $p(no\,event\ in\,(y+1); V_1 = 0) = \exp(-r_{V_1})$ (category 'a' event)

Step 8: Repeat step 6 with V_2 to give

probability, $p(no\,event\ in\,(y+1); V_2 = 0) = \exp(-r_{V_2})$ (category 'b' event)

Step 9: Repeat step 6 with V_3 to give

probability, $p(no\,event\ in\,(y+1); V_3 = 0) = \exp(-r_{V_3})$ (category 'c' event)

Company level statistics:

Note that the company level statistics are those for size bands 3 to 6 taken as a single group. The respective total number of works (N_{works}) is entered in table 16b, column 1, lines 1, 4 and 7. For line 7 the total relates only to those works with ammonia consents.

Step 10: **Report** indicator category 'a' event {entered in column 2} for the company is defined as the expected percentage of 'no events' of V_1 for all STWs:

I_a = 100 x [sum of all values of $p(no\,event\ in\,(y+1); V_1 = 0)$] / N_{works}

Step 11: **Report** indicator category 'b' event {entered in column 3} for the company is defined as the expected percentage of 'no events' of $V_{2\,for}$ all STWs:

I_b = 100 x [sum of all values of $p(no\,event\ in\,(y+1); V_2 = 0)$] / N_{works}

Step 12: **Report** indicator category 'c' event {entered in column 4} for the company is defined as the expected percentage of 'no events' of V_3 for all STWs:

I_c = 100 x [sum of all values of $p(no\,event\ in\,(y+1); V_3 = 0)$] / N_{works}

The company should report in the commentary how many works do not have three sets of data with 12 or more samples reported for each report year.

Expectations on enumeration

In step 10 of the procedure we ask the company to report the indicator of the category 'a' event {entered in column 2} which is the expected percentage of 'no events' of V_1 for 'N_{works}':
I_a = 100 x [sum of all values of $p(no\,event\ in\,(y+1); V_1 = 0)$] / N_{works}

And similarly in steps 11, 12, for the 'b' and 'c' events and steps 13, 14 and 16 for the 'a', 'b' and 'c' events at company level.

We confirm that the figure in the square brackets is the sum of the probabilities for each works calculated in step 7 (and similarly steps 8 and 9).

Noting that there are just four possible values for the probability of no event forecast for the next year (i.e. current calendar year) of any one works, that is when rv values are such that:

Works that have had a category 'a' event in each of the last 3 years, thus rv = (1 + 1+ 1) / 3 = 1;
Works that have had had a category 'a' event in two of the last 3 years, thus rv = (0 + 1 + 1) / 3 = 2/3;
Works that have had a category 'a' event in one of the last 3 years, thus rv = (0 + 0 + 1) / 3 = 1/3;
Works that have not had a category 'a' event in last 3 years, thus rv = (0 + 0 + 0) / 3 = 0.

And respectively exp(-rv) [also written e^{-rv}] values of probability of now event are therefore:

exp (-1)	=	0.368
exp (-2/3)	=	0.513
exp (-1/3)	=	0.717
exp (0)	=	1.000

The figure reported from step 10 into table 16b, a percentage figure, is thus one hundred times the sum of the relevant values for each works in the group, divided by the number (N_{works}) of works in the group. Taking the trivial example, where (for example) there were five works in the group, and, for convenience of illustration they respectively had performed across the range including, (for example, two works with no events in the last 3 years), the report figure is calculated thus:

Works1	probability of no event	= 0.368	corresponds to 3 events in last 3 years
Works 2	probability of no event	= 0.513	corresponds to 2 events in last 3 years
Works 3	probability of no event	= 0.717	corresponds to 1 events in last 3 years
Works 4	probability of no event	= 1.000	corresponds to 0 events in last 3 years
Works 5	probability of no event	= 1.000	corresponds to 0 events in last 3 years
Sum of all values		= 3.598	
Number of works, 'N_{works}'		= 5	
Probability for group of no event (in current year)		= 0.720	
Multiply by 100, and report		= 72.0 %	

This answer is to be interpreted as the percentage of works where no event is forecast for the current calendar year and reported in column 2 in table 16b. The company should check that they have included works where the probability is less than 1 (for example works 1, 2 and 3 in the illustration) and their respective probabilities in the summation.

Table 16b line definitions

A SEWAGE TREATMENT WORKS – BOD PERFORMANCE

1	Equivalent population band 3 to 6	nr %	0dp 1dp
Definition	Percentage of sewage treatment works (STW) where there are no BOD events forecast for the current calendar year in the relevant category a, b, c described below, based on the evidence of the previous three years' actual performance. See Appendix A for offline calculations. The number of works for which the forecast is made is reported in column 1 (0 dp). Event category: a) Maximum value more than twice the prevailing consent value; b) 95 percentile is greater than the prevailing consent value; and c) Mean value is more than half the prevailing consent value Column 2: percentage of STWs in column 1 where there are no events predicted in category a) (1dp) Column 3: percentage of STWs in column 1 where there are no events predicted in category b) (1dp) Column 4: percentage of STWs in column 1 where there are no events predicted in category c) (1dp).		
Primary Purpose	Confirming delivery of key outputs and service.		
Processing rule	Column 1; input Column 2 to 4: input to be calculated separately		
Responsibility	Network Regulation Team		

2	Excluded STWs	nr	0dp
Definition	Number of sewage treatment works where BOD performance cannot be calculated. Include all STWs in bands 1 and 2 (i.e. with a p.e. of <500) in line with tables 17a-g.		
Primary Purpose	Confirming delivery of key outputs and service.		
Processing rule	Input		
Responsibility	Network Regulation Team		

3	Total STWs	nr	0dp
Definition	Total number of sewage treatment works		
Primary Purpose	Confirming delivery of key outputs and service.		
Processing rule	Copied: from table 15 line 8.		
Responsibility	Comparative Efficiency & Performance Team		

B SEWAGE TREATMENT WORKS – SS PERFORMANCE

4	Equivalent population band 3 to 6	nr %	0dp 1dp
Definition	Percentage of sewage treatment works (STW) where there are no SS events forecast for the current calendar year in the relevant category a, b, c described below, based on the evidence of the previous three years' actual performance. See Appendix A for offline calculations. The number of works for which the forecast is made is reported in column 1 (0dp). Event category: a) Maximum value more than twice the prevailing consent value; b) 95 percentile is greater than the prevailing consent value; and c) Mean value is more than half the prevailing consent value Column 2: Percentage of STWs in column 1 where there are no events predicted in category a) (1dp) Column 3: Percentage of STWs in column 1 where there are no events predicted in category b) (1dp) Column 4: Percentage of STWs in column 1 where there are no events predicted in category c) (1dp).		
Primary Purpose	Confirming delivery of key outputs and service.		
Processing rule	Column 1: input Column 2 to 4: input to be calculated separately		
Responsibility	Network Regulation Team		

5	Excluded STWs	nr	0dp
Definition	Number of sewage treatment works where SS performance cannot be calculated. Include all STWs in bands 1 and 2 (i.e. with a p.e. of <500) in line with tables 17a-g.		
Primary Purpose	Confirming delivery of key outputs and service.		
Processing rule	Input		
Responsibility	Network Regulation Team		

6	Total STWs	nr	0dp
Definition	Total number of sewage treatment works		
Primary Purpose	Confirming delivery of key outputs and service.		
Processing rule	Copied from table 15 line 8		
Responsibility	Comparative Efficiency & Performance Team		

C SEWAGE TREATMENT WORKS – NH_3 PERFORMANCE

7	Equivalent population band 3 to 6	nr %	0dp 1dp
Definition	Percentage of sewage treatment works (STW) where there are no NH_3 events forecast for the current calendar year in the relevant category a, b, c described below, based on the evidence of the previous three years' actual performance. See Appendix A for offline calculations. The number of works for which the forecast is made is reported in column 1 (0dp). Event category: a) Maximum value more than twice the prevailing consent value; b) 95 percentile is greater than the prevailing consent value; and c) Mean value is more than half the prevailing consent value Column 2: Percentage of STWs in column 1 where there are no events predicted in category a) (1dp) Column 3: Percentage of STWs in column 1 where there are no events predicted in category b) (1dp) Column 4: Percentage of STWs in column 1 where there are no events predicted in category c) (1dp).		
Primary Purpose	Confirming delivery of key outputs and service.		
Processing rule	Column 1: input Column 2 to 4: input to be calculated separately		
Responsibility	Network Regulation Team		

8	Excluded STWs	nr	0dp
Definition	Number of sewage treatment works where NH_3 performance cannot be calculated. Include all STWs in bands 1 and 2 (i.e. with a p.e. of <500) in line with tables 17a-g.		
Primary Purpose	Confirming delivery of key outputs and service.		
Processing rule	Input		
Responsibility	Network Regulation Team		

9	Total STWs	nr	0dp
Definition	Total number of sewage treatment works		
Primary Purpose	Confirming delivery of key outputs and service.		
Processing rule	Copied from table 15 line 8		
Responsibility	Comparative Efficiency & Performance Team		

CHANGE CONTROL SHEET

CHAPTER 16b

2008/1.0	First issue of chapter for the SBP period