Gippsland Water

Drouin WWTP Discharge ERA

MBR Discharge Assessment

July 2018

Executive summary

Gippsland Water are planning to construct a membrane bioreactor (MBR) plant at Drouin to meet future growth in wastewater which will be up to three times the present volume. Work was undertaken in early 2018 to assess the environmental risks associated with current Drouin WWTP discharge to the receiving waters of Shillinglaw Creek and King Parrot Creek to support the works approval application for the MBR. This current report provides additional information to the environmental risk report, with a focus on mixing zones associated with current and future MBR plant discharges.

There will be an increased discharge volume of 4.2 megalitres per day (ML/day) associated with future MBR discharges, which is greater than current median discharge volumes from the existing dissolved air flotation / filtration (DAFF) plant of 1.34 ML/day during summer and 2.13 ML/day in winter. However, even with the increase in discharge volume, mixing zones associated with the future MBR discharge in Shillinglaw Creek are shown in this report to be either lower, equal to or not significantly greater than mixing zones for existing discharges for the majority of the year. This is mainly due to the better quality effluent from the proposed MBR plant (for most parameters except total P), compared to the existing DAFF treatment plant at Drouin. For parameters with which mixing zone distances were observed to increase, this was attributable in part to the increased volume of discharge which results in a higher velocity (and consequently further distance travelled in a given time) when travelling down Shillinglaw Creek. Mixing zone calculations undertaken within this report utilised a low streamflow scenario within the receiving waters of Shillinglaw Creek (as required by EPA's guideline for mixing zone assessments) - a value of 0.07 ML/day. This streamflow volume is the 4th percentile value (i.e. streamflow is higher than 0.07 ML/day in Shillinglaw Creek for 96% of the time). Higher streamflow typically allows for great dilution of treated wastewater discharge (although higher velocities), so the low streamflow scenario utilised within mixing zone calculations may be considered as conservative.

A mixing zone, as defined in the EPA guidelines, is the distance downstream of a discharge point where in-stream concentrations return to upstream levels or meet guideline values. Mixing zone distances were determined for current and future (2019 and 2030) discharge scenarios using median values of concentrations for the discharge and in Shillinglaw Creek. Mixing zone analyses were undertaken for four key parameters – ammonia, nitrate, total N and total P.

Results show that the parameter with the longest mixing zone was total N (for both current scenarios and future scenarios). The total N mixing zone under current discharge scenarios reached beyond the confluence of Shillinglaw and King Parrot Creeks to around 5.3 – 5.7 km in winter and summer. Under future scenarios, this mixing zone decreases to 3.1 – 3.8 km during winter, but increases to 7.1 km during the summer of 2030. The main reason for the increase in mixing zone distance for summer 2030 was that there was not as much reduction in the concentration of total N within the discharge in the future summer scenario compared to future winter scenarios and that the increased flow results in a higher in-stream velocity and distance travelled, compared to existing discharges for summer.

For total P, there were no mixing zones under current discharge scenarios in summer or winter. This is due to the concentration of total P in the current discharge (a median of 0.025 mg/L) being less than the SEPP objective of 0.05 mg/L. The mixing zone increases to 5.4 km in winter 2019, 4.7 km in summer 2030 and 1.7 km in winter 2030. These increases in mixing zone distance were due to future total P concentration in MBR discharge being higher than existing DAFF discharge concentrations.

For ammonia, there was only relatively small mixing zones (1.1 – 1.8 km) present during winter scenarios both current and future, and no mixing zones during the summer for either current or future scenarios. For nitrate, there were either no or small mixing zones (0 – 0.1 km) under current or future discharge scenarios.

Mixing zone calculations presented above were calculated using a defined low flow scenario which, as discussed above, occurs relatively infrequently. In order to determine what the mixing zones would be under conditions experienced more frequently, analyses were undertaken for median streamflow conditions (i.e. a median streamflow for winter and summer scenarios). Results showed a reduction in mixing zone distance for each median streamflow scenario compared to the equivalent low flow scenario. Low flow analysis may be considered a conservative estimate of the mixing zone, given that mixing zones will differ depending on streamflow (and other factors) which continuously vary with time.

The risks to the receiving waterway within the mixing zone for total N and total P are essentially around eutrophication i.e. excess nutrients leading to nutrient enrichment of the waterway that may stimulate macrophyte (aquatic plant) and algal growth. Excessive plant and algal growth can have secondary effects on other instream biota and the visual amenity of the waterway. However, Shillinglaw Creek already exceeds guideline limits for total N and total P upstream of the Drouin WWTP discharge point (due to land use such as agriculture and urban runoff), as such the risks around eutrophication are already present in the natural waterway prior to the influence of the discharge. The risks for toxicity (i.e. from ammonia and nitrate) are low and contained within relatively short mixing zones downstream of the discharge point.

Compliance of future Drouin WWTP discharges into Shillinglaw and King Parrot Creeks may be best managed by applying a revised mixing zone into the licence.

This report is subject to, and must be read in conjunction with, the limitations set out in section 1.3 and the assumptions and qualifications contained throughout the Report.

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1. Introduction

1.1 Background Information

A membrane bioreactor (MBR) plant is planning to be constructed at Drouin to manage the predicted growth (to cater for three times the current population) in future inflows of wastewater. The MBR plant is to be progressively brought online as growth occurs and there will be the ability to switch between the MBR and existing technology of a DAFF and lagoon system.

The new MBR plant needs an EPA works approval (with a 4 to 5 year timeline to plan, construct and commission the plant). Previous work recently undertaken in early 2018 assessed risks to the beneficial uses of the receiving waters of Shillinglaw Creek and downstream in King Parrot Creek associated with current Drouin WWTP discharge. The work also defined the mixing zone associated with the WWTP discharge with available data.

This report provides additional information to support Gippsland Water's Works Approval application and to answer the questions that EPA have had around the initial submission. The key output from this report is the calculation of the extent of the mixing zone associated with the future MBR plant and for the interim period between now and when it becomes fully operational.

1.1.1 Discharge Scenarios

A range of discharge scenarios have been investigated within this report involving a range of water quality and water volume values for streamflow and WWTP discharge. An overview of the scenarios is presented in Table 1. Scenarios 1 and 2 are existing WWTP discharges in summer and winter. Future discharges will be a volume of 4.2 ML/day (compared to existing discharges of approximately 2 ML/day). A 'hybrid' scenario of existing discharge water quality but future volumes is calculated (scenarios 3 and 4). Future scenarios are included - winter 2019 (scenario 5), summer 2030 (scenario 6) and winter 2030 (scenario 7).

Table 1 Discharge scenarios

Scenario	Scenario Name	Season	Discharge Volume (ML/day)	Discharge Quality
1	Existing - Winter	Winter	2.13	Current w inter median values
2	Existing - Summer	Summer	1.34	Current summer median values
3	Existing - Winter (4.2 ML)	Winter	4.2	Current w inter median values
4	Existing - Summer (4.2 ML)	Summer	4.2	Current summer median values
5	Winter 2019	Winter	4.2	Future 2019 w inter values
6	Summer 2030	Summer	4.2	Future 2030 summer values
7	Winter 2030	Winter	4.2	Future 2030 w inter values

Streamflow for Shillinglaw Creek for each scenario is required to be a low flow as defined in EPA's guidelines for the determination and assessment of mixing zones - publication 1344 (EPA 2010). Additional scenarios under 'median' streamflow conditions have also been included in this report to allow comparison between these differing background conditions.

1.2 Purpose of this report

The purpose of this report is to estimate the mixing zone and risks to the receiving waters of Shillinglaw and King Parrot Creeks from the proposed MBR discharge at Drouin WWTP for a range of defined scenarios.

1.3 Scope and limitations

This report: has been prepared by GHD for Gippsland Water and may only be used and relied on by Gippsland Water for the purpose agreed between GHD and the Gippsland Water as set out in section 1.2 of this report.

GHD otherwise disclaims responsibility to any person other than Gippsland Water arising in connection with this report. GHD also excludes implied warranties and conditions, to the extent legally permissible.

The services undertaken by GHD in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the report.

The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.

The opinions, conclusions and any recommendations in this report are based on assumptions made by GHD described in this report (refer section 1.4 of this report). GHD disclaims liability arising from any of the assumptions being incorrect.

GHD has prepared this report on the basis of information provided by Gippsland Water and others who provided information to GHD (including Government authorities), which GHD has not independently verified or checked beyond the agreed scope of work. GHD does not accept liability in connection with such unverified information, including errors and omissions in the report which were caused by errors or omissions in that information.

1.4 Assumptions

Design specifications and assumptions about the operation and performance of the proposed MBR plant are accurate.

Stream velocity and nutrient decay rates determined for reaches of King Parrot Creek further downstream and lower in the catchment (i.e. as determined for South East Water's Longwarry wastewater plant discharges) are appropriate for use within Shillinglaw Creek for Drouin WWTP's discharge.

Streamflow data measured for King Parrot Creek at Longwarry was available from 1964 until 1977. It has been assumed that this streamflow data is representative of streamflow for 2018 and future scenarios through until 2030/31, however, factors such as climate change and alteration of land use (e.g. increasing urbanisation of Drouin leading to quicker rainfall runoff and additional irrigation extractions in King Parrot Creek) may mean there will be differences.

No assessment of mixing zones has been undertaken for parameters with which no data was available (e.g. heavy metals or micropollutants). It is assumed that these mixing zones are minimal or insignificant, however this may change with additional data available in the future.

2. Water quantity data

2.1 Streamflow data

2.1.1 Streamflow data

Streamflow data was available for King Parrot Creek at gauging station 228 216 from July 1964 to June 1977. This data is used to identify seasonal trends and to help estimate the streamflow at the Drouin WWTP discharge point on Shillinglaw Creek. Daily streamflow is presented in Figure 1.

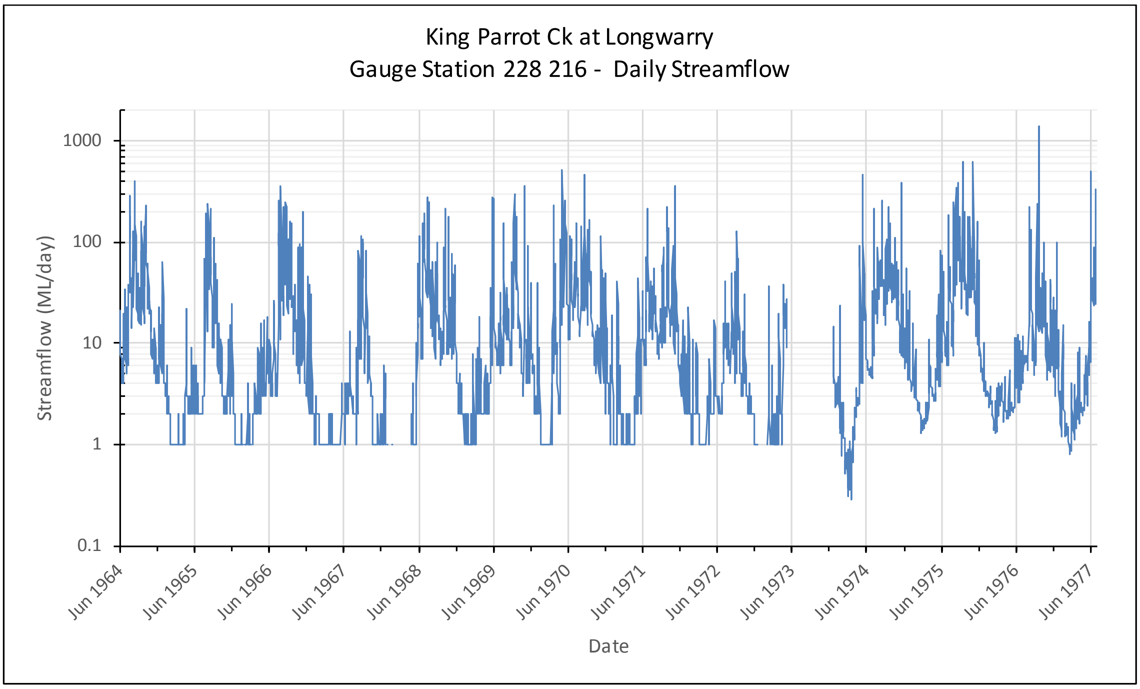

Figure 1 Streamflow data for King Parrot Creek at Longwarry

Streamflow is higher in the months during winter and spring and lower in summer and autumn as shown by daily streamflow statistics grouped on a monthly basis presented in Figure 2 and in Table 2. These monthly statistics are presented in order to find the month with the lowest average streamflow which is February with 1.79 ML/day. The 10th percentile of streamflow during this low flow month of February (0.6 ML/day) is used later on in this report within mixing zone calculations. The frequency of streamflow of 0.6 ML/day is relatively low – out of the whole streamflow record for King Parrot Creek (with data available for 4551 days between 1964 and 1977), a streamflow of 0.6 ML/day occurs approximately 4% of the time (i.e. streamflow exceeded 0.6 ML/day around 96% of the time).

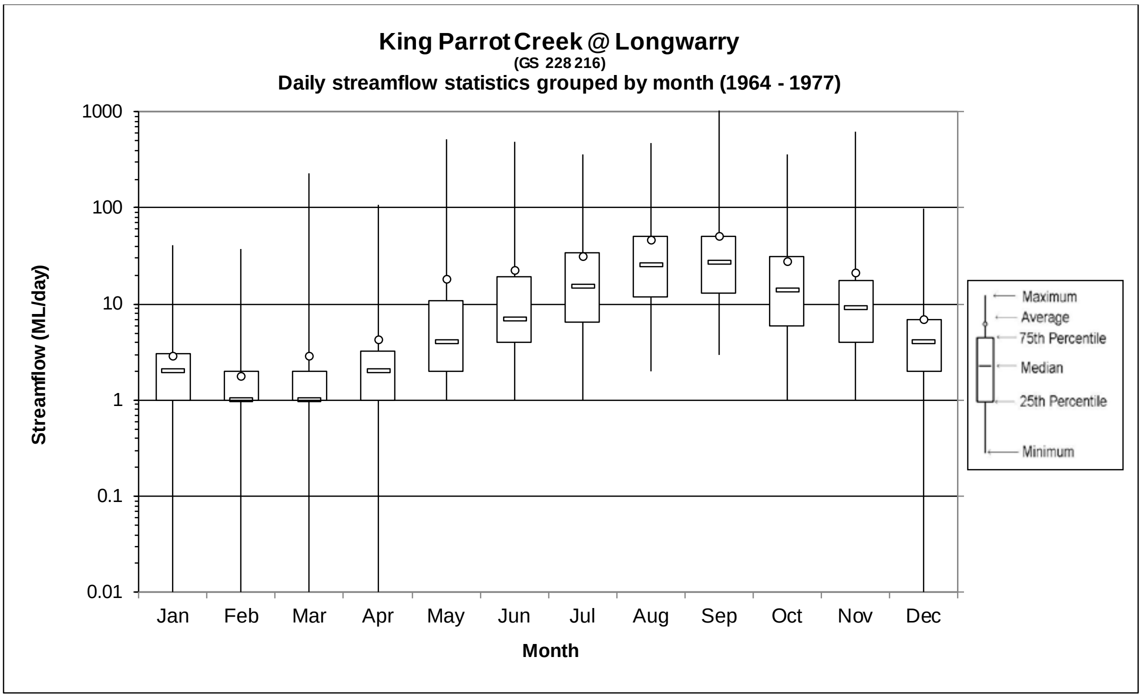

Figure 2 Streamflow statistics for King Parrot Creek at Longwarry – daily streamflow data grouped by month

Table 2 Streamflow statistics for King Parrot Creek at Longwarry – daily streamflow data grouped by month

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Maximum	41.0	37.0	232.0	108.0	514.0	491.1	357.0	472.0	1386.2	360.0	612.8	99.0
90th percentile	5.0	2.7	3.1	8.1	35.1	45.4	66.9	104.8	100.0	67.6	40.3	14.7
75th percentile	3.0	2.0	2.0	3.2	11.0	19.0	33.9	51.1	51.0	31.0	17.5	7.0
median	2.0	1.0	1.0	2.0	4.0	7.0	15.3	25.1	26.9	14.0	8.9	4.0
25th percentile	1.00	1.00	1.00	1.00	2.00	4.00	6.50	12.00	13.01	6.00	4.00	2.00
10th percentile	0.00	0.60	0.45	1.00	2.00	2.00	3.00	7.79	7.33	3.00	2.00	1.00
Minimum	0.00	0.00	0.00	0.00	1.00	1.00	1.00	2.00	3.00	1.00	1.00	0.00
Average	2.83	1.79	2.90	4.23	18.09	22.47	31.11	46.47	49.91	28.04	20.86	6.81
Number / Count	403	367	403	390	380	389	372	372	360	372	360	383

*Note the month with the lowest average streamflow is February with 1.79 ML/day and the 10th percentile flow in February in 0.6 ML/day. This data is used within the mixing zone assessment.

Daily streamflow data for King Parrot Creek at Longwarry that has been grouped by season is presented in Figure 3 and in Table 3. This shows winter streamflow (median value of 14.74 ML/day) to be about seven times that of summer flows (a median value of 2 ML/day). This seasonal data is used to help define streamflow under current and future Drouin WWTP discharge scenarios for summer and winter.

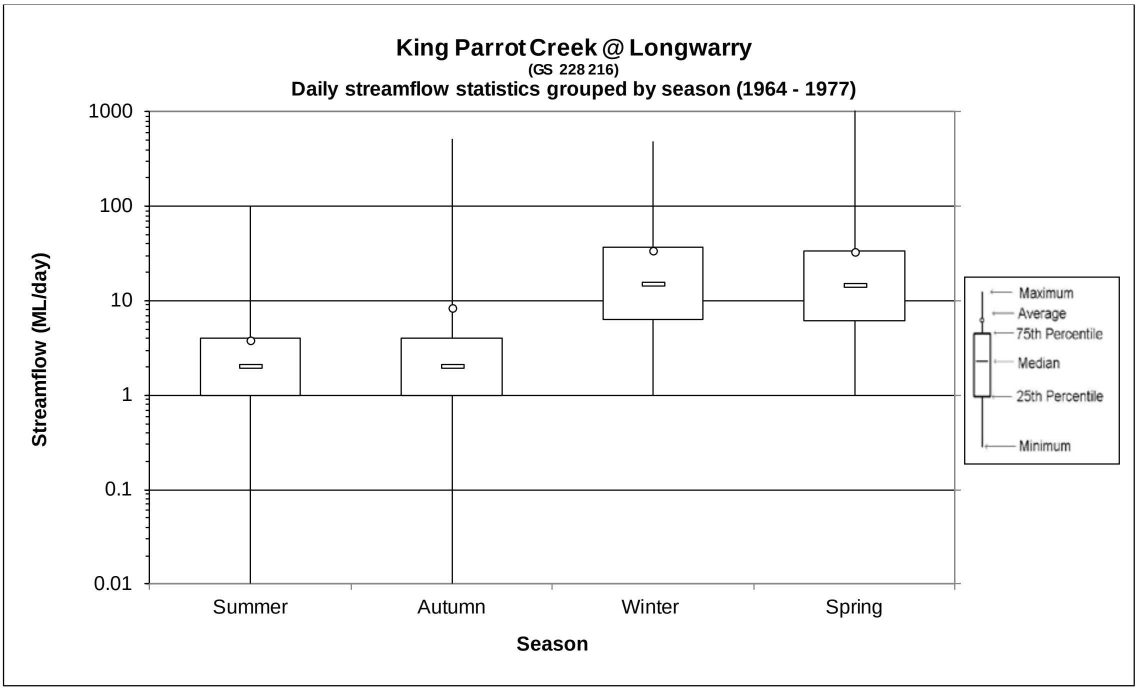

Figure 3 Streamflow statistics for King Parrot Creek at Longwarry – daily streamflow data grouped by season

Table 3 Streamflow statistics for King Parrot Creek at Longwarry – daily streamflow data grouped by season

	Summer	Autumn	Winter	Spring
Maximum	99	514	491	1386
90th percentile	8.00	13.80	72.93	71.00
75th percentile	4.00	4.00	36.49	33.87
Median	2.00	2.00	14.74	14.48
25th percentile	1.00	1.00	6.30	6.07
10th percentile	0.59	1.00	3.00	3.00
Minimum	0.00	0.00	1.00	1.00
Average	3.82	8.27	33.19	32.88
Number / Count	1153	1173	1133	1092

2.1.2 Catchment areas for gauging station and discharge point

A map of catchment area for the gauging station at Longwarry and the Drouin WWTP discharge point is presented in Figure 4. The area of each catchment is presented in Table 4 and shows the ratio of the two catchments to be 0.118. This ratio is used to estimate streamflow at the Drouin WWTP discharge point, i.e. multiplication of the gauging station streamflow by the ratio gives an estimate of streamflow at the WWTP discharge point. An example is as follows: if 10 ML/day was measured at the gauging station, then 10 x 0.118 = 1.18 ML/day would be expected at the Drouin WWTP discharge point.

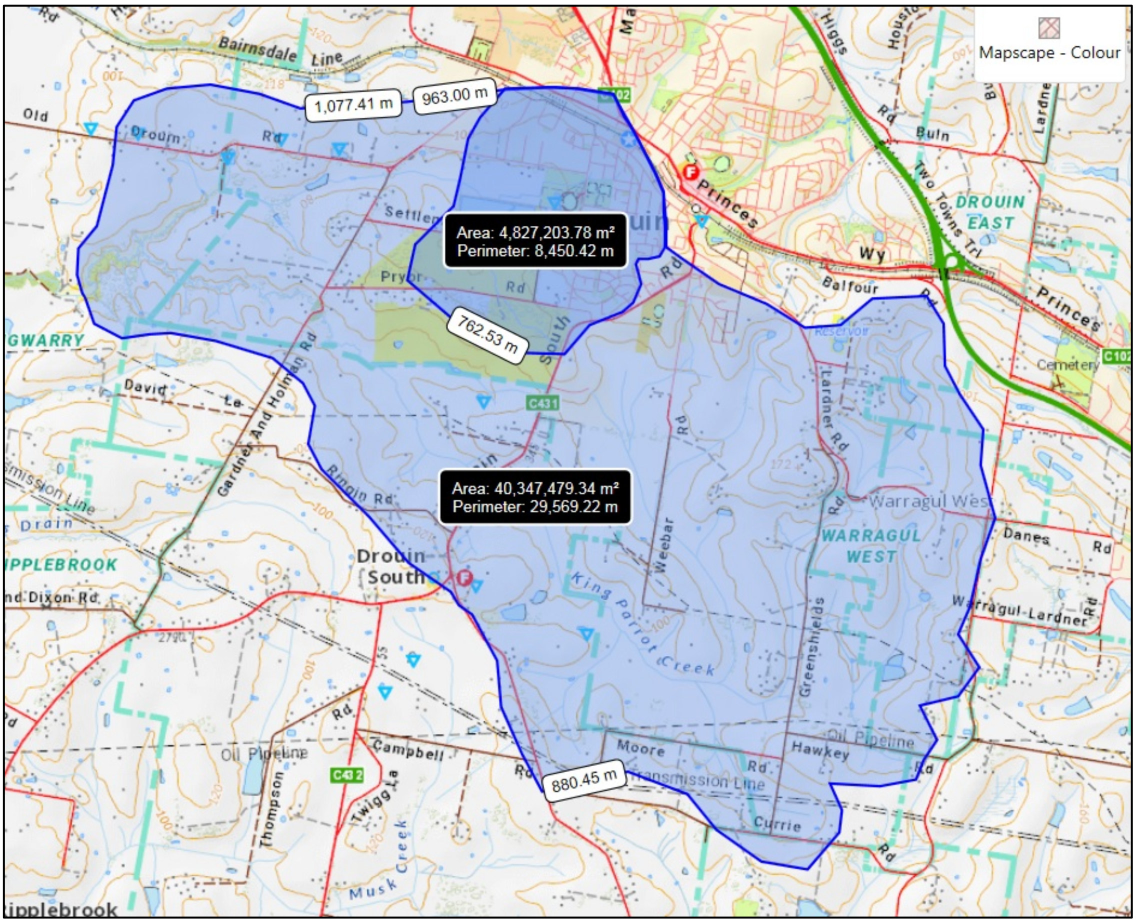

Figure 4 Catchment areas for the King Parrot Creek streamflow gauging station and Drouin WWTP discharge point (background map source: MapShare Vic (DELWP 2018))

Table 4 Catchment areas for streamflow gauging station and the Drouin WWTP discharge point

Location in catchment	Area (ha)
King Parrot Creek at Longwarry	4034
Drouin WWTP discharge point	482
Ratio	0.118

2.1.3 Stream velocity estimation

The velocity of streamflow in Shillinglaw and King Parrot Creeks is an important factor in determining mixing zone distances. The 'decay' of nutrient concentrations within the waterway (also described as nutrient assimilation) is typically measured with time. For this report, mixing zone distances downstream from the Drouin WWTP discharge point is the metric of interest (rather than the time elapsed). In order to convert between nutrient decay time and the mixing zone distance travelled for that decay to occur, the velocity of streamflow in Shillinglaw Creek and King Parrot Creek needs to be estimated.

There is no permanent streamflow gauging station available for Shillinglaw Creek and only historical data for King Parrot Creek. As such, stream velocity is estimated at the gauging station as a surrogate for velocity within Shillinglaw Creek downstream of the discharge point.

Stream velocity typically varies with the bed / water surface slope, volume of discharge and with the shape and the 'roughness' of the stream cross section. In order to reduce the complexity associated with potentially large variations of stream velocity that might occur within various in-stream features such as pools and riffles, it is helpful to consider derived values for stream velocity as an average velocity within the waterway.

There are several methods available to determine stream velocity under different streamflow conditions within Shillinglaw Creek including direct in-stream measurement, hydraulic modelling, and range of mathematical techniques using streamflow data available for Shillinglaw / King Parrot Creeks. The velocity of streamflow was estimated using Manning's equation:

$Q = \frac{1}{n} A R^{2/3} s^{1/2}$ or in another form: $V = \frac{1}{n} R^{2/3} s^{1/2}$.

Where Q = streamflow (m^3/s)

V = velocity (m/s)

n = Manning's roughness coefficient ($s/m^{1/3}$)

A = flow cross sectional area (m^2)

R = hydraulic radius (m) = area / wetted perimeter

s = slope of river bed (m/m)

A rating curve was available (i.e. the relationship between stream depth and streamflow) for the King Parrot Creek gauging station, – presented in Figure 5.

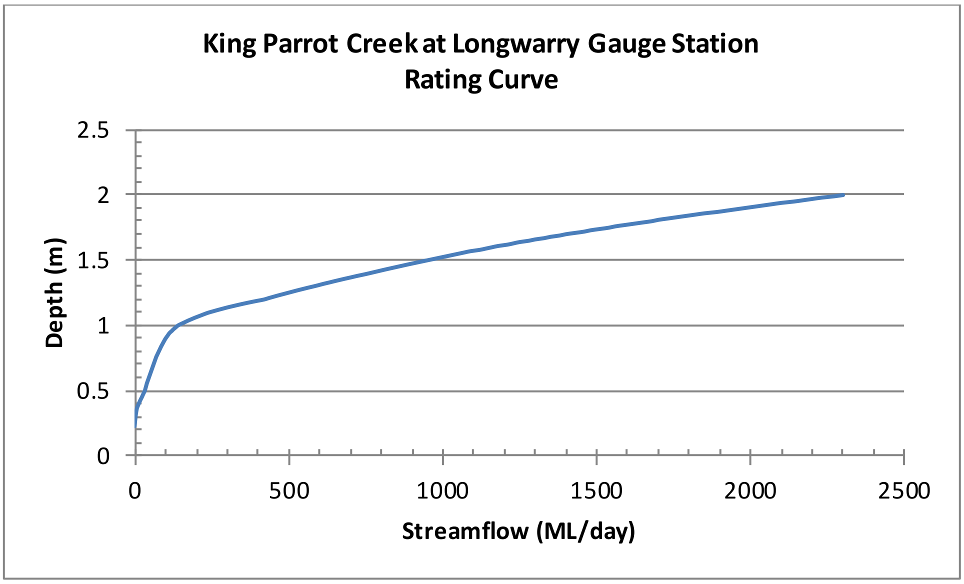

Figure 5 Rating curve for King Parrot Creek gauging station

The bed slope of the watercourse was determined at the gauging station to be average slope of 0.0011 or 0.11%. This average slope was then increased by 50% to represent the slope across higher velocity riffle sections (slope = 0.17%) and decreased by 50% to represent the slope through the lower velocity pool sections (slope = 0.06%) of Shillinglaw and King Parrot Creeks.

Calculations for velocity using Manning's equation were undertaken at the gauging station using depths (d) determined from the rating curve – this site was considered to be a riffle zone (relatively shallow depth and faster velocities). For pool zones, velocities were calculated using an additional depth of 1 metre above the rating curve depths for a given streamflow.

It was assumed for ease of calculation that the stream cross section had a bed width (b) of 1 metre and that the side slopes were at a ratio of 1:1 (x = 1) (see Figure 6). Using an iterative process, the Manning's roughness coefficient was varied so that the streamflow and depth matched the equation. Inputs and outputs of the Manning's equation analysis are presented in Table 5 and in Figure 7.

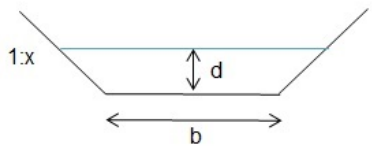

Figure 6 Typical stream cross section diagram

Table 5 Inputs (and outputs) to calculate velocity through pool and riffle sections in King Parrot Creek

Parameter	Unit	Pool	Riffle
x	m	1	1
b	m	1	1
s	m/m	0.06%	0.17%
d	m	Gauge station depth + 1m	Gauge station depth
Outputs			
n_{median}	$s/m^{1/3}$	0.104	0.02
$V_{average}$	m/s	0.23	1.16

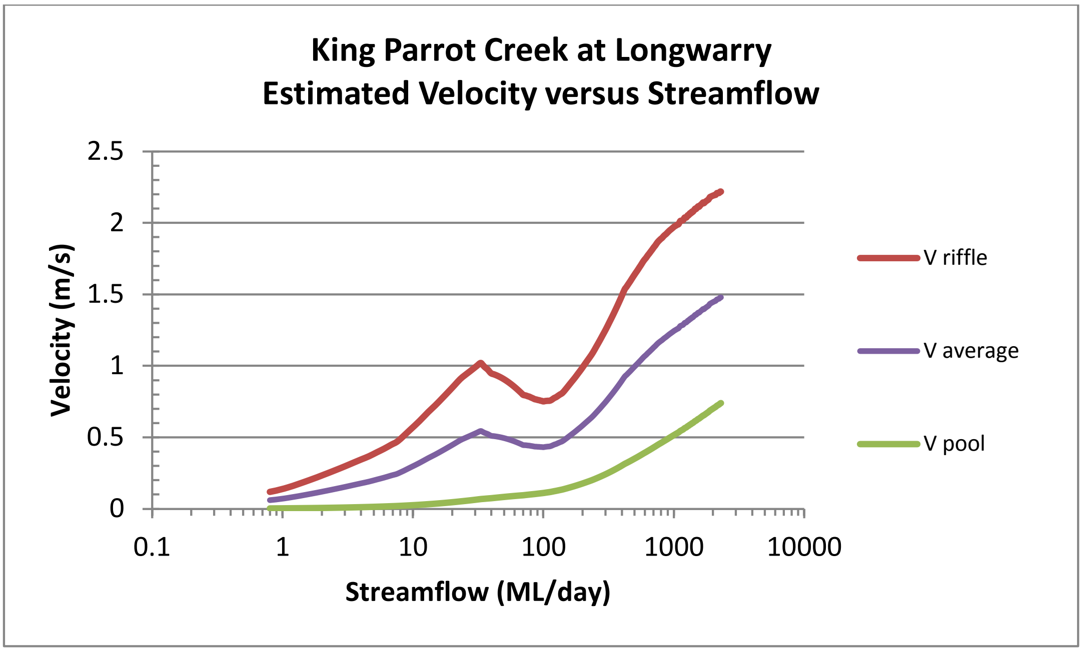

Figure 7 Velocity of flow for King Parrot Creek derived using Manning’s equation

2.2 Drouin WWTP discharge volume data

Daily discharge from Drouin WWTP from 2012 – 2017 is summarised in Table 6 and in Figure 8. Daily discharge statistics are grouped into all data, summer and winter. Median discharge volume for summer was 1.34 ML/day whilst for winter median discharge volume was higher at 2.13 ML/day. Future discharge for the MBR plant is deemed to be 4.2 ML/day.

Table 6 Drouin WWTP - DAFF daily discharge to Shillinglaw Creek 2012-17

Statistic	All Data	Summer	Winter
		(ML/day)	
Maximum	3.311	2.704	3.311
90th percentile	2.346	2.073	2.372
75th percentile	2.216	1.676	2.274
Median	1.920	1.343	2.131
25th percentile	1.254	1.031	1.953
10th percentile	0.838	0.693	1.480
Minimum	0.001	0.060	0.054
Average	1.733	1.348	2.047
Count	1499	365	423

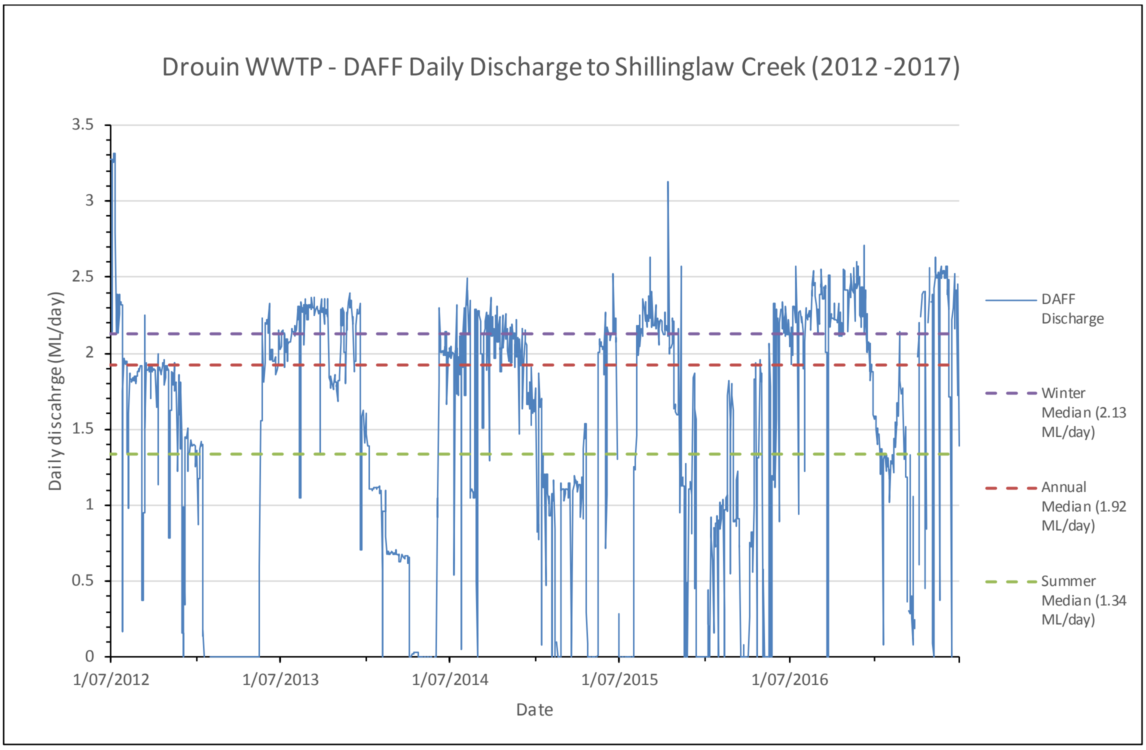

Figure 8 Drouin WWTP - DAFF plant daily discharge to Shillinglaw Creek 2012-2017

3. Water quality data

Water quality data was available for Shillinglaw Creek and Drouin WWTP for current and future discharge scenarios. Results are summarised below.

3.1 Shillinglaw Creek upstream of the discharge point

Median concentrations of key parameters for Shillinglaw upstream of the discharge point are presented in Table 7. Results show there to be generally higher concentrations in winter compared to summer. Whilst the parameters BOD, COD and suspended solids are presented, there was not enough data available in either WWTP discharge or Shillinglaw Creek to utilise these in the mixing zone assessment.

Table 7 Shillinglaw Creek median concentrations upstream of Droiun WWTP discharge point (post July 2012)

	Units	All Data	Summer	Winter
Ammonia -N	mg/L	0.024	0.017	0.039
Nitrate –N	mg/L	0.69	0.035	1.70
Total Nitrogen	mg/L	1.7	0.65	2.85
Total Phosphorus	mg/L	0.058	0.041	0.061
BOD	mg/L	1.5	No Data	No Data
COD	mg/L	No Data	No Data	No Data
Suspended Solids	mg/L	14.5	No Data	No Data

3.2 Drouin WWTP discharge

Median concentrations for key parameters within current Drouin WWTP discharge are presented in Table 8. Results show that winter concentrations are generally higher than or equal to summer concentrations.

Table 8 Drouin WWTP discharge median concentrations – (post July 2012)

	Units	All Data	Summer	Winter
Ammonia -N	mg/L	1.65	0.5	1.2
Nitrate –N	mg/L	7.8	5.5	7.4
Total Nitrogen	mg/L	12	7.1	11
Total Phosphorus	mg/L	0.025	0.025	0.025
BOD	mg/L	4	3	3
COD	mg/L			
Suspended Solids	mg/L	1	1	1

The expected concentrations of key parameters for three discharge scenarios are presented in Table 9.

Table 9 Shillinglaw Creek upstream of Drouin WWTP discharge point

	Units	2031 Summer	2030 Winter (no lagoons, 2 BNR trains)	2019 Winter (no lagoons, 1 BNR train)
Ammonia -N	mg/L	0.1	1.2	1.1
Nitrate –N	mg/L	1.5	~3	~3
Total Nitrogen	mg/L	3.1	5.2	4.7
Total Phosphorus	mg/L	0.2	0.1	0.3
BOD	mg/L	<2	<2	<2
COD	mg/L	<40	<40	<40
Suspended Solids	mg/L	<5	<5	<5

4. Nutrient assimilation and mixing zone calculations

4.1 Mixing zone modelling overview

The Victorian EPA sets out a number of definitions and requirements of mixing zones within Publication 1344: Guidance for the determination and assessment of mixing zones. (EPA 2010)

Key parts include:

- A mixing zone is more than just the point at which a discharge physically mixes with the receiving water. It is an area with explicitly defined boundaries where water quality or biological objectives may not be met, but beyond which objectives must be met.
- For inland waters this must be calculated under low flow conditions, taking into account seasonal and climatic variability. Low-flow conditions must be determined from long-term flow data under recent climatic conditions (for example, to allow for drought). This would typically be five to 10 years of flow data. These flow data are used to identify the month with the lowest average flow over the whole data set. The minimum flow for the mixing zone calculation is the 10th percentile value for all observations for that month.

The change in form of non-conservative parameters (e.g. nutrients) within Drouin WWTP effluent downstream of the discharge point on Shillinglaw and King Parrot Creeks will typically influence the mixing zone distances for these parameters. For nutrients (i.e. nitrogen and phosphorus), the change in form is commonly termed 'decay' or 'assimilation' – and this describes the pathways by which mobilised nutrients are removed (or change form) during the transport process.

Once the rate of decay for nutrients have been estimated, this will allow mixing zones to be defined for a range of wastewater plant discharge volumes and concentrations in different streamflow conditions (i.e. for other conditions other than those experienced in the two recent discharge periods). Estimation of the decay rate can be undertaken with the following data and methods:

- Water samples are available at regular and known intervals downstream of the discharge point.
- The discharge volumes for streamflow and the wastewater plant need to be known.
- Velocity of the streamflow needs to be estimated.
- Travel time to each sample point needs to be calculated.
- A line of best fit can then be drawn through the data to estimate the decay rate.

All of the required data was available for King Parrot Creek downstream of the Longwarry WRP discharge point as part of discharge risk assessment by South East Water (2016).

Decay rates for nutrients are typically measured with time. However, mixing zones are measured in distance rather than time. Therefore, it is important to know the stream velocity within King Parrot Creek at any given flow rate so that a conversion between decay time and the distance travelled over that time can be made. The details of the velocity derivation of streamflow in King Parrot Creek at the gauging station are shown in section 2.1.3 of this report.

4.2 Derivation of decay rates

The methods for determining mixing zones begins with determining or measuring a concentration of total nitrogen, total phosphorus ammonia and nitrate within the receiving waters immediately downstream of the discharge point (as a result of the Drouin WWTP discharge). The next step is to apply a defined decay rate to the concentration in order to determine how long it takes for the concertation to reduce to either upstream values or guideline values. The decay rate is determined by examining the water quality data and the velocity of streamflow in the creek. The decay equation is in the form of $C_t=C_o\ e^{-kt}$,

where C_t is the concentration at time t,

C_o is the initial concentration (i.e. at time = 0),

k is the decay rate (units of 1/day),

t is time in days.

Decay rates of nutrients have not been derived for Shillinglaw Creek due to the lack of suitable streamflow and water quality data. However decay functions were derived from instream water quality data collected for King Parrot Creek downstream of the Longwarry WRP discharge point (SEW (2016)). A summary of the decay rates is presented in Table 10. Graphs of example days on which nutrient decay downstream of the Longwarry WRP discharge point was observed to take place are shown in Figure 9 and Figure 10.

The adopted decay rate for total phosphorus is K = -4.491 day^{-1} (median value) with a maximum of -1.823 and a minimum of -9.846. The equation is $C=C_o\,e^{-4.491t}$. The adopted decay rate for total N is K = -2.401 day^{-1} (median value) with a maximum of -1.428 and a minimum of -3.452. The equation is $C=C_o\,e^{-2.401t}$.

There was no decay rate data available for ammonia and nitrate. However, it has been assumed that the decay rate for total nitrogen is an acceptable substitute for these nitrogen based parameters.

Table 10 Decay rates for King Parrot Creek derived from instream data downstream of South East Water's Longwarry WRP discharge point

Date	Total P (day^{-1})	Date	Total N (day^{-1})
4/11/2015	-4.491	4/11/2015	-1.428
6/10/2015	-9.846	6/10/2015	-3.452
24/09/2015	-1.823	16/09/2015	-2.401
Maximum	-1.823		-1.428
Median	-4.491		-2.401
Minimum	-9.846		-3.452

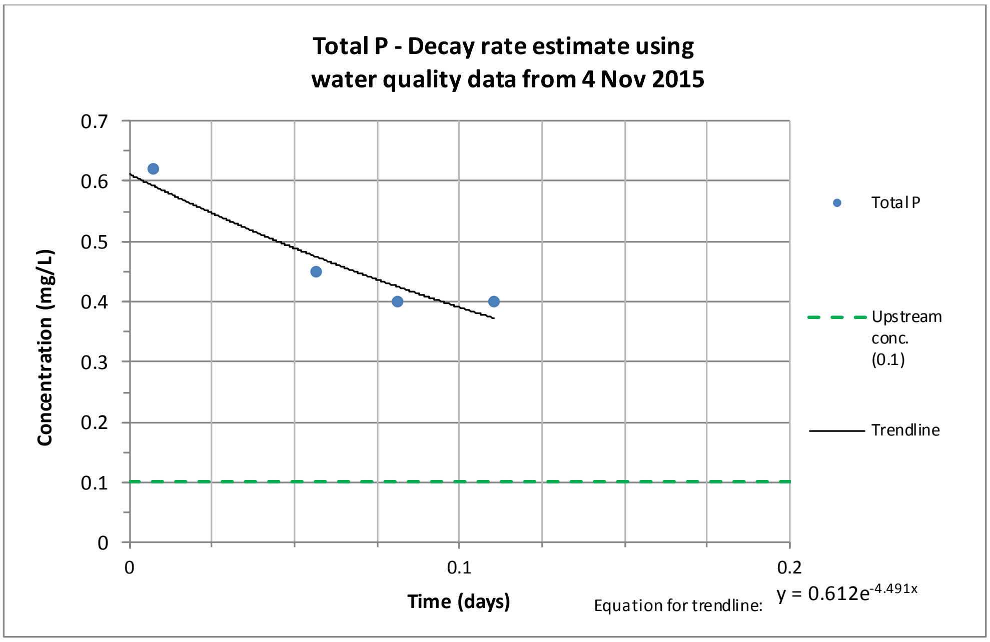

Figure 9 Observed decay in total P in King Parrot Creek downstream of the Longwarry WRP discharge point on 4 November 2015

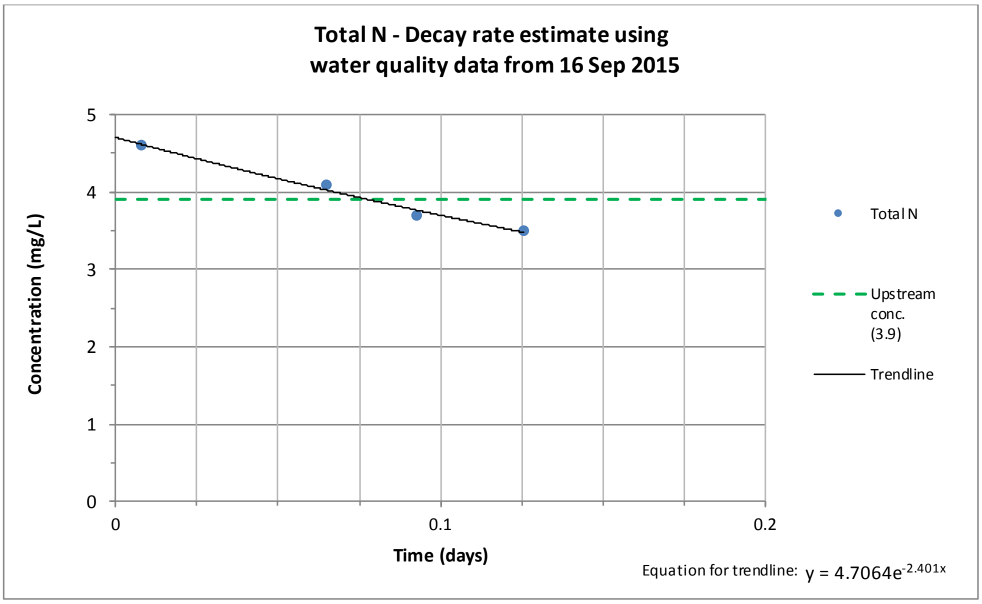

Figure 10 Observed decay in total N in King Parrot Creek downstream of the Longwarry WRP discharge point on 16 September 2015

4.3 Mixing zone calculations and results – various scenarios under low flow conditions

Determining the mixing zone distance downstream of the discharge point requires a starting concentration at the discharge point. This starting or initial concertation is used within the decay calculations to determine the distance downstream at which concentrations return to upstream values or SEPP guideline values.

The starting or initial concentrations at the discharge point can be determined using mass balance calculations. This essentially involves finding the mass flow rate (concentration multiplied by flow) for both Shillinglaw Creek upstream of the Drouin WWTP discharge point and the discharge from Drouin WWTP, adding these together and resolving the equation to find the final flow rate and concentration. Mass balance calculations are required for each of the parameters of interest. Once a starting concentration and flow rate is determined, it can then have the decay calculations applied to it (using the appropriate velocity for the given streamflow).

Mixing zone distance calculations and results are presented in this section for low flow conditions (as required by the Guidance for the Determination and Assessment of Mixing Zones – EPA (2010)). The streamflow in King Parrot Creek upstream of the Drouin WWTP discharge point is defined as the 10th percentile of the month with the lowest average streamflow. Using data from section 2.1.1 of this report, the month with the lowest average streamflow was February with 1.79 ML/month. The 10th percentile streamflow of February is 0.6 ML/day. Taking into account catchment area between the gauging station and the discharge point (a ratio of 0.118 – see section 2.1.2), and multiplying the streamflow by this ratio results in a representative low streamflow of 0.07 ML/day for Shillinglaw Creek. This low streamflow value is applied in both winter and summer scenarios.

Results for mass balance calculations and mixing zone distances for each of the defined seven discharge scenarios under low flow conditions are shown in Table 11 for ammonia -N, Table 12 for nitrate –N, Table 13 for total N and in Table 14for total P.

Table 11 Mass balance and mixing zone calculations for ammonia -N using a defined low flow streamflow value for Shillinglaw Creek

Scenario Number →		1	2	3	4	5	6	7
Scenario Name →		Existing - Winter	Existing - Summer	Existing - Winter (4.2 ML)	Existing - Summer (4.2 ML)	Winter 2019	Summer 2030	Winter 2030
Drouin WWTP discharge	ML/day	2.131	1.343	4.2	4.2	4.2	4.2	4.2
Drouin WWTP concentration	mg/L	1.2	0.5	1.2	0.5	1.1	0.1	1.2
Shillinglaw Ck upstream streamflow	ML/day	0.07	0.07	0.07	0.07	0.07	0.07	0.07
Shillinglaw Ck upstream conc.	mg/L	0.039	0.017	0.039	0.017	0.039	0.017	0.039
Mass Balance								
Downstream flow (% increase from upstream)	ML/day	2.2 (3044%)	1.41 (1919%)	4.27 (6000%)	4.27 (6000%)	4.27 (6000%)	4.27 (6000%)	4.27 (6000%)
Downstream conc. (% increase from upstream)	mg/L	1.16 (2882%)	0.48 (2700%)	1.18 (2928%)	0.49 (2795%)	1.08 (2676%)	0.1 (480%)	1.18 (2928%)
Mixing Zone								
Is downstream conc. higher than upstream?		Yes	Yes	Yes	Yes	Yes	Yes	Yes
Is downstream conc. Higher than SEPP (0.9 mg/L)?		Yes	No	Yes	No	Yes	No	Yes
Mixing Zone	km	1.1	0	1.8	0	1.2	0	1.8

Table 12 Mass balance and mixing zone calculations for nitrate-N using a defined low flow streamflow value for Shillinglaw Creek

Scenario Number →		1	2	3	4	5	6	7
Scenario Name →		Existing - Winter	Existing - Summer	Existing - Winter (4.2 ML)	Existing - Summer (4.2 ML)	Winter 2019	Summer 2030	Winter 2030
Drouin WWTP discharge	ML/day	2.131	1.343	4.2	4.2	4.2	4.2	4.2
Drouin WWTP concentration	mg/L	7.4	5.5	7.4	5.5	3	1.5	3
Shillinglaw Ck upstream streamflow	ML/day	0.07	0.07	0.07	0.07	0.07	0.07	0.07
Shillinglaw Ck upstream conc.	mg/L	1.7	0.035	1.7	0.035	1.7	0.035	1.7
Mass Balance								
Downstream flow (% increase from upstream)	ML/day	3.87 (122%)	1.58 (569%)	5.94 (241%)	4.44 (1780%)	5.94 (241%)	4.44 (1780%)	5.94 (241%)
Downstream conc. (% increase from upstream)	mg/L	4.84 (185%)	4.68 (13281%)	5.73 (237%)	5.21 (14784%)	2.62 (54%)	1.42 (3963%)	2.62 (54%)
Mixing Zone								
Is downstream conc. higher than upstream?		Yes	Yes	Yes	Yes	Yes	Yes	Yes
Is downstream conc. Higher than SEPP (7.2 mg/L)?		Yes	No	Yes	No	No	No	No
Mixing Zone	km	0	0	0.1	0	0	0	0

Table 13 Mass balance and mixing zone calculations for total N using a defined low flow streamflow value for Shillinglaw Creek

Scenario Number →		1	2	3	4	5	6	7
Scenario Name →		Existing - Winter	Existing - Summer	Existing - Winter (4.2 ML)	Existing - Summer (4.2 ML)	Winter 2019	Summer 2030	Winter 2030
Drouin WWTP discharge	ML/day	2.13	1.34	4.20	4.20	4.20	4.20	4.20
Drouin WWTP concentration	mg/L	11.00	7.10	11.00	7.10	4.70	3.1	5.2
Shillinglaw Ck upstream streamflow	ML/day	0.07	0.07	0.07	0.07	0.07	0.07	0.07
Shillinglaw Ck upstream conc.	mg/L	2.85	0.65	2.85	0.65	2.85	0.65	2.85
Mass Balance								
Downstream flow (% increase from upstream)	ML/day	3.87 (122%)	1.58 (569%)	5.94 (241%)	4.44 (1780%)	5.94 (241%)	4.44 (1780%)	5.94 (241%)
Downstream conc. (% increase from upstream)	mg/L	7.34 (157%)	6.14 (844%)	8.61 (202%)	6.76 (940%)	4.16 (46%)	2.97 (357%)	4.51 (58%)
Mixing Zone								
Is downstream conc. higher than upstream?		Yes	Yes	Yes	Yes	Yes	Yes	Yes
Is downstream conc. Higher than SEPP (0.6 mg/L)?		Yes	Yes	Yes	Yes	Yes	Yes	Yes
Mixing Zone	km	5.7	5.3	8.5	12.5	3.1	7.1	3.8

Table 14 Mass balance and mixing zone calculations for total P using a defined low flow streamflow value for Shillinglaw Creek

Scenario Number →		1	2	3	4	5	6	7
Scenario Name →		Existing - Winter	Existing - Summer	Existing - Winter (4.2 ML)	Existing - Summer (4.2 ML)	Winter 2019	Summer 2030	Winter 2030
Drouin WWTP discharge	ML/day	2.13	1.34	4.20	4.20	4.20	4.20	4.20
Drouin WWTP concentration	mg/L	0.03	0.03	0.03	0.03	0.30	0.2	0.1
Shillinglaw Ck upstream streamflow	ML/day	0.07	0.07	0.07	0.07	0.07	0.07	0.07
Shillinglaw Ck upstream conc.	mg/L	0.06	0.04	0.06	0.04	0.06	0.041	0.061
Mass Balance								
Downstreamflow (% increase from upstream)	ML/day	3.87 (122.5%)	1.58 (569.1%)	5.94 (241.4%)	4.44 (1779.7%)	5.94 (241.4%)	4.44 (1779.7%)	5.94 (241.4%)
Downstream conc. (% increase from upstream)	mg/L	0.04 (-32.5%)	0.03 (-33.2%)	0.04 (-41.7%)	0.03 (-36.9%)	0.23 (277%)	0.19 (367.2%)	0.09 (45.2%)
Mixing Zone								
Is downstream conc. higher than upstream?		No	No	No	No	Yes	Yes	Yes
Is downstream conc. Higher than SEPP (0.05 mg/L)?		No	No	No	No	Yes	Yes	Yes
Mixing Zone	km	0	0	0	0	5.4	4.7	1.7

A summary of mixing zone distances for each scenario under low flow conditions is presented in Table 15 and in Figure 11.

Table 15 Estimated mixing zone distances for each scenarios a defined low streamflow in Shillinglaw Creek

Scenario	Mixing zone (km)			
	Ammonia -N	Nitrate -N	Total N	Total P
1 - Existing - Winter	1.1	0	5.7	0
2 - Existing - Summer	0	0	5.3	0
3 - Existing - Winter (4.2 ML)*	1.8	0.1	8.5	0
4 - Existing - Summer (4.2 ML)*	0	0	12.5	0
5 - Winter 2019	1.2	0	3.1	5.4
6 - Summer 2030	0	0	7.1	4.7
7 - Winter 2030	1.8	0	3.8	1.7

* - Scenarios 3 and 4 use existing concentrations for Shillinglaw Creek and Drouin WWTP discharge, but with a WWTP discharge volume of 4.2 ML/day to allow comparison to scenarios 5, 6 and 7.

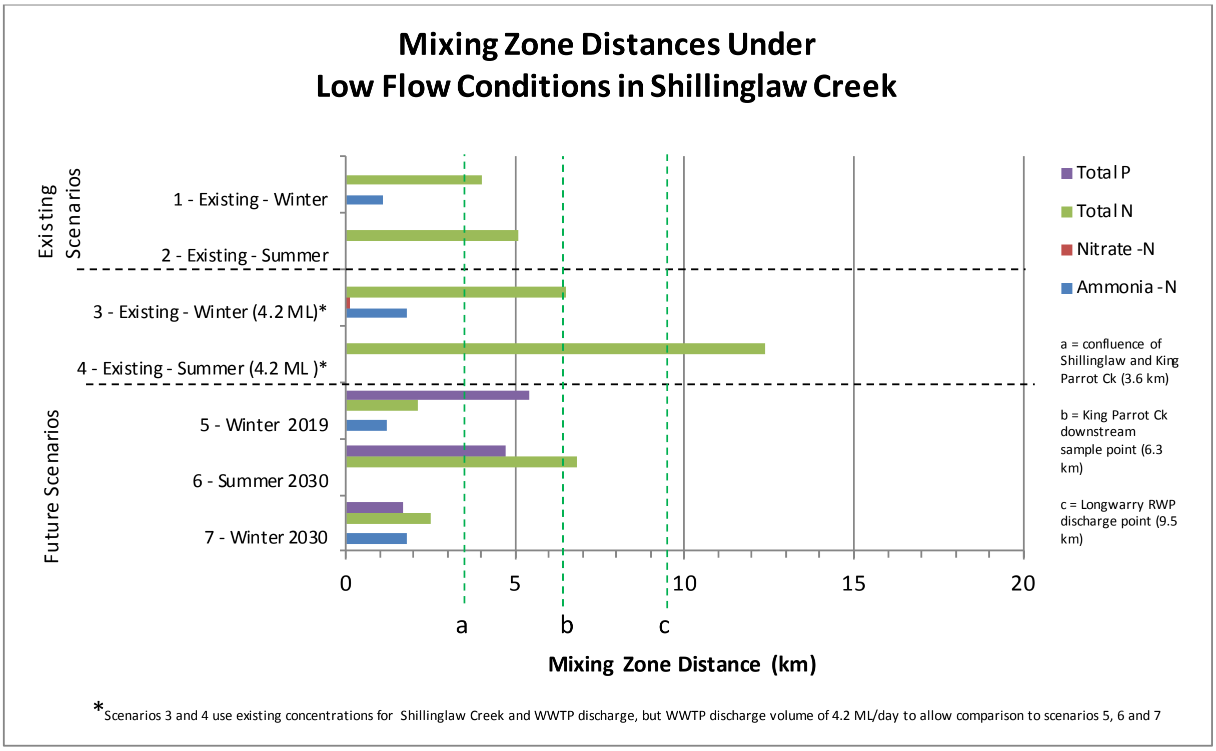

Figure 11 Estimated mixing zone distances for each scenarios a defined low streamflow in Shillinglaw Creek

For total N, the key risk is around eutrophication, rather than toxicity to the waterway. Results show that under existing scenarios (1 and 2) that total N has the longest mixing zone of all the parameters, and this is confirmed by results from the recent report Drouin WWTP Discharge Environmental Risk Assessment (GHD 2018). Summer mixing zones are longer than winter mixing zones for total N, this is mainly because upstream concentrations for total N are considerably lower in summer (a median of 0.65 mg/L) compared to winter (a median of 2.85 mg/L) - i.e. the total N concentration has to reduce further in summer to meet the upstream value than in winter.

Under the theoretical scenarios 3 and 4, in which current water quality with future discharge volumes are used, mixing zones are longer compared to existing scenarios 1 and 2 due to the increase in volume of discharge. With higher streamflow in Shillinglaw Creek (as a result of increased WWTP discharge), the resulting flow has a higher velocity and is typically able to travel further in a given time period than a lesser streamflow

For the future scenarios 5, 6 and 7, the total N mixing zone is longest in summer 2030 at 7.1 km (and longer than existing mixing zone for summer in scenario 2 at 5.3 km). The main reason for this is the reduction in total N concentration in the WWTP discharge for future summer, compared to the existing scenario 2, is not as big as the reduction in concentrations for winter scenarios. Also, the relative increase in summer WWTP discharge volume (from 1.34 ML/day to the future scenario value of 4.2 ML/day) is higher than the increase in winter discharge (from 2.13 ML/day to 4.2 ML/day) – i.e. there are relatively higher velocities in summer 2030 discharges.

It should be noted that the future scenarios (5, 6 and 7) have considerably lower mixing zones for total N than scenarios 3 and 4. This shows the improvement in water quality and mixing zone distance in Drouin WWTP with MBR discharge will have compared to the 'do nothing about discharge quality' alternative shown scenario 3 and 4 with a future increased discharge volume of 4.2 ML/day.

For ammonia, there are small mixing zones of 1.8 km or less in winter discharges only for both existing and future scenarios. For nitrate, there were no mixing zones calculated under existing or future scenarios for either winter or summer.

For total P, there are essentially no mixing zones under existing scenarios 1 and 2. Under future scenarios, the mixing zone is a maximum of 5.4 km in winter 2019 (scenario 5), reducing to 1.7 km in winter 2030 (scenario 7). Summer 2030 discharges (scenario 6) result in a mixing zone of 4.7 km. The main reason for the increase in mixing zones of scenarios 5, 6 and 7 compared to scenarios 1 and 2 is essentially that future concentrations of total P are higher than those being discharged under existing scenarios. Currently, the median concentration for total P in Drouin WWTP discharge is 0.025 mg/L for both summer and winter. For future scenarios, this increases to 0.1 mg/L for winter 2030 (scenario 7), 0.2 mg/L for summer 2030 (scenario 6) and 0.3 mg/L for winter 2019 (scenario 5). As for total N, the risks associated with elevated total P concentrations are essentially around eutrophication of the waterway, not a toxicity risk.

4.4 Mass balance calculations – median flow conditions in Shillinglaw Creek

As a comparison to mixing zone results under low streamflow conditions presented in section 4.3, an analysis under median conditions is presented in this section. This set of analyses uses median streamflow values for winter and summer in place of the single value low flow value used in section 4.3. Results for mass balance calculations and mixing zone distances for each of the defined seven discharge scenarios under low flow conditions are shown in Table 16 for ammonia-N, Table 17 for nitrate –N, Table 18 for total N and in Table 19 for total P.

Table 16 Mass balance and mixing zone calculations for ammonia-N using median streamflow values for Shillinglaw Creek

Scenario Number →		1	2	3	4	5	6	7
Scenario Name →		Existing - Winter	Existing - Summer	Existing - Winter (4.2 ML)	Existing - Summer (4.2 ML)	Winter 2019	Summer 2030	Winter 2030
Drouin WWTP discharge	ML/day	2.131	1.343	4.2	4.2	4.2	4.2	4.2
Drouin WWTP concentration	mg/L	1.2	0.5	1.2	0.5	1.1	0.1	1.2
Shillinglaw Ck upstream streamflow	ML/day	1.74	0.236	1.74	0.236	1.74	0.236	1.74
Shillinglaw Ck upstream conc.	mg/L	0.039	0.017	0.039	0.017	0.039	0.017	0.039
Mass Balance								
Downstream flow (% increase from upstream)	ML/day	3.87 (122%)	1.58 (569%)	5.94 (241%)	4.44 (1780%)	5.94 (241%)	4.44 (1780%)	5.94 (241%)
Downstream conc. (% increase from upstream)	mg/L	0.68 (1639%)	0.43 (2417%)	0.86 (2105%)	0.47 (2690%)	0.79 (1924%)	0.1 (462%)	0.86 (2105%)
Mixing Zone								
Is downstream conc. higher than upstream?		Yes	Yes	Yes	Yes	Yes	Yes	Yes
Is downstream conc. Higher than SEPP (0.9 mg/L)?		No	No	No	No	No	No	No
Mixing Zone	km	0	0	0	0	0	0	0

Table 17 Mass balance and mixing zone calculations for nitrate-N using median streamflow values for Shillinglaw Creek

Scenario Number →		1	2	3	4	5	6	7
Scenario Name →		Existing - Winter	Existing - Summer	Existing - Winter (4.2 ML)	Existing - Summer (4.2 ML)	Winter 2019	Summer 2030	Winter 2030
Drouin WWTP discharge	ML/day	2.131	1.343	4.2	4.2	4.2	4.2	4.2
Drouin WWTP concentration	mg/L	7.4	5.5	7.4	5.5	3	1.5	3
Shillinglaw Ck upstream streamflow	ML/day	1.74	0.236	1.74	0.236	1.74	0.236	1.74
Shillinglaw Ck upstream conc.	mg/L	1.7	0.035	1.7	0.035	1.7	0.035	1.7
Mass Balance								
Downstream flow (% increase from upstream)	ML/day	3.87 (122%)	1.58 (569%)	5.94 (241%)	4.44 (1780%)	5.94 (241%)	4.44 (1780%)	5.94 (241%)
Downstream conc. (% increase from upstream)	mg/L	4.84 (185%)	4.68 (13281%)	5.73 (237%)	5.21 (14784%)	2.62 (54%)	1.42 (3963%)	2.62 (54%)
Mixing Zone								
Is downstream conc. higher than upstream?		Yes	Yes	Yes	Yes	Yes	Yes	Yes
Is downstream conc. Higher than SEPP (7.2 mg/L)?		No	No	No	No	No	No	No
Mixing Zone	km	0	0	0	0	0	0	0

Table 18 Mass balance and mixing zone calculations for total N using median streamflow values for Shillinglaw Creek

Scenario Number →		1	2	3	4	5	6	7
Scenario Name →		Existing - Winter	Existing - Summer	Existing - Winter (4.2 ML)	Existing - Summer (4.2 ML)	Winter 2019	Summer 2030	Winter 2030
Drouin WWTP discharge	ML/day	2.13	1.34	4.20	4.20	4.20	4.20	4.20
Drouin WWTP concentration	mg/L	11.00	7.10	11.00	7.10	4.70	3.1	5.2
Shillinglaw Ck upstream streamflow	ML/day	1.74	0.24	1.74	0.24	1.74	0.24	1.74
Shillinglaw Ck upstream conc.	mg/L	2.85	0.65	2.85	0.65	2.85	0.65	2.85
Mass Balance								
Downstream flow (% increase from upstream)	ML/day	3.87 (122%)	1.58 (569%)	5.94 (241%)	4.44 (1780%)	5.94 (241%)	4.44 (1780%)	5.94 (241%)
Downstream conc. (% increase from upstream)	mg/L	7.34 (157%)	6.14 (844%)	8.61 (202%)	6.76 (940%)	4.16 (46%)	2.97 (357%)	4.51 (58%)
Mixing Zone								
Is downstream conc. higher than upstream?		Yes	Yes	Yes	Yes	Yes	Yes	Yes
Is downstream conc. Higher than SEPP (0.6 mg/L)?		Yes	Yes	Yes	Yes	Yes	Yes	Yes
Mixing Zone	km	4	5.1	6.5	12.4	2.1	6.8	2.5

Table 19 Mass balance and mixing zone calculations for total P using median streamflow values for Shillinglaw Creek

Scenario Number →		1	2	3	4	5	6	7
Scenario Name →		Existing - Winter	Existing - Summer	Existing - Winter (4.2 ML)	Existing - Summer (4.2 ML)	Winter 2019	Summer 2030	Winter 2030
Drouin WWTP discharge	ML/day	2.13	1.34	4.20	4.20	4.20	4.20	4.20
Drouin WWTP concentration	mg/L	0.03	0.03	0.03	0.03	0.30	0.2	0.1
Shillinglaw Ck upstream streamflow	ML/day	1.74	0.24	1.74	0.24	1.74	0.236	1.74
Shillinglaw Ck upstream conc.	mg/L	0.06	0.04	0.06	0.04	0.06	0.041	0.061
Mass Balance								
Downstream flow (% increase from upstream)	ML/day	3.87 (122.5%)	1.58 (569.1%)	5.94 (241.4%)	4.44 (1779.7%)	5.94 (241.4%)	4.44 (1779.7%)	5.94 (241.4%)
Downstream conc. (% increase from upstream)	mg/L	0.04 (-32.5%)	0.03 (-33.2%)	0.04 (-41.7%)	0.03 (-36.9%)	0.23 (277%)	0.19 (367.2%)	0.09 (45.2%)
Mixing Zone								
Is downstream conc. higher than upstream?		No	No	No	No	Yes	Yes	Yes
Is downstream conc. Higher than SEPP (0.05 mg/L)?		No	No	No	No	Yes	Yes	Yes
Mixing Zone	km	0	0	0	0	5.2	4.6	1.5

Results are summarised in Table 20 and in Figure 12.

Table 20 Summary of mixing zone distances for each scenario under median flow conditions in Shillinglaw Creek

Scenario	Mixing zone (km)			
	Ammonia-N	Nitrate-N	Total N	Total P
1 - Existing - Winter	0	0	4	0
2 - Existing - Summer	0	0	5.1	0
3 - Existing - Winter (4.2 ML)*	0	0	6.5	0
4 - Existing - Summer (4.2 ML)*	0	0	12.4	0
5 - Winter 2019	0	0	2.1	5.2
6 - Summer 2030	0	0	6.8	4.6
7 - Winter 2030	0	0	2.5	1.5

* - Scenarios 3 and 4 use existing concentrations for Shillinglaw Creek and Drouin WWTP discharge, but with a WWTP discharge volume of 4.2 ML/day to allow comparison to scenarios 5, 6 and 7.

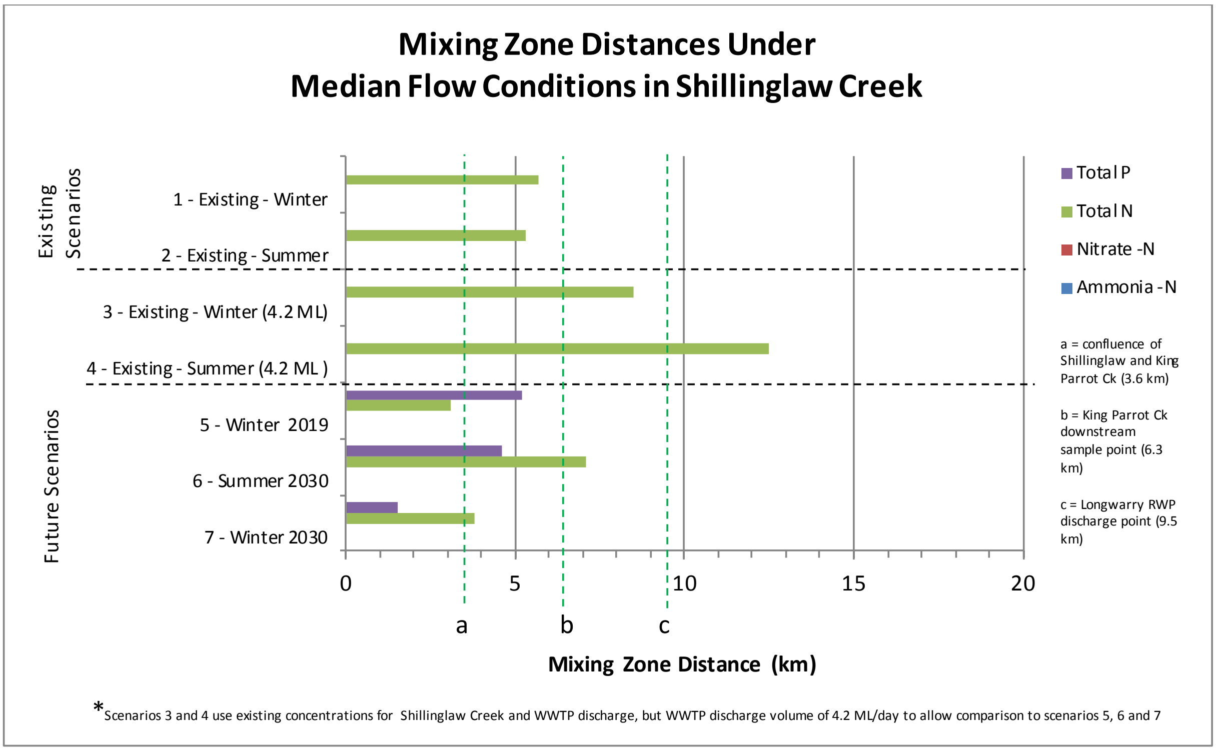

Figure 12 Estimated mixing zone distances for various theoretical scenarios (median flow conditions)

Mixing zone distances are essentially smaller under median streamflow conditions compared to low flow conditions. For ammonia, nitrate and total P, there are no mixing zones under existing scenarios. For future scenarios, there are mixing zones for both total N and total P, however these are smaller than those under low flow conditions.

5. Discussion and conclusion

Future discharge volumes from the MBR plant are proposed to be 4.2 ML/day, somewhat higher than current discharge volumes which are a median of 1.34 ML/day during summer and 2.13 ML/day in winter. The MBR plant will produce effluent water quality that is equivalent to or lower in ammonia, nitrate and total N concentrations than present day effluent. Total P concentrations in the MBR discharge will be an increase from present day concentrations (currently the median value is 0.025 mg/L which will increase to 0.1 mg/L in winter 2030, 0.2 mg/L in summer 2030 and 0.3 mg/L in winter 2019.

An analysis was undertaken on current and future discharge scenarios for Drouin WWTP discharges into Shillinglaw Creek to determine the mixing zone distances for each discharge scenario. The mixing zone was defined to be the distance downstream of the discharge point at which concentrations reduce to those found upstream of the discharge point, or to the relevant guideline value.

The analyses was undertaken under low streamflow conditions (defined to be the 10th percentile flow in the month with the lowest average streamflow – i.e. 0.07 ML/day in Shillinglaw Creek upstream of the discharge point). Results show that the parameter with the longest mixing zone was total N under most scenarios (both current scenarios and future scenarios). The total N mixing zone reaches beyond the confluence of Shillinglaw and King Parrot Creeks (which is 3.6 km downstream of the discharge point) to around 5.3 – 5.7 km in winter and summer. Under future scenarios, this decreases to 3.1 – 3.8 km during winter, but increases to 7.1 km downstream during summer of 2030. The main reasons for the increase includes the increase in discharge volume but relatively lower reduction in concentration for total N in future summer scenarios compared to future winter scenarios.

For total P, there are no mixing zones under current discharge scenarios in summer or winter. The mixing zone increases to 5.4 km in winter 2019, 4.7 km in 2030 and 1.7 km in winter 2030. These increases are due to the future total P concentration in WWTP discharge being higher than existing discharge concentrations.

For ammonia, there is only relatively small mixing zones present during winter scenarios both current and future, and no mixing zones during the summer. For nitrate there were essentially no mixing zones under current or future discharge scenarios.

Mixing zone calculations were also undertaken with median streamflow conditions (i.e. a median streamflow for winter and summer scenarios). Results essentially showed a reduction in mixing zone distance for each scenario and that the low flow analysis may be considered a conservative estimate of the mixing zone, given that mixing zones will differ depending on streamflow.

Results from this analysis in this report draw on a range of data from a variety of sources. Confidence in this mixing zone assessment could be improved with improved data on stream flow and water quality. There is an opportunity to improve monitoring for data requirements with regards to mixing zone assessments on Shillinglaw and King Parrot Creeks. Streamflow data was obtained from 1964 to 1977 from King Parrot Creek at Longwarry, however the gauging station has since been closed, leaving a gap in data (which may be important with regards to climate change, land use runoff changes and future streamflow). Stream velocity was determined at the King Parrot Creek gauging station rather than a site closer to the Drouin WWTP discharge point, which may be a source of error in the mixing zone assessment. Nutrient decay rates were determined for King Parrot Creek near the Longwarry WRP discharge point (South East Water's treatment plant 9.5 km downstream of Drouin WWTP). Insufficient water quality sampling in Shillinglaw Creek has limited the ability to determine localised nutrient decay rates for Shillinglaw Creek. As such the confidence in future evaluations of Drouin WWTP discharge risks and mixing zone assessments would be improved by reinstating the streamflow gauge station (and potentially an additional gauge closer to Drouin WWTP discharge point) and to optimise the existing water sampling program.

6. References

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EPA (2010). Guidance for the determination and assessment of mixing zones. Publication 1344 June 2010. Victorian Environmental Protection Authority.

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South East Water (2016). King Parrot Creek Risk Assessment - Comprehensive Environmental Risk Assessment. May 2016.

Appendices

Appendix A – Guidelines values used with mixing zone analyses

Table A1 - Environmental water quality guideline indicators used in mixing zone analyses

Indicator	Unit	Objective statistic / range	Objective value	Guideline
Total phosphorus	mg/L	Maximum at base flow	<0.05	SEPP WoV Waters of Western Port, South Eastern Rural segment
Total nitrogen	mg/L	Maximum at base flow	<0.6	
Ammonia as N	mg/L	Toxicant trigger value - 95% species level of protection at pH of 8	0.9	ANZECC (2000) – Table 3.4.1
Nitrate as N	mg/L	95% Level of species protection. Figures protect against toxicity and do not relate to eutrophication issues. Concentration for Nitrate (NO_3) divided by 4.43 = Nitrate as N (NO_3-N) – i.e. 31.9 mg/L NO_3 = 7.2 mg/L NO_3-N.	31.9 as NO_3 or 7.2 as NO_3-N	

GHD

Level 8
180 Lonsdale Street
T: 61 3 8687 8000 F: 61 3 8687 8111 E: melmail@ghd.com

3135513-3777/https://projects.ghd.com/oc/Victoria/drouinwwtpdischargee/Delivery/Documents/3135513-REP_Drouin WWTP - MBR Discharge Assessment.docx

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Revision	Author	Reviewer		Approved for Issue		
		Name	Signature	Name	Signature	Date
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