Appendix 9



Maelor Foods Wrexham - Proposed Increased Discharge Impact Assessment

Report Reference: UC16765
February 2023

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Maelor Foods Wrexham - Proposed Increased Discharge Impact Assessment

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Summary

WRc was engaged by Maelor Foods Ltd in 2015 to assess the impact of their proposed discharge at their new site in Wrexham. Maelor Foods now wish to understand the impact of doubling their current discharge from its poultry plant and has engaged WRc to undertake an assessment of this increased flow.

A water quality modelling assessment has been carried out for a proposed increase in discharge by Maelor Foods Ltd to the River Dee in Wrexham. The assessment used the Environment Agency's River Quality Planning (RQP) Monte Carlo tool to model the effect of the discharge on the downstream river quality, specifically for determinands: BOD, ammonia, orthophosphate, iron, chloride, and pH. A mass balance spreadsheet tool was used to model the resultant river temperature downstream of the discharge.

The river quality modelling using RQP showed that the predicted impact of increased discharge that had undergone tertiary treatment was small, with a <4% decrease predicted in downstream BOD, ammonia, and orthophosphate concentrations when compared to the current discharge. Downstream iron and chloride concentrations were higher. No change was observed in pH. All modelled downstream river concentrations were lower than the face value of the relevant river standard.

This was also reflected in the monthly temperature modelling, which showed a very small increase in temperature, apparent only at the second decimal place, under both average and Q95 (low) flow conditions in the river.

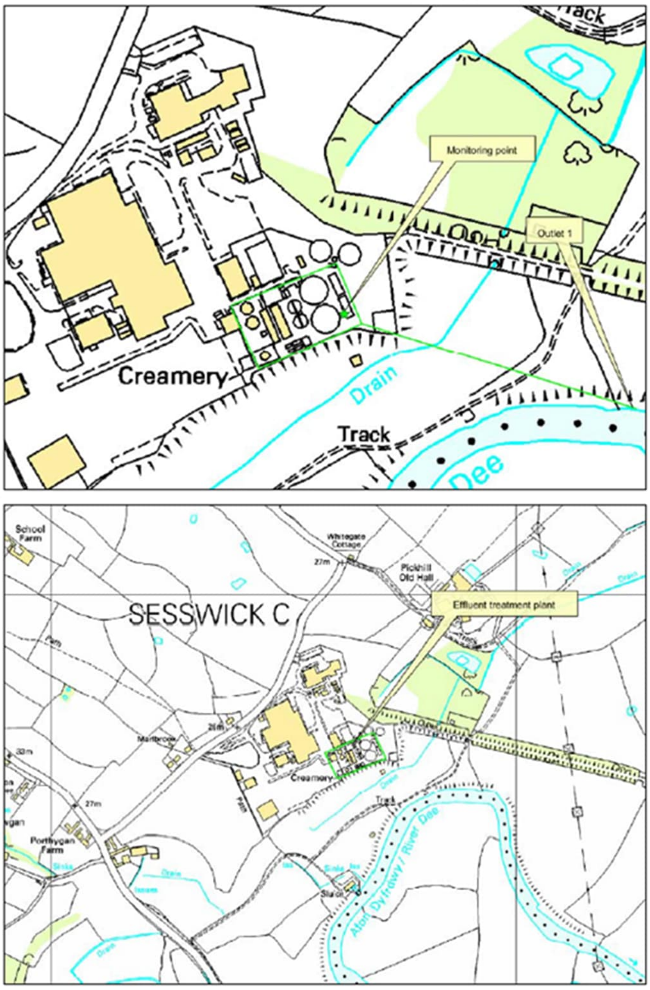
The results were based on proposed discharge flows of an average 2,400 m^3/d and a maximum 3,120 m^3/d, with quality based on the discharge concentrations associated with additional tertiary treatment at the site. The results showed negligible impact at this loading (flow and concentration) from the discharge, with a decrease in most determinands when compared to the current discharge.

1. Introduction

1.1 Background

Maelor Foods Ltd, a subsidiary of Salisbury Poultry Ltd, is to increase weekly processing potential within its poultry plant, 4 km southeast of Wrexham. It has been proposed that weekly throughput is to be doubled from the currently permitted 1 million birds per week, to 2 million birds per week. The approximate location of the site is shown in Figure 1.1.

Figure 1.1 Site plan from previous permit.



In 2015, WRc was commissioned to undertake a permit modelling assessment for the proposed discharge from the Maelor poultry plant into the River Dee.

In 2023, WRc was again commissioned to undertake a modelling assessment for a proposed doubling in discharge. The same modelling tool was used to assess the water quality impacts of the current and proposed increased discharge flows. This was to understand the current and future impacts of the discharge on the River Dee. To do this, the upstream river flow and water quality was updated based on the latest observed data.

1.2 Determinands

The assessment was required for the following determinands:

- BOD
- Total suspended solids
- Ammonia
- Orthophosphate
- Iron
- Chloride
- Temperature
- pH

1.3 Modelling tool

The Environment Agency's (EA) River Quality Planning Monte Carlo modelling tool is the most appropriate way of completing the impact assessment for all determinands, except temperature, as it can be used to predict the impact of point source discharges on receiving waters.

Temperature was modelled with a spreadsheet tool developed by WRc, rather than the River Quality Planning tool, as assessment of the impact of a discharge on temperature is required on a month-by-month basis and it is not possible to do this in RQP. A monthly assessment is required because the effluent is to be discharged above ambient river temperatures, which will vary throughout the year.

2. Data and Methodology

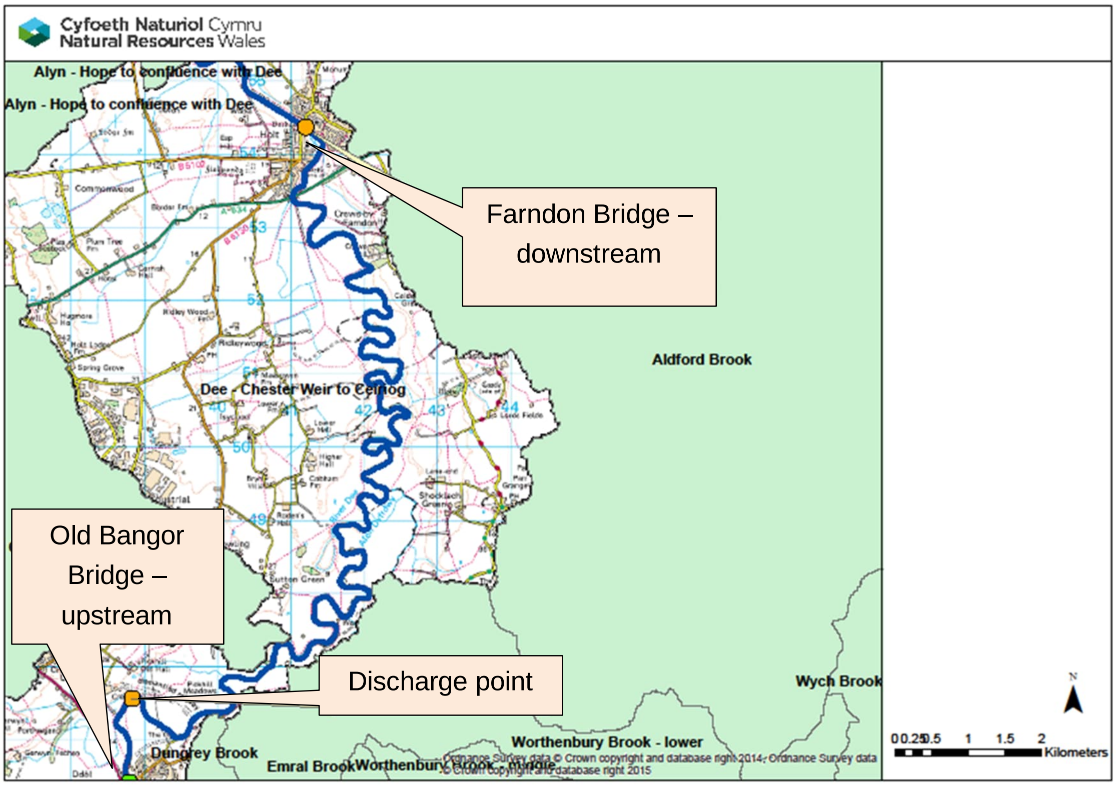
2.1 Upstream river flow and quality

Data for the river quality upstream and downstream of the proposed discharge were supplied by Natural Resources Wales (NRW) as a spreadsheet of approximately monthly values taken at two sampling points (Figure 2.1). The two sites were:

1. ID 87 – River Dee at Old Bangor Bridge, which is located 1.5 km immediately upstream of the discharge site. Grid Ref SJ 38780 45439

2. ID 671 – River Dee at Farndon Bridge, which is approximately 20 km downstream of the discharge site. Grid Ref SJ 4117054370

Figure 2.1 Location of discharge and sampling points.



Source: Natural Resources Wales

The data provided covered the period 3 January 2018 to 14 December 2022. Samples with indicated caveats were excluded, as they indicate sampling and methodology error and may not represent the routine quality of the River Dee. No data were available for aluminium or total suspended solids.

Daily data from a flow gauge approximately 15 km upstream of the discharge point on the River Dee at Manley Hall (ID = 67015) were downloaded from the UK Centre for Ecology and Hydrology website and used to calculate the upstream average and Q95. The most recent five-year period of data was used, from 1 October 2016 to 30 September 2021.

Statistical analysis of the water quality data provided the mean and standard deviation for each determinand (Table 2.1). Any 'less than' values were halved in accordance with the EA Codes of Practice for Data Handling (Ellis *et al*., 1993).

Table 2.1 River flow and quality in the River Dee upstream of the discharge

Determinand	Upstream river conditions			
	Mean (mg/l)	SD (mg/l)	Q95 (flow only)	Source
Flow	33.06 (m^3/s)	33.11 (m^3/s)	8.91 (m^3/s)	Manley Hall
BOD	1.35	0.21	n/a	Farndon Bridge*
Ammonia	0.016	0.012	n/a	Old Bangor Bridge
Orthophosphate	0.013	0.011	n/a	Old Bangor Bridge
pH	8.10	0.31	n/a	Old Bangor Bridge
Temperature	10.6	4.2	n/a	Old Bangor Bridge

*No data available at Old Bangor Bridge upstream of the discharge so downstream site used instead.

Determinand concentrations within the river have remained similar to 2015. River flow has generally increased from 32.0 to 33.1 m^3/s and 8.6 to 8.9 m^3/s for average and Q95 respectively. Similarly, pH has increased from 7.7 to 8.1.

2.2 Discharge flow and quality

Discharge quality parameters were defined by the existing concentrations permitted for the site, whilst current average and maximum daily discharge flows were increased in accordance with the proposed doubling of weekly throughput (Table 2.2). Maelor Foods determined the higher average discharge as the water used per bird (7 litres) multiplied by the number of birds (2 million), and then divided by the number of operational days (6). To determine the higher maximum discharge, the maximum hourly discharge (130 m^3h^{-1}) was multiplied by the maximum operational hours in a day (24).

Table 2.2 Discharge limits applied in modelling

Determinand	Discharge limit	Units	Expressed as	Distribution applied in RQP	
				Mean (mg/l)	SD (mg/l)
Current Average daily flow	1,200	m^3/d	Mean	0.014 m^3/s	0.003 m^3/s
Current Maximum daily flow	1,500	m^3/d	Maximum	0.017 m^3/s	0 m^3/s
Proposed Average daily flow	2,400	m^3/d	Mean	0.028 m^3/s	0.006 m^3/s
Proposed Maximum daily flow	3,120	m^3/d	Maximum	0.036 m^3/s	0 m^3/s
BOD	10	mg/l	Maximum	4.98	1.64
Ammonia	2	mg/l	Maximum	1.00	0.33
Orthophosphate	1	mg/l	Maximum	0.50	0.16
pH	6 to 9	n/a	Minimum and maximum	7.50	1.29
Iron	-	mg/l	-	0.862	0
Chloride	-	mg/l	-	841	0
Temperature	30	°C	Maximum	n/a	n/a

Note: There are no permitted limits for iron and chloride, therefore the modelled concentrations were derived from laboratory analysis of effluent.

As the limits were all maxima, values were treated as upper tier limits (99th percentile). Discharge quality is defined in the River Quality Planning (RQP) tool by a mean and standard deviation, which were calculated from the maximum values assuming a coefficient of variation (CofV) of 0.33. A CofV of 0.2 was used for average discharge daily flow, as limited variation was assumed.

It should be noted that the values applied in RQP for iron and chloride were based on analysis of a single effluent sample .

2.3 River quality standards

NRW provided details of the High and Good physico-chemical Environmental Quality Standards (EQS) at two sites:

1. ID 87 – River Dee at Old Bangor Bridge. This is located immediately upstream of the discharge. Grid Ref SJ 38780 45439

2. ID 671 – River Dee at Farndon Bridge. This is located downstream of the discharge point (Figure 2.1). Grid Ref SJ 4117054370

The High and Good river quality standards at site 671 are shown in Table 2.3. The High standard from 671 was used in the modelling, as this is downstream and therefore affected by the discharge.

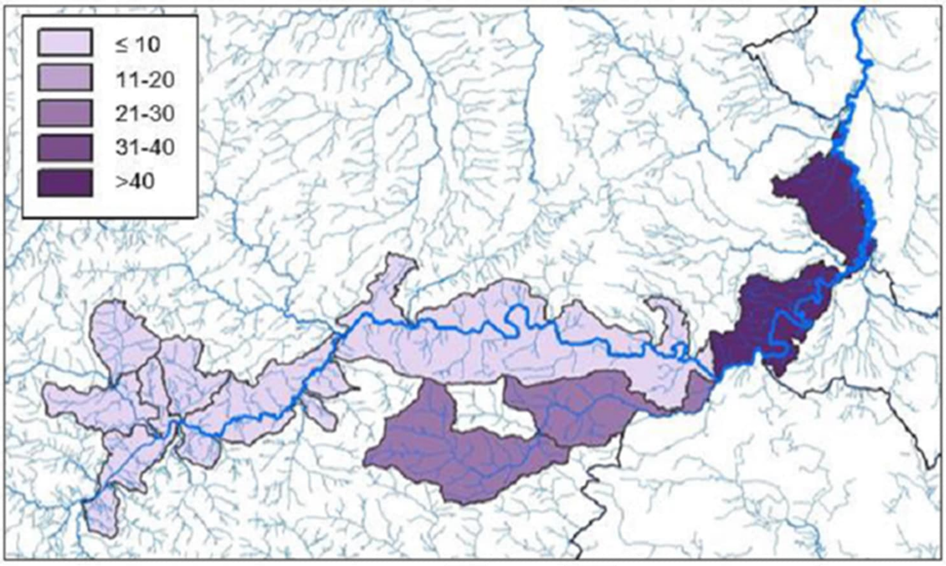
An additional standard for orthophosphate is relevant for parts of the River Dee in relation to the River Dee & Llyn Tegid SAC. Figure 2.1 shows a map of orthophosphate targets for the River Dee & Llyn Tegid SAC and the location of the Maelor Foods Installation's discharge of treated wastewater. This shows the orthophosphate concentration target for the river at the discharge point is >40 µg/l. The target is in fact 50 µg/l.

Table 2.3 Physico-chemical EQS at site 671, River Dee at Farndon Bridge and for orthophosphate in the River Dee & Llyn Tegid SAC

Determinand	EQS expressed as[1]	High Standard	Good Standard
BOD	90^{th} percentile	3 mg/l	4 mg/l
Ammonia	90^{th} percentile	0.3 mg/l	0.6 mg/l
Orthophosphate (WFD standard)	Mean	0.028 mg/l	0.054 mg/l
Orthophosphate (SAC standard)	Mean	50 µg/l	
pH	Range	6 (5%ile) to 9 (95%ile)	5.2 (10%ile)
Temperature	Maximum	20°C	23°C

[1] The 90^{th} percentile (or 90%ile) is the value for which 90% of the data points are smaller. It is a value from a statistical distribution.

Figure 2.2 Orthophosphate Targets for River Dee & Lyn Tegid SAC (Hatton-Lewis *et al.*, 2021)



All concentrations are annual means and growing season means in µg/l.

Figure 2.3 shows the Chester Weir to Ceiriog stretch of the River Dee, the location of the Maelor Foods Wastewater Treatment Plant (WWTP) discharge and NRW's upstream and downstream river monitoring points:

- Site ID 87 – River Dee at Old Bangor Bridge, which is located 1.5 km immediately upstream of the discharge site. Grid Ref SJ 38780 45439

- Site ID 671 – River Dee at Farndon Bridge, which is approximately 20 km downstream of the discharge site. Grid Ref SJ 4117054370

Figure 2.3 WWTP discharge point and river monitoring points upstream & downstream

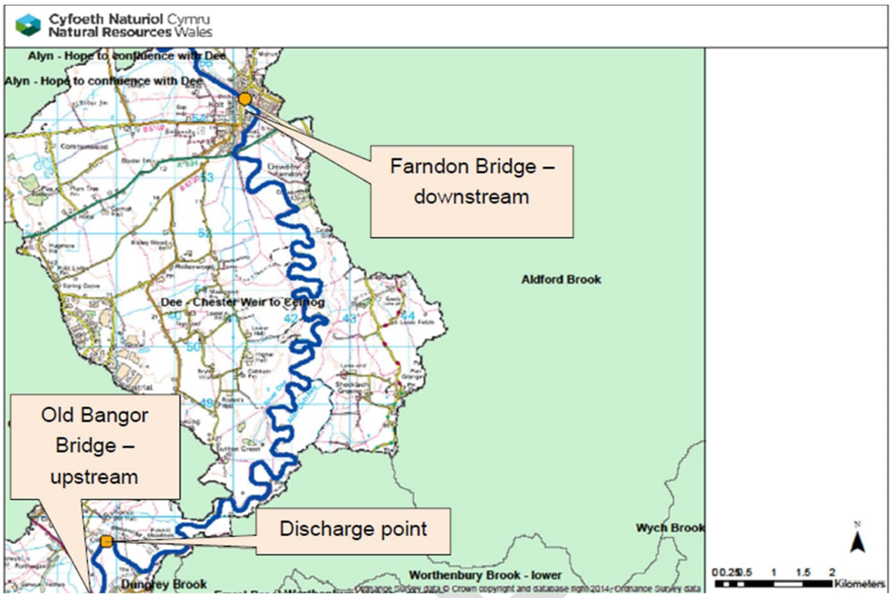


Figure 2.4 shows an extract of Table 2, page 28 of NRW's report "Compliance Assessment of Welsh River SACs against Phosphorus Targets (Hatton-Lewis *et al.,* 2021) which shows results of river water monitoring undertaken over 3 years (2017 – 2019).

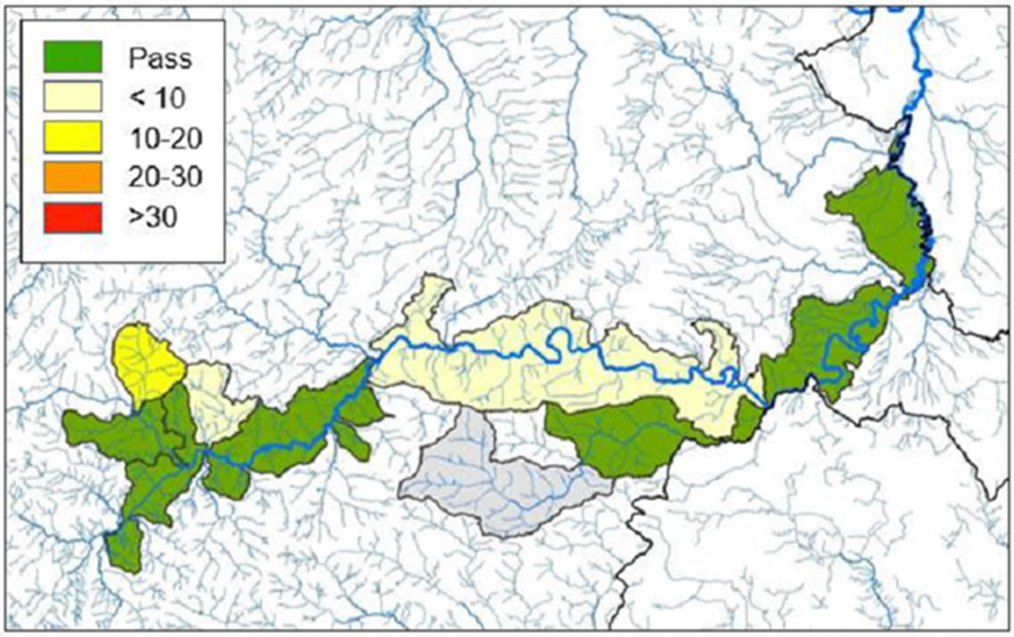
Figure 2.4 Results of River Dee water monitoring undertaken over 3 years (2017 – 2019)

Waterbody ID	Waterbody Name	Site	Target (μg l⁻¹)	N Samples	Annual Mean (μg l⁻¹)	Growing Season Mean (μg l⁻¹)	Result	Status
GB111067051990	Mynach	300	10	19	25	27	Fail	Confirmed
GB111067051900	Tryweryn - Dee to Mynach	294	10	25	10	4	Pass	-
GB111067051960	Meloch	496	10	19	20	9	Fail	Unconfirmed
GB111067052240	Dee - Alwen to Llyn Tegid/ Bala Lake	1	10	27	7	4	Pass	-
GB111067052060	Dee - Ceiriog to Alwen	70	10	31	15	16	Fail	Confirmed
GB111067051610	Ceiriog - upstream of Teirw	-	28	No data			Not Assessed	-
GB111067051910	Ceiriog - confluence Dee to Teirw	578	28	31	22	26	Pass	-
GB111067057080	Dee - Chester Weir to Ceiriog	87, 671, 689	50	60	15, 50, 47	17, 46, 49	Pass	-

Table 2. Phosphorus Compliance for the River Dee SAC. All orthophosphate concentrations are in μg l⁻¹.

Figure 2.5 shows the Phosphorus compliance map for the River Dee SAC (Hatton-Lewis *et al.,* 2021). Water bodies shaded green pass their target. Other colours fail the target with different colours representing the magnitude of failures in µg/l, expressed as the larger of annual means and growing season means.

Figure 2.5 Phosphorus compliance map for the River Dee SAC



This shows that the Chester Weir to Ceiriog stretch of the River Dee into which the Maelor Foods WWTP discharge is made is passing its SAC orthophosphate target of 50 µg/l.

2.4 Methodology

2.4.1 River Quality Planning Monte Carlo modelling

The EA's River Quality Planning Monte Carlo modelling tool was used to determine the impact of the increased effluent discharge to the River Dee for the following determinands:

- BOD
- Ammonia
- Orthophosphate
- pH
- Iron
- Chloride

- Temperature

Total suspended solid data was not available for the River Dee and was therefore not included in the modelling.

The following assumptions were applied to the modelling:

1. Upstream river concentrations were based on summary statistics from the observed data provided by NRW, as outlined in section 2.1.

2. Discharge concentrations were based on summary statistics calculated from the maxima issued within the site's current permit, as outlined in section 2.2.

3. Mixing between effluent flow and river flow occurs instantaneously at the point of discharge.

4. All determinands have a maximum consent; pH also has a minimum limit.

2.4.2 Temperature modelling

The Maelor Foods discharge is at a higher temperature than the ambient temperatures of the River Dee. Modelling was required to identify by how much the downstream temperature would change compared to the upstream temperatures under a higher discharge flow.

The modelling was completed using WRc's in-house mass and energy balance spreadsheet tool, which assumes that the mixing between effluent and river waters occurs instantaneously. It does not include any representation of cooling through heat losses to the atmosphere, and therefore provides a conservative estimate of the temperature rise.

Results were calculated on a monthly average basis, with the observed temperature data from monitoring site 87 (River Dee at Old Bangor Bridge) and observed monthly river flow data from the upstream flow gauge at Manley Hall (Table 4). The temperature record for site 87 was incomplete, with data only available for 7 months. Furthermore, some months only had one data point, reducing confidence in the temperature record. Data were supplemented from the previous 2015 analysis for the 5 months missing data, as well as for May, which appeared to be a single anomalous result when compared to the trend seen downstream and in 2015. The discharge was modelled for a constant discharge flow of 2,400 m^3/d and 3,120 m^3/d, both at a constant temperature of 30.0°C.

Table 2.4 Mean monthly temperature and flow in the River Dee upstream of discharge

Month	Mean monthly river temperature (°C)	Monthly River flow (m^3/s)	
		Mean	Q95
January	5.0*	46.5	13.2
February	4.7*	57.4	14.5
March	7.3	46.8	12.7
April	9.9*	23.8	8.3
May	11.5*	12.3	8.3
June	14.7	19.7	8.7
July	17.4*	14.4	8.7
August	17.1	20.6	9.1
September	13.7	24.2	9.4
October	11.6*	33.6	8.7
November	10.2	42.6	10.9
December	6.7	62.4	15.9

* Data from 2015 analysis

3. River Quality Planning tool results

3.1 Receiving water impact based on current discharge regime

3.1.1 Current average discharge – 1,200 m^3/d

The modelled impact of the current average discharge of 1,200 m^3/d, (equivalent to a mean of 0.014 m^3/s and a standard deviation of 0.003 m^3/s), with discharge quality based on the site's current permit, is summarised in Table 3.1.

Table 3.1 Summary of the River Quality Planning Monte Carlo modelling – current average discharge flow (1,200 m^3/d). River standards provided for context.

Determinand	Observed upstream river concentration		Modelled discharge permit		Modelled downstream river concentration		% change in river from upstream		River standards[2]	
	Mean	90%ile	Limit	Type	Mean	90%ile	Mean	90%ile	Mean	90%ile
BOD (mg/l)	1.35	1.62	20	Max	1.36	1.63	0.9	0.6		3
Ammonia (mg/l)	0.015	0.029	5	Max	0.016	0.031	3.5	6.9		0.3
Orthophosphate (µg/l)	13.0	24.9	2500	Max	13.7	25.9	5.4	4.0	54 50	
pH	8.10	8.49	6 to 9	Range	8.10	8.49	0	0	6 to 9	
Iron (mg/l)	0.156	0.230			0.16	0.23	2.6	0	1000[3]	
Chloride (mg/l)	11.7	17.0			12.2	17.7	4.3	4.1	250[4]	

Note: Orthophosphate was converted to µg/l to improve resolution.

[2] See Table 2.3 for the derivation of most of the river standards

[3] An annual average freshwater EQS for iron (dissolved) as a specific pollutant for use in surface water risk assessment for permit applications (https://www.gov.uk/guidance/surface-water-pollution-risk-assessment-for-your-environmental-permit)

[4] An annual average freshwater operational EQS for chloride for use in surface water risk assessment for permit applications (https://www.gov.uk/guidance/surface-water-pollution-risk-assessment-for-your-environmental-permit)

The current average discharge has the following predicted modelled impacts:

- Small (<1%) increases are observed in the mean and 90 percentile downstream BOD concentration.
- A small 0.001 mg/l increase is predicted for mean ammonia concentration, with a 0.002 mg/l increase at the 90 percentile. This corresponds to a 3.5% and 6.9% downstream increase respectively.
- A small 0.7 µg/l increase is predicted for mean orthophosphate concentration, with a 1 µg/l increase at the 90 percentile. This corresponds to a 5.4% and 4% downstream increase respectively.
- A small (<5%) increase is predicted for iron and chloride concentration downstream.
- pH is unaffected.

All modelled downstream river concentrations are lower than the face value of the relevant river standard.

3.1.2 Current maximum discharge – 1,500 m^3/d

The modelled impact of a maximum discharge flow of 1,500 m^3/d (0.017 m^3/s), with discharge quality based on the site's current permit, is summarised in Table 3.2.

Table 3.2 Summary of the River Quality Planning Monte Carlo modelling – current maximum discharge flow (1,500 m^3/d). River standards provided for context.

Determinand	Observed upstream river concentration		Modelled discharge permit		Modelled downstream river concentration		% change in river from upstream		River standards[5]	
	Mean	90%ile	Limit	Type	Mean	90%ile	Mean	90%ile	Mean	90%ile
BOD (mg/l)	1.35	1.62	20	Max	1.36	1.63	0.9	0.6		3
Ammonia (mg/l)	0.015	0.029	5	Max	0.017	0.032	9.9	10.3		0.3

[5] See Table 2.3 for the derivation of most of the river standards

Determinand	Observed upstream river concentration		Modelled discharge permit		Modelled downstream river concentration		% change in river from upstream		River standards[5]	
	Mean	90%ile	Limit	Type	Mean	90%ile	Mean	90%ile	Mean	90%ile
Orthophosphate (µg/l)	13.0	24.9	2500	Max	14.0	26.3	7.7	5.6	54 50	
pH	8.10	8.49	6 to 9	Range	8.10	8.49	0	0	6 to 9	
Iron (mg/l)	0.156	0.230			0.16	0.23	2.6	0	1000[6]	
Chloride (mg/l)	11.7	17.0			12.2	17.7	4.3	4.1	250[7]	

Note: Orthophosphate was converted to µg/l to improve resolution.

The current average discharge has the following predicted modelled impacts:

- Small (<1%) increases are observed in the mean and 90 percentile downstream BOD concentration.
- A small 0.002 mg/l increase is predicted for mean ammonia concentration, with a 0.003 mg/l increase at the 90 percentile. This corresponds to a 9.9% and 10.3% downstream increase respectively. Because the river upstream has a low ammonia concentration, a small absolute increase in the downstream concentration results in a large percentage difference.
- A 1 µg/l increase is predicted for mean orthophosphate concentration, with a 1.4 µg/l increase at the 90 percentile. This corresponds to a 7.7% and 5.6% downstream increase respectively. As with ammonia, because the river upstream has a low orthophosphate concentration, a small absolute increase in the downstream concentration results in a large percentage difference.

[6] An annual average freshwater EQS for iron (dissolved) as a specific pollutant for use in surface water risk assessment for permit applications (https://www.gov.uk/guidance/surface-water-pollution-risk-assessment-for-your-environmental-permit)

[7] An annual average freshwater operational EQS for chloride for use in surface water risk assessment for permit applications (https://www.gov.uk/guidance/surface-water-pollution-risk-assessment-for-your-environmental-permit)

- A small (<5%) increase is predicted for iron and chloride concentration downstream.
- pH is unaffected.

All modelled downstream river concentrations are lower than the face value of the relevant river standard.

3.2 Receiving water impact based on proposed increased discharge regime

3.2.1 Proposed average discharge – 2,400 m^3/d

The modelled impact of an average discharge flow of 2,400 m^3/d, with discharge quality based on the site's current permit, is summarised in Table 3.3.

Table 3.3 Summary of the River Quality Planning Monte Carlo modelling – proposed average discharge flow (2,400 m^3/d). River standards provided for context.

Determinand	Observed upstream river concentration		Modelled discharge permit		Modelled downstream river concentration		% change in river from upstream		River standards[8]	
	Mean	90%ile	Limit	Type	Mean	90%ile	Mean	90%ile	Mean	90%ile
BOD (mg/l)	1.35	1.62	10	Max	1.35	1.62	0.1	0.0		3
Ammonia (mg/l)	0.015	0.029	2	Max	0.016	0.03	3.5	3.4		0.3
Orthophosphate (µg/l)	13.0	24.9	1000	Max	13.6	25.7	4.6	3.2	54 50	
pH	8.10	8.49	6 to 9	Range	8.10	8.49	0	0	6 to 9	
Iron (mg/l)	0.156	0.230			0.16	0.23	2.6	0	1000[9]	
Chloride (mg/l)	11.7	17.0			12.7	18.3	8.5	7.6	250[10]	

[8] See Table 2.3 for the derivation of most of the river standards

[9] An annual average freshwater EQS for iron (dissolved) as a specific pollutant for use in surface water risk assessment for permit applications (https://www.gov.uk/guidance/surface-water-pollution-risk-assessment-for-your-environmental-permit)

[10] An annual average freshwater operational EQS for chloride for use in surface water risk assessment for permit applications (https://www.gov.uk/guidance/surface-water-pollution-risk-assessment-for-your-environmental-permit)

Note: Orthophosphate was converted to µg/l to improve resolution.

The current average discharge has the following predicted modelled impacts:

- Small (<1%) increases are observed in the mean and 90 percentile downstream BOD concentration.
- A small 0.001 mg/l increase is predicted for both mean and 90 percentile ammonia concentration. This corresponds to a 3.5% and 3.4% downstream increase respectively.
- A 0.6 µg/l increase is predicted for mean orthophosphate concentration, with a 0.8 µg/l increase at the 90 percentile. This corresponds to a 4.6% and 3.2% downstream increase respectively.
- A small (2.6%) increase in mean iron is predicted, although this may relate to RQP rounding values to two decimal places.
- A 1 mg/l and 1.3 mg/l increase is predicted in the downstream mean and 90 percentile for chloride, equating to an 8.5% and 7.6% increase respectively.
- pH is unaffected.

All modelled downstream river concentrations are lower than the face value of the relevant river standard.

3.2.2 Proposed maximum discharge – 3,120 m^3/d

The modelled impact of a maximum discharge flow of 3,120 m^3/d, with discharge quality based on the site's current permit, is summarised in Table 3.4.

Table 3.4 Summary of the River Quality Planning Monte Carlo modelling – proposed maximum discharge flow (3,120 m^3/d). River standards provided for context.

Determinand	Observed upstream river concentration		Modelled discharge permit		Modelled downstream river concentration		% change in river from upstream		River standards[11]	
	Mean	90%ile (from RQP)	Limit	Type	Mean	90%ile	Mean	90%ile	Mean	90%ile
BOD (mg/l)	1.35	1.62	10	Max	1.36	1.63	0.9	0.6		3
Ammonia (mg/l)	0.015	0.029	2	Max	0.017	0.031	9.9	6.9		0.3
Orthophosphate (µg/l)	13	24.9	1000	Max	13.8	26.0	6.2	4.4	54 50	
pH	8.10	8.49	6 to 9	Range	8.10	8.49	0	0	6 to 9	
Iron (mg/l)	0.156	0.230			0.16	0.24	2.6	4.3	1000[12]	
Chloride (mg/l)	11.7	17.0			13.1	19.0	12.0	11.8	250[13]	

Note: Orthophosphate was converted to µg/l to improve resolution.

The current average discharge has the following predicted modelled impacts:

- Small (<1%) increases are observed in the mean and 90 percentile downstream BOD concentration.
- A small 0.002 mg/l increase is predicted for both mean and 90 percentile ammonia concentration. This corresponds to a 9.9% and 6.9% downstream increase respectively.

[11] See Table 2.3 for the derivation of most of the river standards

[12] An annual average freshwater EQS for iron (dissolved) as a specific pollutant for use in surface water risk assessment for permit applications (https://www.gov.uk/guidance/surface-water-pollution-risk-assessment-for-your-environmental-permit)

[13] An annual average freshwater operational EQS for chloride for use in surface water risk assessment for permit applications (https://www.gov.uk/guidance/surface-water-pollution-risk-assessment-for-your-environmental-permit)

Because the river upstream has a low ammonia concentration, a small absolute increase in the downstream concentration results in a large percentage difference.

- A 0.8 µg/l increase is predicted for mean orthophosphate concentration, with a 1.1 µg/l increase at the 90 percentile. This corresponds to a 6.2% and 4.4% downstream increase respectively. As with ammonia, because the river upstream has a low orthophosphate concentration, a small absolute increase in the downstream concentration results in a large percentage difference.

- A small (<5%) increase in downstream mean and 90 percentile iron is predicted.

- A 1.4 mg/l and 2 mg/l increase is predicted in the downstream mean and 90 percentile for chloride, equating to an 12% and 11.8% increase respectively.

- pH is unaffected.

All modelled downstream river concentrations are lower than the face value of the relevant river standard.

3.3 Comparison between current and proposed discharge regime

The predicted downstream impacts from the proposed higher discharge average and maximum flows were compared to that of the current average and maximum flows.

Table 3.5 Comparison between in river quality for current permit and proposed discharge

Determinand	% change in river quality compared to current permit			
	2,400 m^3/d		3,120 m^3/d	
	Mean	90%ile	Mean	90%ile
BOD	-0.7	-0.6	0	0
Ammonia	0	-3.2	0	-3.1
Orthophosphate	-1	-0.8	-1.4	-1.1
pH	0	0	0	0
Iron	0	0	0	4.3
Chloride	4.1	3.4	7.4	7.3

The proposed increase in average (from 1,200 m^3/d to 2,400 m^3/d) and maximum (from 1,500 m^3/d to 3,120 m^3/d) operational discharge is predicted to not increase the concentrations of the modelled determinands when a tertiary treatment is used. Small (<4%) decreases are observed in the mean and 90 percentile of BOD, ammonia, and orthophosphate. No change is seen in pH.

Chloride is predicted to increase in both the mean and 90 percentile at the average and maximum proposed discharge. Iron is predicted to increase in the 90 percentile at the maximum proposed discharge. However, modelled downstream concentrations are much less than the face value of river standards and are based on the Phase 1 wastewater treatment plant typical discharge. For Phase 2 tertiary treatment in a MBR plant is added and is expected to decrease emissions from Phase 1.

4. Monthly temperature modelling results

4.1 Monthly average river flows

The temperature modelling showed that the predicted impact on the river temperature downstream for both the average discharge flow of 2,400 m^3/d and the maximum flow of 3,120 m^3/d at 30.0°C is small, with differences only at the second decimal place (Table 4.1).

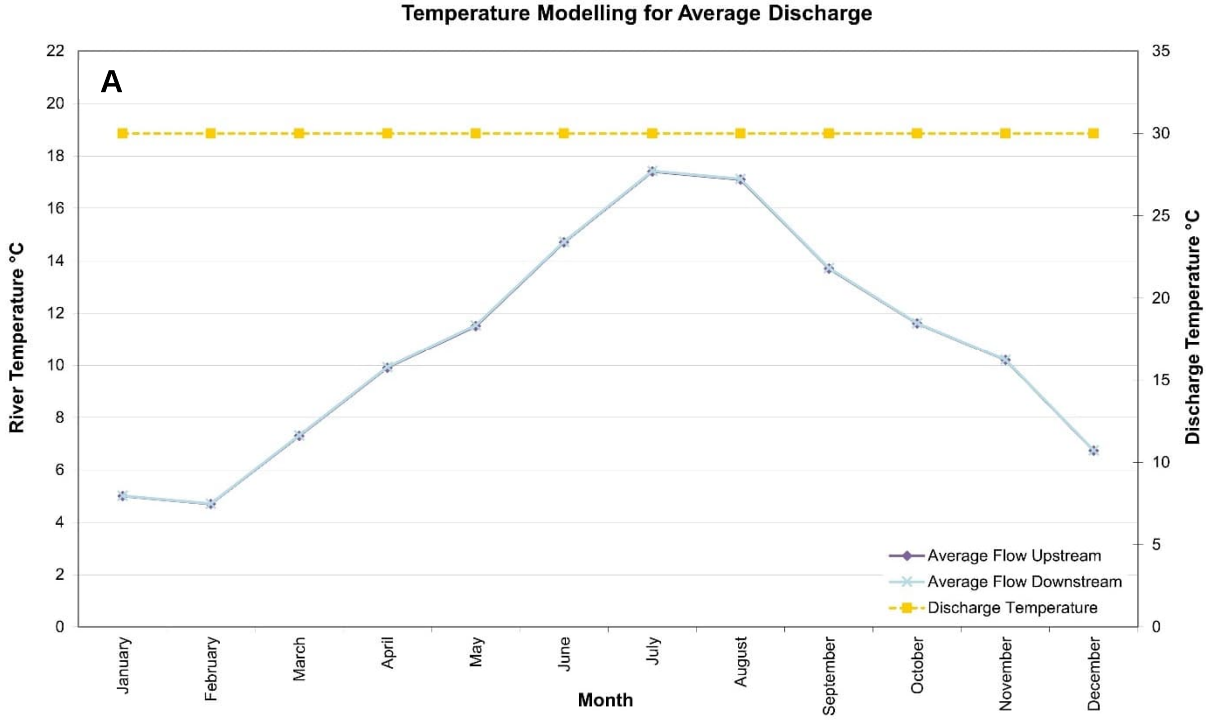
The temperature modelling assumes that the discharge is instantaneously mixed within the river. The results are illustrated in Figure 4.1 and show the monthly temperatures of the discharge and the river upstream and downstream of the discharge. Graph A shows the results simulating the average discharge flows and Graph B shows the results of the maximum discharge flows. The predicted increase is small in both cases, and the resultant series are almost co-incident on the graph illustrating the negligible effect on river temperature.

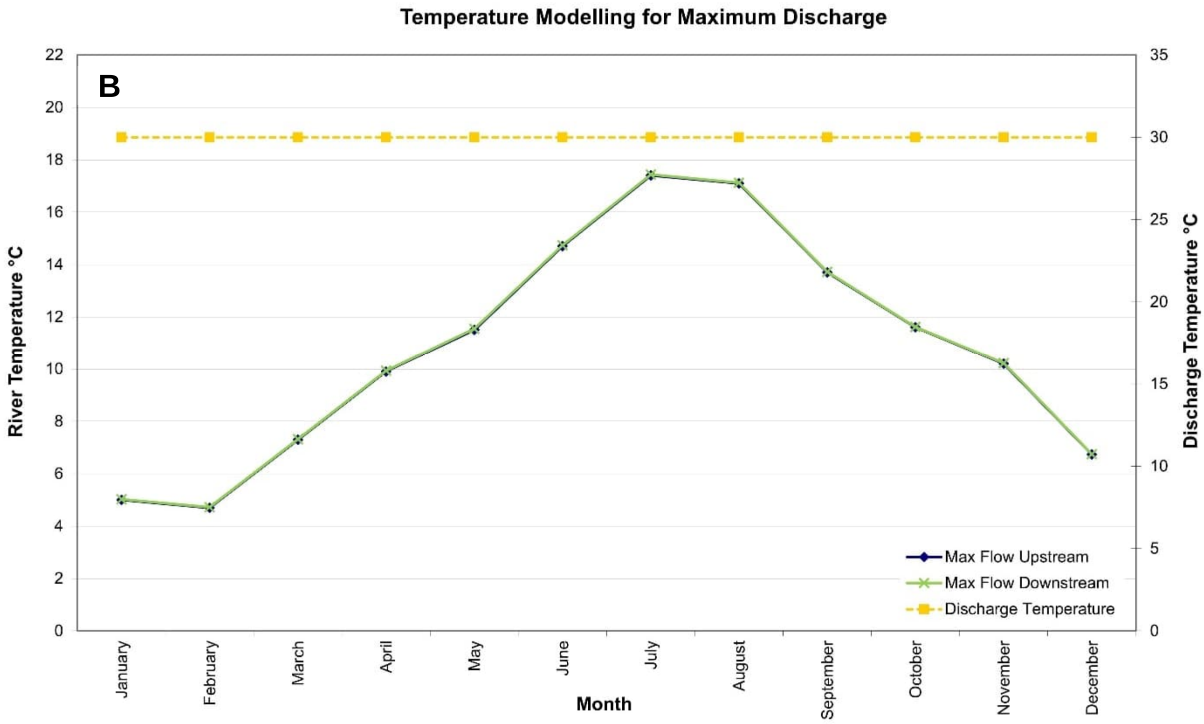
Table 4.1 Summary of the impact of the proposed discharge on temperature in the River Dee – average and maximum river flow

Month	Temperature (°C)				
	Upstream	Average discharge flow (2,400 m^3/d)		Maximum discharge flow (3,120 m^3/d)	
		Downstream	Differential	Downstream	Differential
January	5.0*	5.0	0.015	5.0	0.019
February	4.7*	4.7	0.012	4.7	0.016
March	7.3	7.3	0.013	7.3	0.017
April	9.9*	9.9	0.023	9.9	0.031
May	11.5*	11.5	0.042	11.6	0.054
June	14.7	14.7	0.022	14.7	0.028
July	17.4*	17.4	0.024	17.4	0.031
August	17.1	17.1	0.017	17.1	0.023
September	13.7	13.7	0.019	13.7	0.024
October	11.6*	11.6	0.015	11.6	0.020
November	10.2	10.2	0.013	10.2	0.017
December	6.7	6.7	0.010	6.7	0.013

* Data from 2015 analysis

Figure 4.1 Comparison of mean monthly upstream and downstream river temperature profiles





4.2 Monthly Q95 river flows

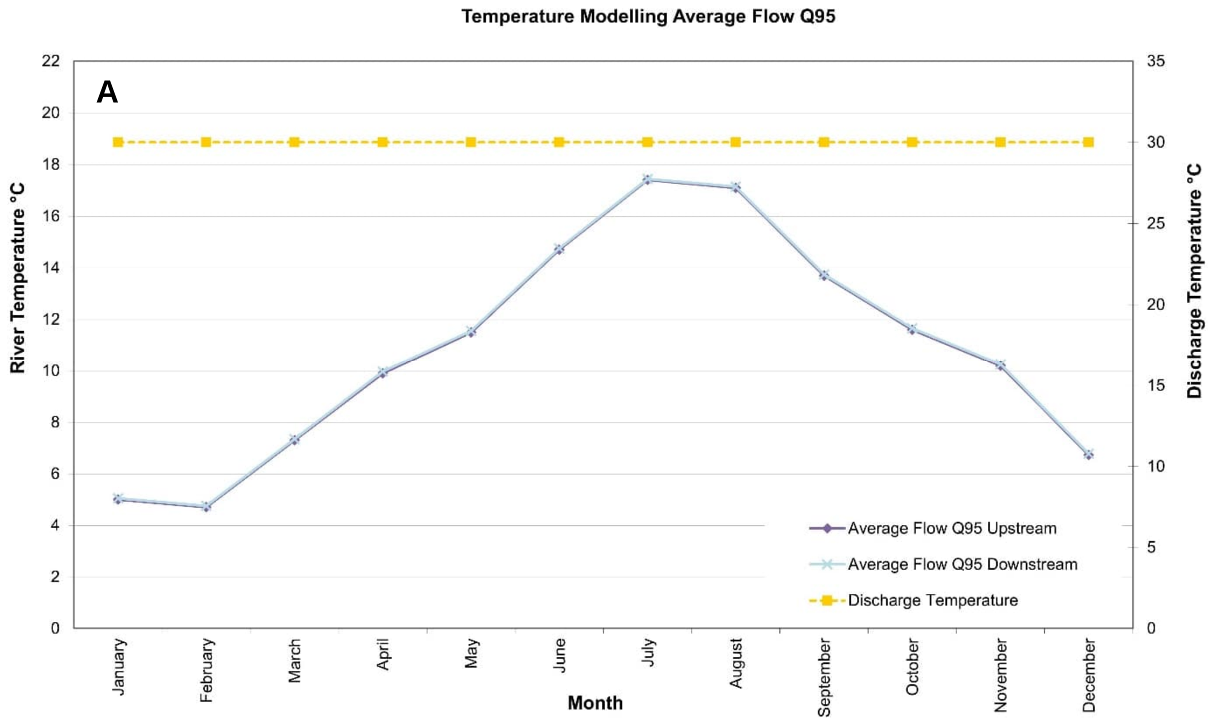
The modelling also examined the effect on low river flows, the Q95 or 5%ile flow. The results showed that the predicted impact on the downstream river temperature from the average and maximum discharge flow is small (Table 4.2). Increases in the downstream river temperature were predicted at only the second decimal place. The results are illustrated in Figure 4.2 and show that the effect of both average (Plot A) and maximum (Plot B) discharges when the flow in the river is low (Q95) is negligible.

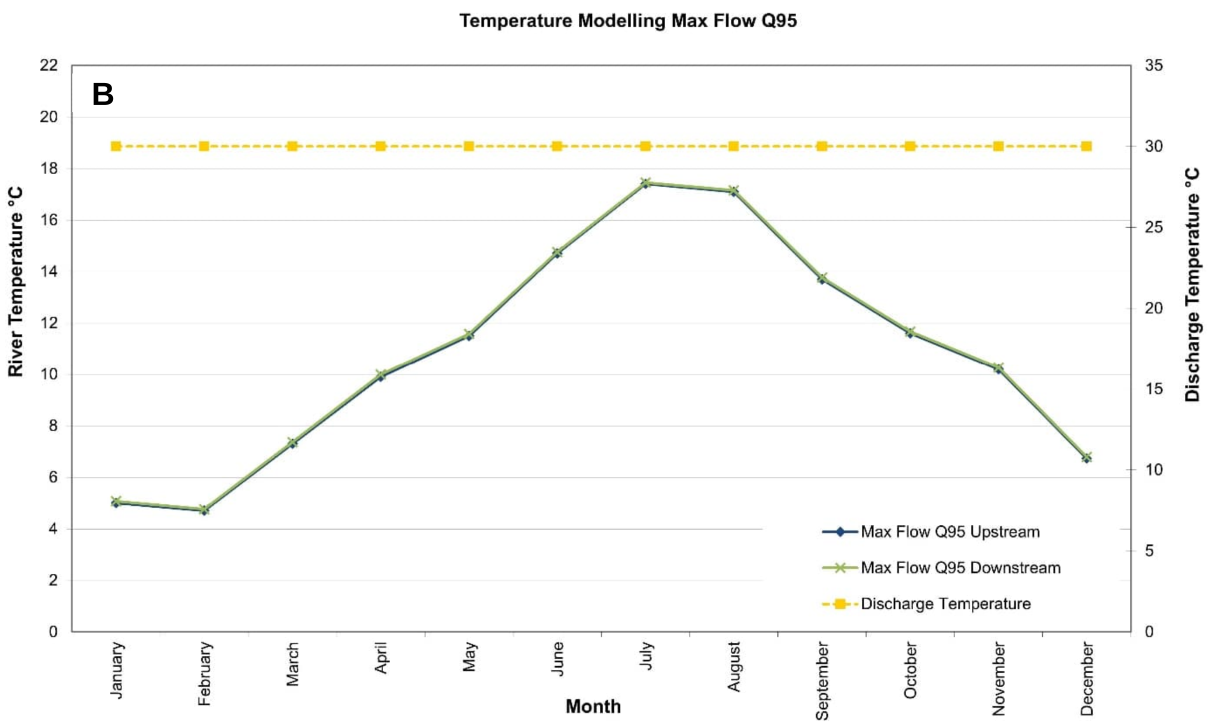
Table 4.2 Summary of the impact of the proposed discharge on temperature in the River Dee – Q95 river flow

Month	Temperature (°C)				
	Upstream	Average discharge flow		Maximum discharge flow	
		Downstream	Differential	Downstream	Differential
January	5.0*	5.1	0.052	5.1	0.068
February	4.7*	4.7	0.048	4.8	0.063
March	7.3	7.3	0.050	7.4	0.065
April	9.9*	9.9	0.067	10.0	0.087
May	11.5*	11.5	0.062	11.6	0.080
June	14.7	14.7	0.049	14.8	0.063
July	17.4*	17.4	0.040	17.5	0.052
August	17.1	17.1	0.039	17.2	0.051
September	13.7	13.7	0.048	13.8	0.062
October	11.6*	11.6	0.059	11.7	0.076
November	10.2	10.2	0.050	10.3	0.066
December	6.7	6.7	0.041	6.8	0.053

* Data from 2015 analysis

Figure 4.2 Comparison of modelled changes in downstream river temperature profiles compared to upstream at 30.0°C – Q95 monthly river flows





4.3 Summary

The temperature modelling showed that the proposed increased discharges of 2,400 m^3/d and 3,120 m^3/d at a temperature of 30 °C would not increase the river temperature under average or Q95 river flow conditions.

It should be noted that the modelling assumes that the discharge and river flows are fully mixed across the river at the point of discharge. In reality, the discharge is unlikely to be fully mixed until further downstream, with the effluent plume possibly hugging one side of the river. This is likely to result in higher temperature differential than described, especially closer to the discharge.

5. Conclusions

A water quality modelling assessment has been carried out for a proposed doubling of discharge flow by Maelor Foods Ltd to the River Dee in Wrexham. The assessment used the Environment Agency's River Quality Planning (RQP) Monte Carlo tool to model the effect of the discharge on the downstream river quality, specifically for determinands: BOD, ammonia, orthophosphate, and pH. A mass balance spreadsheet tool was used to model the resultant river temperature downstream of the discharge.

The results were based on proposed discharge flows of an average 2,400 m^3/d and a maximum 3,120 m^3/d, with quality based on the predicted discharge concentrations associated with the use of a tertiary treatment. The results showed that the predicted impact of the treated discharge on downstream river quality was:

- A 9.9% and 6.2% increase was predicted at maximum discharge (3,120 m^3/d) for downstream mean ammonia and orthophosphate respectively, with 6.9% and 4.4% increases at the 90 percentile. These relate to ≤0.002 mg/l predicted increases. Because the river upstream has low ammonia and orthophosphate concentrations, a small absolute increase in the downstream concentration results in a large percentage difference. Despite these increases, they are still lower than the current predicted impact of discharge on downstream ammonia and orthophosphate concentrations.

- A 12% and 11.8 % increase was predicted at maximum discharge for downstream mean and 90 percentile chloride. This equates to a 7.4% and 7.3% increase in mean and 90 percentile when compared the current maximum discharge (1,500 m^3/d).

- No change was predicted for pH.

- When compared to the current discharge, downstream BOD, ammonia and orthophosphate concentrations decreased slightly (<4%).

- All modelled downstream river concentrations were lower than the face value of the relevant river standard.

This was also reflected in the monthly temperature modelling, which showed no increase in temperature except at the second decimal place under Q95 (low) flow and average flow conditions in the river, however, the simple spreadsheet tool assumes full and instantaneous mixing whereas in relative the temperature will be higher closer to the discharge.

6. References

Ellis, J.C., van Dijk, P.A.H. and Kinley, R.D. (1993) Codes of Practice for Data Handling. NRA Report No. R&D 241.

Hatton-Ellis TW, Jones TG. 2021. Compliance Assessment of Welsh River SACs against Phosphorus Targets. NRW Evidence Report No: 489, 96pp, Natural Resources Wales, Bangor

Appendix A Detailed results from RQP

Maelor Foods - RQP Analysis Outputs.xlsx contains the RQP modelling inputs and results and has been provided electronically as an appendix to this report.