Monash University
Faculty of Engineering
Master of Professional Engineering
Civil Engineering Specialization
CIV5178 – Advanced Water Treatment

Wastewater Treatment Plant Design

Presented by:
Kevin González – 111
Jhon Solórzano – 222
Julian Mejia – 34774564

Presented to:
Unit coordinator and chief examiner: Brandon Winfrey

May 9, 2025

EXECUTIVE SUMMARY

Executive summary to be added here afterwards

CONTENTS

1 INTRODUCTION AND CONCEPTUAL DESIGN DESCRIPTION

Population and economical growth among other factors require the subsequently development of cities and the general infrastructure that supports them. As a cities expand, the electrical grid, road systems, drinking water and Wastewater recolection and treatment, among others, need to increase their capabilities as well. In the recent years, a northwest area in Melbourne has been rapidly developping and therefore, requires the construction of a new Wastewater treatment plant that can address the current and future needs of the community. In the presente report, the authors present the design of the abovementioned plant following local guidlines.

The designed is conformed by a *Preliminary Treatment - Section 2* where the screeing is designed to remove coarse material on the flow stream to protect downstream process equipment and increse its reliability [Metcalf and Eddy, 2014]. The next step is the *Primary Sedimentation - Section 3*, designed to remove the settleted solids and floating material. This process can reach removals ratios of 50% to 70% of the suspended solids (*SST*) and 25% to 40% of the BOD. It is followed by the *Secondary Treatment - Section 4*, in which sludge and activation systems are used to remove the soluble, coloidal and particulate suspended organic substances by coagulating them through the microorganisms (sludge).

Finally, the environmental impact of the incorporation of the treated wastewater into the waterway is assessed against the local guidelines applicable to determine whether it complies with its requirements or if further treatment shall be implemented.

1.1 Population estimations

To determine the waswater flowrates and mass loads for develoment areas that the plant should be capable of process, where actual flow and load measurements are not avilable, the population equivalent can be used. This is a standarization of the wastewater production and characteristics based on the amount of people that would produce the same values. For example, in the *AMF L8 Sewerage Planning and Design Principles* which is the standard for wastewater treatment plants, developed by *Yarra Valley Water* which covers the area underdesign in the present report, on its *Table 3-4* equivalent population factors are presented for different development types for both residential and commercial use. For this report, based on previous surveys and analysis, it is known that the equivalent population from domestic contributions (PE_{domestic}) is equal to 340000. Similarly, for commercial contributions, the equivalent population is known to comply with the following calculation: $PE_{\text{commercial}} = \lceil \sqrt{10} \times 9000 \rceil = 28461$.

1.2 Current flowrates estimation

According to the *Water Service Association of Australia* the inflow rate percapita can be estimated as 180 L/PE/day [Yarra Valley Water, 2023]. Therefore, the $Q_{\text{current avg, domestic}}$ can be calculated as $\frac{Q_{\text{domestic per capita}} \times PE_{\text{domestic}}}{1000} = 61200.0\ \mathrm{m^3/day}$. Similarly, based on previous surveys it got determine that the commercial contribution for this area is 280 L/PE/day. Therefore the $Q_{\text{current avg, commercial}}$ can be calculated as $\frac{Q_{\text{commercial per capita}} \times PE_{\text{commercial}}}{1000} = 7969.08\ \mathrm{m^3/day}$.

The infiltration/inflow flowrate, when no data is available, can be estimated based on either the total length of the sewer system, or based on the area to be covered. For the last one, the ratio can vary from 0.2 up to 28 $\mathrm{m}^3/\mathrm{ha}/\mathrm{day}$ [Metcalf and Eddy, 2014]. In this report, the authors has choosen the lower limit as the system will be new and therefore the damage on the pipelines will be minimum.

As no data of the covered area is available, the autors have estimated it based on the average population per area ratio of Melbourne suburbs. The Melbourne population density per suburb data is available in the *Australian Bureau of Statistics* web page, see Apendix 1 for the raw data. From it, the Population average per suburb (P_{average}) and the average landscape area ($A_{average}$ km^2) were calculated. With the P_{average} / $A_{average}$ ratio, multiplied by the PE_{domestic} the estimated area of the understudy suburb ($A_{estimated}$) is obtained. The $PE_{\text{commercial}}$ is not included as it does not represents actual population. In the Table 1 the obtained results for the infiltration rate estimation. In the Table 2 the current flow rates obtained are summarized.

Table 1: Understudy landscape area estimation

P_{average}	A_{average} (km^2)	$A_{\text{average}}/P_{\text{average}}$	$A_{\text{estimated}}$ (km^2)	Ratio (m^3/ha/day)	$Q_{\text{infiltration}}$ (m^3/day)
11200.0	18.65	0.0017	5.66	0.2	11323.41

1.3 Minimum current flow rates

The minimum flow rates can be estimated using the minimum peaking factor which from the 1 is equal to 0.3. The current flow rates shown in the Table 2 are multiplied by this factor, and results are presented in Table 3.

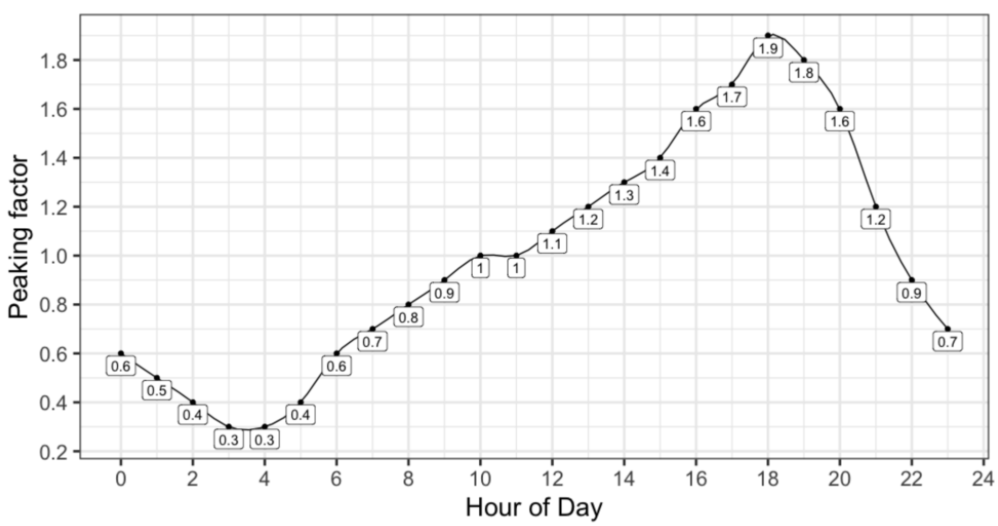

Figure 1: Daily fluctuation of peaking factors at each hour of the day for flow rates on an average day in a similar wastewater catchment.

1.4 Maximum current flow rates

The maximum flow rates can be estimated using the maximum peaking factor which from the Figure 1 is equal to 1.9. The current flow rates shown in the Table 2 are multiplied by this factor, and results are presented in Table 3.

Population Growth and Future Design Considerations

To account for future demand on the wastewater treatment plant, the design incorporates a projected population growth. Based on previous analysis, it was determined that the annual growth reate can be estimated as: $G_{rate} = 1 + 10^{0.015} = 2.04\%$. The current population is therefore projected during the life span of the plant. The life span is commonly adopted as 20 years as it balances the need to consider future growth and technological advancements while ensuring economic feasibility [Water Environment Federation, 2017]. The projected population can be calculated based on (Eq. 1).

$$PE_{\text{projected}} = \left[PE \times \left(1 + \frac{\text{Growth Percentage}}{100} \right)^{20} \right] \quad \text{(Eq. 1)}$$

With the per capita flow rates mentioned in the Section 1.2, following the same procedure there mentioned the flow rates for the projected population can be calculated as well. Additionally, the minimum and maximum projected flowrates can be calculated following the peak minimum factor and peak maximum factor mentioned in Sections 1.3 and 1.4, respectively. Results are shown in the Table 3.

To project the infiltration, a different approach is used. This value is not controlled by the population as it depends more on the environmental phenomenon. Because of this, it is projected based on an environmental factor instead. The *Environment, Land, Water and Planning* department of the *Victoria State Goverment* in their *Guidelines for the Adaptive Management of Wastewater Systems Under Climate Change in Victoria*, especified that the climate change factor can be taken as 1.2. The infiltration flow rate presented in Table 2 is therefore multiplied by this factor and presented in the Table 3.

Table 2: Current population and flow rates

Contribution type	**Population Equivalent**	**Minimum flow rate (m^3/day)**	**Average flow rate (m^3/day)**	**Maximum flow rate (m^3/day)**
Domestic	340000	18360.00	61200.00	116280.00
Commercial	28461	2390.72	7969.08	15141.25
Infiltration	–	11657.00	11657.00	11657.00
Total	–	32407.72	80826.08	143078.25

1.5 Influent Pollutant Load Estimation

Following the guidelines established for wastewater treatment design [Water Environment Federation, 2017, Metcalf and Eddy, 2014], the analysis focused on two key

Table 3: Projected population and flow rates

Contribution type	**Population**	**Minimum flow rate (m^3/day)**	**Average flow rate (m^3/day)**	**Maximum flow rate (m^3/day)**
Domestic	427363	23077.60	76925.34	23077.60
Commercial	35775	3005.10	10017.00	3005.10
Infiltration	–	13988.40	13988.40	13988.40
Total	–	40071.10	100930.74	179178.85

pollutants: Biochemical Oxygen Demand *(BOD)* and Total Suspended Solids (TSS), which are considered the most relevant indicators for organic and solids loading.

As no specific influent quality data was available for the study area, representative pollutant concentrations were obtained from Melbourne Water's open dataset on the Eastern Treatment Plant (ETP) [Melbourne Water, 2024]. This dataset, which includes daily influent quality records from 2014 onwards, is publicly accessible at https://data-melbournewater.opendata.arcgis.com. In Figure 2, the box plot of the *(BOD)* of the abovementioned data is presented.

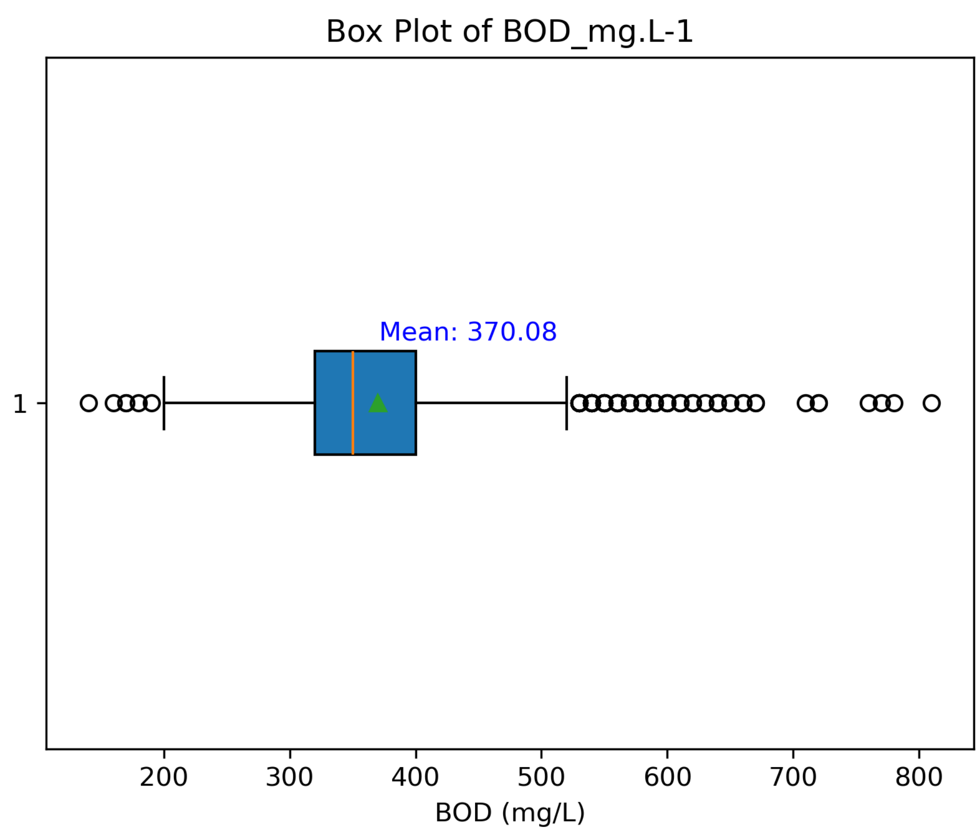

Figure 2: Boxplots of Biochemical Oxygen Demand (BOD) from Melbourne Water ETP dataset

2 PRELIMINARY TREATMENT DESIGN

The preliminary treatment includes coarse screening to remove large solids and protect downstream units. The flow velocity through the screen is assumed within the recommended range of 0.3 to 1.0 m/s. The screen bar spacing is selected to capture gross solids greater than 10 mm, and a bar width is chosen based on commercial availability.

2.1 Facility types

The preliminary treatment is conformed by screeing, also known as *bar racks*, and grit chambers. In the Table 4 the types of screening are categorized based on the size of the screen opening which determines the removal type the screen would provide.

Table 4: Screening clasification per opening size [Davis, 2010]

Type	Typical opening	Removal
Trash racks/Primary screening	40-150 mm	Large heavy debris.
Coarse screens	6-75 mm	Large solids, rags and debris.
Fine screens	1.5-6 mm	Small solids, usually used after a coarse screen.
Very fine screens	0.25-1.5 mm	Suspended solids to near primary treatment level. Usually used when no primary treatment is implemented.
Microscreens	1μm-0.3 mm	Used in conjunction with very fine screens for effluent polishing.

The screens can also be clasified depending on the type of cleaning, if it is manually or mechanically, in case of the second one they can be further categorized depending of the mechanism type. The cleaning type does not impact the design calculations and can, therefore, be selected based on commercial and economical constrains.

2.2 Screens design

When the flow goes through the screens, it might suffer a headloss due to the obstruction and turbulunce created by the screens limited open area. This headloss can be neglected in the primary screening as the opening area remains big enough to not cause significant headloss. To determine head loss and sizing of the secondary screening, the velocity upstream of the bars, the hydraulic head loss, and the cross-sectional flow area are calculated. The design assumes that flow depth is governed by the downstream hydraulic condition, and the channel width is then determined accordingly. The calculations are based on the peak projected flow rate.

The values used for this calculation are summarised in Table 5. The flow velocity thorugh the screen v_{screen} should be between 0.3 and 1.0 m/s, the latter is selected and checked against the other constrains of the design. The bar spacing or opening size (b) is taken as 0.01 m as the screen should remove particles bigger than 10mm. The bar width w is selected as 0.004 m based on commercial screens availability. The discharge coefficient (C_d) is commonly taken as 0.84, although it might be adjusted based on the screening specifications. Finally, the minimum required downstream flow depth was determined to be 1.0 m based on previous analysis.

Table 5: Design input values for screen and channel

Parameter	Value	Description
v_{screen}	1.0 m/s	Flow velocity through the screen
b	0.01 m	Spacing between bars
w	0.004 m	Bar width
C_d	0.84	Discharge coefficient
g	9.81 m/s^2	Gravitational acceleration
d	1.0 m	Assumed downstream flow depth

From Equations (2) to (5) Table 6 the upstream velocity (v_{upstream}), the headloss (H_{loss}), the upstream flow rate (d_{upstream}), the wetted cross-sectional area (A_{wet}) and required channel width (W_{channel}) were determined. The screens width is recommended to be between 0.6 and 1.1m. The number of screens required (N_{screens}) is therefore calculated based on the channel width divided by the maximum recomended screen width (1.1 m) and rounding up to the nearest integer. Results are shown in the Table 6.

$$v_{\text{upstream}} = v_{\text{screen}} \cdot \frac{b}{b+w} \tag{2}$$

$$h_{\text{loss}} = \frac{1}{2gC_d^2}\left(v_{\text{screen}}^2 - v_{\text{upstream}}^2\right) \tag{3}$$

$$A_{\text{wet}} = \frac{Q_{\text{peak}}}{v_{\text{upstream}}} \tag{4}$$

$$W_{\text{channel}} = \frac{A_{\text{wet}}}{d + h_{\text{loss}}} \tag{5}$$

Table 6: Screen and channel design results

Output	Value	Description
v_{upstream}	0.714 m/s	Velocity before the screen
h_{loss}	0.04 m	Head loss across the screen
d_{upstream}	1.04 m	Flow depth upstream
A_{wet}	2.9 m^2	Wetted cross-sectional area
W_{channel}	2.8 m	Required screen channel width
N_{screens}	3	Number of screens required

To ensure that the screen performs under minimum flow conditions, the upstream velocity at low flow was recalculated. The downstream control flow depth should not exceed the value shown in Table 6 to maintain sufficient velocity during low flow conditions.

2.3 Equalisation basin

The Equalization basins were calculated to control the downstreams peak flow, ensuring an addecuated primary treatment achieving the targeted efficiency in the BOD_5 removal. See Section 3 for more information related to its design.

3 PRIMARY TREATMENT

3.1 Fecility Types

3.2 Primary Sedimentation

3.2.1 Clarifier Sizing and Flow Equalization

To determine the volume of the primary clarifiers, the removal efficiencies required for suspended solids (SS) and biochemical oxygen demand (BOD) were referenced from standard design tables [Metcalf and Eddy, 2014]. The detention times required for each are calculated using the following empirical formula:

$$t = \frac{R \cdot a}{1 - R \cdot b} \tag{6}$$

where R is the removal efficiency, and a, b are parameters defined for SS and BOD. The greater of the two detention times governs the total volume design:

$$V_{\text{clarifier}} = Q_{\text{PHR}} \cdot t \cdot 3600 \tag{7}$$

This volume is then checked against the acceptable detention time range for average dry weather flow (ADWF), 1.5 h $< t <$ 2.5 h, and revised accordingly. The excess volume, if any, is allocated for equalization.

Table 7 summarizes the input values used for this step.

Table 7: Input values for clarifier sizing

Parameter	Value	Units
Q_{ADWF}	`[insert]`	m^3/h
Q_{PHR}	`[insert]`	m^3/h
t_{SS}	`[insert]`	h
t_{BOD}	`[insert]`	h
t_{max} (ADWF)	2.5	h

The adjusted volume is then used to calculate surface area and surface loading rates (SLR) for both PHR and ADWF conditions:

$$A = \frac{V}{H} \tag{8}$$

$$SLR = \frac{Q}{A} \cdot \frac{1}{3600 \cdot 24} \tag{9}$$

Following this, the clarifier diameter is calculated based on the required volume and depth:

$$D = \sqrt{\frac{4V}{\pi H}} \tag{10}$$

3.2.2 Weir Loading Rate (WLR) Assessment

The weir length for circular clarifiers with two-sided launders is:

$$L_w = 2 \cdot \pi \cdot (D - 2d_{\text{offset}}) \tag{11}$$

The WLR is then calculated as:

$$WLR = \frac{Q}{L_w \cdot 86400} \tag{12}$$

The critical design case assumes $n-1$ clarifiers are in operation. If the WLR exceeds the design limit (500 m^3/m/day), tank number or dimensions are adjusted iteratively.

3.2.3 Final Configuration and Results

After iterative trials, the final clarifier configuration satisfies all the guidelines. Table 8 summarizes the resulting design parameters.

Table 8: Final clarifier design parameters

Parameter	**Result**	**Unit**
Number of Clarifiers	[insert]	–
Clarifier Diameter	[insert]	m
Sidewater Depth	[insert]	m
Surface Area (total)	[insert]	m^2
SLR (ADWF)	[insert]	m^3/m^2/day
SLR (PHR)	[insert]	m^3/m^2/day
WLR (critical)	[insert]	m^3/m/day
Equalization Tank Volume	[insert]	m^3

3.3 V-Notch and Launder Design

To ensure stable discharge from the primary clarifiers and prevent hydraulic overloading, a V-notch weir system was designed in accordance with standard hydraulic principles. The number of notches is determined based on the critical launder length and a center-to-center spacing of 0.3 m between notches:

$$N_{\text{notch}} = \left\lceil \frac{L_{\text{launder}}}{s} \right\rceil \tag{13}$$

where $s = 0.3$ m is the spacing. The total number of V-notches in the system is then:

$$N_{\text{notch, total}} = N_{\text{notch}} \times N_{\text{clarifiers}} \tag{14}$$

The flow per notch is calculated based on the design peak hourly flow:

$$Q_{\text{notch}} = \frac{Q_{\text{PHR}}}{N_{\text{notch, total}}} \tag{15}$$

The maximum height of water over each V-notch is determined using the general formula for triangular weirs:

$$h = \left(\frac{Q_{\text{notch}}}{\frac{8}{15} C_d \sqrt{2g} \tan(\theta/2)} \right)^{2/5} \tag{16}$$

where $C_d = 0.58$, $g = 9.81$ m/s^2, and $\theta = 90°$. A 15% safety margin is applied to determine the actual design depth above the notch:

$$y = 1.15 \cdot h \tag{17}$$

The top width of the V-notch opening is twice the water depth:

$$w_{\text{notch}} = 2y \tag{18}$$

3.3.1 Launder Flow Conditions

To assess flow behavior in the launder channel, the discharge per unit length of the launder is:

$$q = WLR_{\text{max}} \cdot \frac{1}{3600 \cdot 24} \cdot n_{\text{sides}} \tag{19}$$

The maximum water depth in the launder is calculated from the critical section at the discharge point:

$$Y_c = \left(\frac{q^2 \cdot L^2}{4gw^2}\right)^{1/3} \tag{20}$$

The final maximum water depth is obtained using the equation for uniform flow depth in a launder with one outlet point at distance x:

$$H = \sqrt{Y_c^2 + \frac{2q^2x^2}{gw^2Y_c}} \tag{21}$$

A 50% safety factor is applied to this maximum depth for design purposes:

$$H_{\text{final}} = 1.5 \cdot H \tag{22}$$

Summary of V-Notch and Launder Design Results

Table 9: V-notch and launder design summary

Parameter	**Result**	**Units**
Number of notches per clarifier	`[insert]`	–
Total number of notches	`[insert]`	–
Flow per notch	`[insert]`	m^3/s
Max. height over notch h	`[insert]`	m
Water depth y (with 15% SF)	`[insert]`	m
Top width of V-notch w_{notch}	`[insert]`	m
Discharge per unit length q	`[insert]`	$m^3/m/s$
Critical height Y_c	`[insert]`	m
Max. water depth H	`[insert]`	m
Final design depth H_{final} (with 50% SF)	`[insert]`	m

4 SECONDARY TREATMENT

4.1 Design Overview

The secondary treatment stage is designed as an extended aeration activated sludge process, aiming to achieve 90% BOD_5 removal. Based on the effluent quality requirement 20 mg/L (BOD_5), the influent concentration to this stage can be derived from:

$$BOD_{\text{in}} = \frac{BOD_{\text{effluent}}}{1 - \eta} \tag{23}$$

where $\eta = 0.9$ is the BOD removal efficiency.

4.2 Sludge Characteristics and Return Flow

Mixed liquor suspended solids (MLSS) concentration is chosen based on the process type and operating temperature, and return sludge concentration X_R is assumed. The sludge volume index (SVI) is given by:

$$SVI = \frac{10^6}{X_R} \tag{24}$$

The settled sludge volume is:

$$v = \frac{SVI \cdot X}{1000} \tag{25}$$

The return sludge flow rate is then:

$$Q_R = \frac{Q \cdot v}{1000 - v} \tag{26}$$

4.3 Aeration Tank Sizing

Using a target food-to-microorganism ratio (F/M), the required aeration tank volume is calculated:

$$V_{\text{aeration}} = \frac{Q \cdot BOD_{\text{in}}}{F/M \cdot X} \tag{27}$$

This is followed by residence time:

$$t_{\text{aeration}} = \frac{V_{\text{aeration}}}{Q} \cdot 24 \tag{28}$$

The organic loading is:

$$OL = \frac{Q \cdot BOD_{\text{in}}}{V_{\text{aeration}}} \tag{29}$$

4.4 Sludge Age and Stability

The sludge age is estimated from:

$$\theta_c = \frac{1}{Y \cdot (F/M) \cdot \eta - K_d} \tag{30}$$

A safety factor is applied to account for peak organic load variations:

$$\theta_{c,\text{design}} = 1.3 \cdot \theta_c \tag{31}$$

4.5 Contact-Stabilization Configuration

Given the contact time is 0.5 h and stabilization time is 2 h, the aeration tank is split as follows:

$$V_{\text{contact}} = \frac{1}{5} \cdot V_{\text{aeration}} \tag{32}$$

$$V_{\text{stabilization}} = V_{\text{aeration}} - V_{\text{contact}} \tag{33}$$

Contact tank geometry is based on the guideline ratio length $= 4 \times$ depth, and width computed from:

$$W = \frac{V}{L \cdot D} \tag{34}$$

Stabilization tank depth is derived from:

$$D = \frac{V}{L \cdot W} \tag{35}$$

Summary of Inputs and Outputs

Table 10: Input values for secondary treatment

Parameter	Symbol	Value
Target effluent BOD_5	BOD_{effluent}	20 mg/L
BOD removal efficiency	η	90%
MLSS	X	3000 mg/L
Return sludge solids	X_R	11000 mg/L
Yield coefficient	Y	0.6
Decay coefficient	K_d	0.06 d^{-1}
Conversion rate	k	0.2 d^{-1}
F/M ratio	F/M	0.4
Safety factor	–	1.3

5 ENVIRONMENTAL IMPACT ASSESSMENT

To evaluate the impact of the effluent discharge on the receiving waterway, the *Streeter-Phelps model* was applied. This model predicts the variation in dissolved oxygen (DO) downstream of the discharge point based on oxygen consumption due to biochemical oxygen demand (BOD) and oxygen replenishment through atmospheric reaeration.

According to previous surveys and analysis, the receiving waterway has a base flow that complies with: $Q_{\text{waterway}} = 300{,}000 \cdot (10)^{0.2} = 475468\ m^3/day$. The water quality upstream of the discharge point is characterized by a background BOD of 4 mg/L (L_r), a dissolved oxygen saturation of 8.5

Table 11: Design results for secondary treatment

Output	Symbol	Result
Influent BOD to secondary	BOD_{in}	`[insert]`
Return sludge ratio	Q_R/Q	`[insert]`
Aeration volume	V_{aeration}	`[insert]` m^3
Aeration time	t_{aeration}	`[insert]` h
Sludge age	θ_c	`[insert]` d
Final design age	$\theta_{c,\text{design}}$	`[insert]` d
Contact tank volume	V_{contact}	`[insert]` m^3
Stabilization tank volume	$V_{\text{stabilization}}$	`[insert]` m^3
Contact tank (L×W×D)	–	`[insert]` m × `[insert]` m × `[insert]` m
Stabilization tank (L×W×D)	–	`[insert]` m × `[insert]` m × `[insert]` m

mg/L (DO$_saturation$), and an initial oxygen deficit of 0.8 mg/L (DO$_0$). Regulatory guidelines for this region require that DO levels remain above 70% saturation **REFERENCE TBD**, yielding a minimum acceptable DO of 5.95 mg/L (Eq (36)). Additionally, the rearation rate constant (k$_r$), deoxygenation rate constant (k$_d$), BOD reaction rate (k$_1$) and stream velocity (v) are known due to previous assesments. In the Table 12 the input values for the *Streeter-Phelps model* are shown.

The effluent discharge was evaluated based on the project adjusted peak flow rate (80.29 m^3/day), calculated in Section 3 and a maximum BOD$_5$ of 20 mg/L (L$_w$) **REFERENCE TBD**.

Table 12: Input values for Streeter-Phelps DO sag model

Parameter	Value	Description
$DO_{\text{saturation}}$	8.5 mg/L	DO at saturation
DO_0	0.8 mg/L	Initial oxygen deficit
$DO_{\text{min, threshold}}$	5.95 mg/L	Minimum DO required
L_r	4 mg/L	BOD upstream
L_w	20 mg/L	BOD$_5$ of effluent
k_r	0.71 day^{-1}	Reaeration rate constant
k_d	0.51 day^{-1}	Deoxygenation rate constant
k_1	0.23 day^{-1}	BOD reaction rate
v	0.07 m/s	Stream velocity
Q_w	475468 m^3/day	Waterway flowrate
Q_e	80.29 m^3/day	Adjusted flowrate

From this, the ultimate BOD (L$_u$) is estimated using Eq. (37) with the time *t* equals to 5 days. Using Eq. (38) the mixed BOD in the receiving stream is determined, and with Eq. (38) mixed conditions downstream are calculated. The model then determines the time (t_c) at which the minimum DO level occurs using Eq. (39). Finally, the maximum deficit $D(t_c)$ is calculated using Eq. (41). The distance downstream at which the the maximum deficit/minimum saturation is reached can also be calculated using Eq. (40) Results are shown in Table 13.

$$DO_{\text{min, threshold}} = 0.7 \cdot DO_{\text{saturation}} \tag{36}$$

$$L_u = \frac{L_w}{1 - e^{-k_1 t}} \tag{37}$$

$$L_0 = \frac{Q_w \cdot L_r + Q_e \cdot L_u}{Q_w + Q_e} \tag{38}$$

$$t_c = \frac{1}{k_r - k_d} \ln\left[\frac{k_r}{k_d}\left(1 - D_0 \cdot \frac{k_r - k_d}{k_d L_0}\right)\right] \tag{39}$$

$$x_c = t_c \cdot 86400 \cdot v \tag{40}$$

$$D(t_c) = \frac{k_d L_0}{k_r - k_d}\left(e^{-k_d t_c} - e^{-k_r t_c}\right) + D_0 e^{-k_r t_c} \tag{41}$$

Table 13: Environmental impact model results

Output	**Value**	**Description**
L_u	29.27 mg/L	Ultimate BOD of effluent
L_0	7.42 mg/L	Mixed BOD in receiving stream
t_c	1.44 days	Time to reach minimum DO
x_c	8698.64 m	Distance to minimum DO level
$D(t_c)$	2.56 mg/L	DO deficit at time t_c

As shown in Table 13, the dissolved oxygen deficit at its critical point is 2.56 mg/L. Substracting from the saturation $DO_{\text{saturation}}$ the critical deficit $D(t_c)$ the $DO_{\text{calculated}}$ is obtained, equal to 5.94 mg/L which is below the regulatory $DO_{\text{min, threshold}}$ of 5.95 mg/L. Therefore, the discharge complies with the receiving waterway's environmental standard.

6 SUMMARY

REFERENCES

[Australian Bureau of Statistics, 2021] Australian Bureau of Statistics (2021). Suburbs and localities.

[Davis, 2010] Davis, M. L. (2010). *Water and Wastewater Engineering: Design Principles and Practice*. McGraw-Hill Companies, Inc., New York.

[Melbourne Water, 2024] Melbourne Water (2024). Eastern treatment plant daily influent quality data. https://data-melbournewater.opendata.arcgis.com. Accessed: 2025-05-07.

[Metcalf and Eddy, 2014] Metcalf and Eddy (2014). *Wastewater Engineering, Treatment and resource recovery*. McGraw, 5 edition.

[Water Environment Federation, 2017] Water Environment Federation (2017). *Design of Water Resource Recovery Facilities*. McGraw-Hill Education, New York, NY, 6 edition.

[Yarra Valley Water, 2023] Yarra Valley Water (2023). Amf l8 sewerage planning and design principles.

APPENDIX 1 AREA AND POPULATION PER SUBURB

Table of Melbourne suburbs with their area and popluation [Australian Bureau of Statistics, 2021].

Table 14: Melbourne suburbs with area and population

Suburb	Population Density	Population	LGA	Area (km2)
Southbank	11962.280000	22631	Melbourne (City)	1.890000
Carlton	10597.480000	16055	Melbourne (City)	1.510000
Fitzroy	7355.630000	10431	Yarra (City)	1.420000
Melbourne	7269.020000	16055	Melbourne (City)	2.210000
South Yarra	7087.660000	25028	Melbourne (City)	3.530000
Balaclava	7062.830000	5392	Port Phillip (City)	0.760000
Prahran	6975.820000	12203	Stonnington (City)	1.750000
Windsor	6729.210000	7273	Port Phillip (City)	1.080000
Collingwood	6719.020000	9179	Yarra (City)	1.370000
St Kilda	6365.640000	19490	Port Phillip (City)	3.060000
North Melbourne	6325.150000	14953	Melbourne (City)	2.360000
Richmond	6252.540000	28587	Yarra (City)	4.570000
Elwood	5989.600000	15153	Port Phillip (City)	2.530000
St Kilda West	5977.320000	2951	Port Phillip (City)	0.490000
Travancore	5933.010000	2116	Moonee Valley (City)	0.360000
St Kilda East	5784.110000	12571	Glen Eira (City)	2.170000
Glen Huntly	5637.580000	4905	Glen Eira (City)	0.870000
Seddon	5586.700000	5143	Maribyrnong (City)	0.920000
Ripponlea	5510.490000	1532	Port Phillip (City)	0.280000
Kingsville	5442.760000	3920	Maribyrnong (City)	0.720000
Brunswick East	5097.030000	13279	Moreland (City)	2.610000
Kensington	5073.670000	10745	Melbourne (City)	2.120000
Fitzroy North	5007.710000	12781	Moreland (City)	2.550000
South Melbourne	4986.300000	11548	Port Phillip (City)	2.320000
Brunswick	4910.310000	24896	Moreland (City)	5.070000
Princes Hill	4909.930000	2005	Yarra (City)	0.410000
Middle Park	4885.610000	4000	Port Phillip (City)	0.820000
Carnegie	4716.030000	17909	Glen Eira (City)	3.800000
Abbotsford	4700.750000	9088	Yarra (City)	1.930000
Brunswick West	4357.960000	14746	Moreland (City)	3.380000
Armadale	4201.390000	9368	Stonnington (City)	2.230000
Hawthorn East	4110.510000	14834	Boroondara (City)	3.610000
Northcote	4087.370000	25276	Darebin (City)	6.180000
Essendon North	4080.600000	3071	Moonee Valley (City)	0.750000

Continued on next page

Table 14: Melbourne suburbs with area and population

Suburb	Population Density	Population	LGA	Area (km2)
Ormond	4064.220000	8328	Glen Eira (City)	2.050000
Hawthorn	4000.510000	22322	Boroondara (City)	5.580000
Elsternwick	3975.800000	10887	Glen Eira (City)	2.740000
McKinnon	3897.170000	6878	Glen Eira (City)	1.760000
Gardenvale	3884.170000	1019	Glen Eira (City)	0.260000
Ascot Vale	3845.150000	15197	Moonee Valley (City)	3.950000
Caulfield	3806.120000	5748	Glen Eira (City)	1.510000
Coburg	3785.050000	26574	Moreland (City)	7.020000
Murrumbeena	3771.280000	9996	Glen Eira (City)	2.650000
Hughesdale	3759.200000	7563	Monash (City)	2.010000
Clifton Hill	3646.350000	6606	Yarra (City)	1.810000
Caulfield North	3633.750000	16903	Glen Eira (City)	4.650000
Noble Park	3624.230000	32257	Greater Dandenong (City)	8.900000
Caulfield South	3621.750000	12328	Glen Eira (City)	3.400000
Thornbury	3617.380000	19005	Darebin (City)	5.250000
Docklands	3482.850000	15495	Melbourne (City)	4.450000
Malvern	3453.170000	9929	Stonnington (City)	2.880000
Bentleigh	3426.600000	17921	Glen Eira (City)	5.230000
Pascoe Vale	3423.210000	18171	Moreland (City)	5.310000
Carlton North	3367.180000	6177	Melbourne (City)	1.830000
Essendon	3344.050000	21240	Moonee Valley (City)	6.350000
Pascoe Vale South	3309.990000	10534	Moreland (City)	3.180000
Hampton East	3295.150000	5069	Bayside (City)	1.540000
Parkdale	3292.040000	12308	Kingston (City)	3.740000
Moonee Ponds	3272.100000	16224	Moonee Valley (City)	4.960000
Taylors Hill	3254.310000	15419	Melton (City)	4.740000
Kings Park	3242.880000	8203	Brimbank (City)	2.530000
Footscray	3236.630000	17131	Maribyrnong (City)	5.290000
Box Hill	3235.380000	14353	Whitehorse (City)	4.440000
Meadow Heights	3209.080000	14890	Hume (City)	4.640000
Roxburgh Park	3171.080000	24129	Hume (City)	7.610000
Seabrook	3162.960000	4952	Hobsons Bay (City)	1.570000
Oakleigh East	3131.200000	6804	Monash (City)	2.170000
Hampton	3120.720000	13518	Bayside (City)	4.330000
Niddrie	3083.290000	5901	Moonee Valley (City)	1.910000
Glen Iris	3069.860000	26131	Boroondara (City)	8.510000
Surrey Hills	3069.720000	13655	Boroondara (City)	4.450000
Bentleigh East	3057.980000	30159	Glen Eira (City)	9.860000
West Footscray	3056.590000	11729	Maribyrnong (City)	3.840000

Continued on next page

Table 14: Melbourne suburbs with area and population

Suburb	Population Density	Population	LGA	Area (km2)
Oak Park	3053.640000	6714	Moreland (City)	2.200000
Sydenham	3044.380000	10578	Brimbank (City)	3.470000
Burnside Heights	3043.610000	6377	Melton (City)	2.100000
Balwyn	3026.140000	13495	Boroondara (City)	4.460000
Toorak	3021.060000	12817	Stonnington (City)	4.240000
Blackburn South	3000.560000	10939	Whitehorse (City)	3.650000
Box Hill North	2993.190000	12337	Whitehorse (City)	4.120000
Cremorne	2967.650000	2158	Yarra (City)	0.730000
Kingsbury	2964.710000	3460	Darebin (City)	1.170000
Chelsea	2961.140000	8347	Kingston (City)	2.820000
Albanvale	2947.400000	5641	Brimbank (City)	1.910000
Lalor	2924.790000	23219	Whittlesea (City)	7.940000
Heidelberg Heights	2916.630000	6758	Banyule (City)	2.320000
Camberwell	2909.610000	21965	Boroondara (City)	7.550000
Caroline Springs	2904.020000	24488	Melton (City)	8.430000
St Albans	2899.360000	38042	Brimbank (City)	13.120000
Preston	2864.580000	33790	Darebin (City)	11.800000
Mentone	2863.300000	13197	Kingston (City)	4.610000
Maidstone	2858.230000	9389	Maribyrnong (City)	3.280000
Highett	2857.850000	12016	Bayside (City)	4.200000
Mont Albert	2843.710000	4948	Boroondara (City)	1.740000
Brighton East	2823.010000	16757	Bayside (City)	5.940000
Edithvale	2811.620000	6276	Kingston (City)	2.230000
Malvern East	2811.060000	22296	Stonnington (City)	7.930000
Dallas	2808.250000	6762	Hume (City)	2.410000
Springvale South	2782.910000	12766	Greater Dandenong (City)	4.590000
Brighton	2778.140000	23252	Bayside (City)	8.370000
Chadstone	2769.550000	9552	Monash (City)	3.450000
Sandringham	2769.330000	10926	Bayside (City)	3.950000
Blackburn North	2744.920000	7627	Whitehorse (City)	2.780000
Ashwood	2705.700000	7154	Monash (City)	2.640000
Flemington	2687.670000	15197	Melbourne (City)	5.650000
Fawkner	2685.090000	14274	Hume (City)	5.320000
East Melbourne	2674.570000	4896	Melbourne (City)	1.830000
South Kingsville	2663.470000	2156	Hobsons Bay (City)	0.810000
Reservoir (Vic.)	2661.150000	51096	Darebin (City)	19.200000
Ashburton	2651.730000	7952	Boroondara (City)	3.000000
Gowanbrae	2645.990000	2971	Moreland (City)	1.120000
Yarraville	2644.460000	15636	Maribyrnong (City)	5.910000

Continued on next page

Table 14: Melbourne suburbs with area and population

Suburb	Population Density	Population	LGA	Area (km2)
Dandenong	2636.980000	30127	Greater Dandenong (City)	11.420000
Watsonia North	2630.340000	3799	Banyule (City)	1.440000
Forest Hill	2610.810000	10780	Whitehorse (City)	4.130000
Beaumaris	2588.020000	13947	Bayside (City)	5.390000
Newport	2580.100000	13658	Hobsons Bay (City)	5.290000
Canterbury	2573.800000	7800	Boroondara (City)	3.030000
Carrum	2559.490000	4239	Kingston (City)	1.660000
Doncaster East	2553.110000	30926	Manningham (City)	12.110000
Mont Albert North	2542.980000	5609	Whitehorse (City)	2.210000
Rosanna	2518.670000	8616	Banyule (City)	3.420000
Aberfeldie	2510.950000	3925	Moonee Valley (City)	1.560000
Williamstown	2504.300000	14407	Hobsons Bay (City)	5.750000
Clayton	2475.130000	18988	Monash (City)	7.670000
Burwood	2469.010000	15147	Monash (City)	6.130000
Strathmore	2438.170000	8980	Moonee Valley (City)	3.680000
Mitcham	2436.700000	16795	Whitehorse (City)	6.890000
Box Hill South	2416.620000	8491	Whitehorse (City)	3.510000
Glenroy	2411.640000	23792	Moreland (City)	9.870000
Burwood East	2409.810000	10675	Whitehorse (City)	4.430000
Glen Waverley	2394.710000	42642	Monash (City)	17.810000
Delahey	2378.490000	8077	Brimbank (City)	3.400000
Dandenong North	2371.500000	22550	Greater Dandenong (City)	9.510000
Doncaster	2366.780000	11219	Manningham (City)	4.740000
Blackburn	2363.110000	14478	Whitehorse (City)	6.130000
Briar Hill	2354.000000	3220	Banyule (City)	1.370000
Kew	2346.690000	24499	Boroondara (City)	10.440000
Nunawading	2338.260000	12413	Manningham (City)	5.310000
Montmorency	2338.200000	9250	Banyule (City)	3.960000
Huntingdale	2333.330000	1949	Monash (City)	0.840000
Deepdene	2325.710000	2101	Boroondara (City)	0.900000
Doveton	2297.010000	9603	Casey (City)	4.180000
Bonbeach	2293.070000	6855	Kingston (City)	2.990000
Aspendale	2291.190000	7285	Kingston (City)	3.180000
Narre Warren South	2290.990000	30909	Casey (City)	13.490000
Templestowe Lower	2285.400000	14098	Manningham (City)	6.170000
Mill Park	2273.840000	28712	Whittlesea (City)	12.630000
Oakleigh	2270.060000	8442	Monash (City)	3.720000
Watsonia	2265.970000	5352	Banyule (City)	2.360000
Vermont	2265.080000	10993	Maroondah (City)	4.850000

Continued on next page

Table 14: Melbourne suburbs with area and population

Suburb	Population Density	Population	LGA	Area (km2)
Balwyn North	2244.140000	21302	Boroondara (City)	9.490000
Maribyrnong	2223.920000	12573	Maribyrnong (City)	5.650000
Mount Waverley	2213.430000	35340	Monash (City)	15.970000
Ivanhoe	2196.930000	13374	Banyule (City)	6.090000
Ringwood East	2194.780000	10764	Maroondah (City)	4.900000
Cairnlea	2191.780000	10038	Brimbank (City)	4.580000
Albert Park	2189.150000	6044	Port Phillip (City)	2.760000
Heathmont	2171.220000	9933	Maroondah (City)	4.570000
Hoppers Crossing	2159.050000	37216	Wyndham (City)	17.240000
Gladstone Park	2157.870000	8213	Hume (City)	3.810000
Avondale Heights	2150.670000	12388	Moonee Valley (City)	5.760000
Macleod	2137.170000	9892	Banyule (City)	4.630000
Croydon Hills	2136.070000	4839	Maroondah (City)	2.270000
Clarinda	2131.950000	7441	Kingston (City)	3.490000
Braybrook	2126.010000	9682	Maribyrnong (City)	4.550000
Heidelberg	2121.680000	7360	Banyule (City)	3.470000
Deer Park	2113.570000	18145	Brimbank (City)	8.590000
Cheltenham	2107.700000	13947	Bayside (City)	6.620000
Lynbrook	2093.120000	9121	Casey (City)	4.360000
Hillside	2078.730000	17331	Brimbank (City)	8.340000
Taylors Lakes	2075.840000	15174	Brimbank (City)	7.310000
Sunshine	2064.240000	9445	Brimbank (City)	4.580000
Airport West	2058.230000	8173	Moonee Valley (City)	3.970000
Keilor Lodge	2037.210000	1668	Brimbank (City)	0.820000
Seaholme	2035.900000	2067	Hobsons Bay (City)	1.020000
Greensborough	2030.520000	21070	Banyule (City)	10.380000
Aspendale Gardens	2015.430000	6427	Kingston (City)	3.190000
Sunshine West	1995.490000	18552	Brimbank (City)	9.300000
Keilor Downs	1992.620000	9857	Brimbank (City)	4.950000
Noble Park North	1991.470000	7436	Greater Dandenong (City)	3.730000
Cranbourne North	1964.060000	24683	Casey (City)	12.570000
Croydon North	1961.570000	8092	Maroondah (City)	4.130000
Springvale	1958.690000	22174	Greater Dandenong (City)	11.320000
Boronia	1957.230000	23607	Knox (City)	12.060000
Jacana	1934.550000	2187	Hume (City)	1.130000
Black Rock	1933.750000	6389	Bayside (City)	3.300000
Bellfield	1925.890000	1996	Banyule (City)	1.040000
Notting Hill	1918.240000	2895	Monash (City)	1.510000
Hampton Park	1913.510000	26082	Casey (City)	13.630000

Continued on next page

Table 14: Melbourne suburbs with area and population

Suburb	Population Density	Population	LGA	Area (km2)
Croydon	1911.060000	28608	Maroondah (City)	14.970000
Albion	1905.360000	4334	Brimbank (City)	2.270000
Wheelers Hill	1892.230000	20652	Monash (City)	10.910000
Vermont South	1888.420000	11954	Whitehorse (City)	6.330000
Ferntree Gully	1887.580000	27398	Knox (City)	14.510000
Ringwood North	1880.280000	9964	Manningham (City)	5.300000
Burnside	1861.680000	5800	Melton (City)	3.120000
Fairfield	1853.590000	6535	Darebin (City)	3.530000
Mordialloc	1852.960000	8886	Kingston (City)	4.800000
Narre Warren	1849.840000	27689	Casey (City)	14.970000
Hadfield	1843.580000	6269	Moreland (City)	3.400000
Parkville	1829.830000	7074	Melbourne (City)	3.870000
Frankston	1825.020000	37331	Frankston (City)	20.460000
Altona Meadows	1817.840000	18479	Hobsons Bay (City)	10.170000
Ivanhoe East	1817.530000	3762	Banyule (City)	2.070000
Mulgrave	1806.880000	19889	Monash (City)	11.010000
Alphington	1803.340000	5702	Darebin (City)	3.160000
St Helena	1783.400000	2890	Banyule (City)	1.620000
Patterson Lakes	1771.840000	7793	Kingston (City)	4.400000
Croydon South	1763.890000	4759	Maroondah (City)	2.700000
Mooroolbark	1757.080000	23059	Yarra Ranges (Shire)	13.120000
Eaglemont	1754.870000	3960	Banyule (City)	2.260000
Eumemmerring	1739.290000	2285	Casey (City)	1.310000
Williams Landing	1733.890000	9448	Wyndham (City)	5.450000
Ringwood	1726.210000	19144	Maroondah (City)	11.090000
Heidelberg West	1725.800000	5252	Banyule (City)	3.040000
Eltham North	1693.630000	6830	Banyule (City)	4.030000
Port Melbourne	1690.180000	17633	Melbourne (City)	10.430000
Wantirna	1672.880000	14237	Knox (City)	8.510000
Chelsea Heights	1669.270000	5393	Kingston (City)	3.230000
Bulleen	1669.170000	11219	Manningham (City)	6.720000
Bundoora	1662.880000	28068	Banyule (City)	16.880000
Kew East	1632.230000	6620	Boroondara (City)	4.060000
Keilor East	1630.420000	15078	Brimbank (City)	9.250000
Warranwood	1603.940000	4820	Maroondah (City)	3.010000
Clayton South	1592.590000	13381	Kingston (City)	8.400000
Coburg North	1588.840000	8327	Moreland (City)	5.240000
Sandhurst	1569.310000	5211	Frankston (City)	3.320000
Endeavour Hills	1568.470000	24455	Casey (City)	15.590000

Continued on next page

Table 14: Melbourne suburbs with area and population

Suburb	Population Density	Population	LGA	Area (km2)
Rowville	1532.710000	7645	Knox (City)	4.990000
Viewbank	1522.880000	7030	Banyule (City)	4.620000
Broadmeadows	1503.580000	12524	Hume (City)	8.330000
Bayswater	1483.470000	12262	Knox (City)	8.270000
Sunshine North	1458.130000	12047	Brimbank (City)	8.260000
Ardeer	1456.120000	3170	Brimbank (City)	2.180000
Strathmore Heights	1452.970000	1047	Moonee Valley (City)	0.720000
Waterways	1451.920000	2422	Kingston (City)	1.670000
Berwick	1438.260000	50298	Casey (City)	34.970000
Craigieburn	1420.390000	65178	Hume (City)	45.890000
Yallambie	1403.680000	4161	Banyule (City)	2.960000
Essendon West	1402.530000	1559	Moonee Valley (City)	1.110000
Oakleigh South	1392.210000	9851	Kingston (City)	7.080000
Thomastown	1391.960000	20234	Whittlesea (City)	14.540000
Wantirna South	1376.500000	20754	Knox (City)	15.080000
Knoxfield	1365.420000	7645	Knox (City)	5.600000
Bayswater North	1337.340000	9014	Maroondah (City)	6.740000
Seaford	1327.980000	17215	Frankston (City)	12.960000
Cranbourne West	1317.470000	19969	Casey (City)	15.160000
Hallam	1315.080000	11355	Casey (City)	8.630000
Laverton	1307.180000	4760	Hobsons Bay (City)	3.640000
Moorabbin	1286.280000	6287	Kingston (City)	4.890000
Dingley Village	1264.710000	10495	Kingston (City)	8.300000
Caulfield East	1258.140000	1293	Glen Eira (City)	1.030000
Frankston South	1249.930000	18801	Frankston (City)	15.040000
Kealba	1240.870000	3226	Brimbank (City)	2.600000
Cranbourne	1216.930000	21281	Casey (City)	17.490000
Keysborough	1187.480000	30018	Greater Dandenong (City)	25.280000
Kilsyth	1167.310000	11699	Maroondah (City)	10.020000
Westmeadows	1166.570000	6502	Hume (City)	5.570000
Cranbourne East	1164.270000	11177	Casey (City)	9.600000
Tecoma	1147.110000	2064	Yarra Ranges (Shire)	1.800000
Mornington	1137.300000	25759	Mornington Peninsula (Shire)	22.650000
Frankston North	1125.830000	5711	Frankston (City)	5.070000
South Morang	1121.470000	24989	Whittlesea (City)	22.280000
Point Cook	1109.730000	66781	Wyndham (City)	60.180000
Eltham	1104.120000	18847	Banyule (City)	17.070000
Upwey	1069.970000	6818	Yarra Ranges (Shire)	6.370000
Donvale	1056.110000	12644	Manningham (City)	11.970000

Continued on next page

Table 14: Melbourne suburbs with area and population

Suburb	Population Density	Population	LGA	Area (km2)
Templestowe	1031.020000	16966	Manningham (City)	16.460000
Carrum Downs	1019.840000	21976	Frankston (City)	21.550000
Upper Ferntree Gully	1019.090000	3417	Knox (City)	3.350000
Coolaroo	1017.540000	3193	Hume (City)	3.140000
Kurunjang	971.630000	10711	Melton (City)	11.020000
Belgrave	963.700000	3894	Yarra Ranges (Shire)	4.040000
Werribee	940.770000	50027	Wyndham (City)	53.180000
Rosebud	939.680000	14381	Mornington Peninsula (Shire)	15.300000
Epping	918.380000	33489	Whittlesea (City)	36.470000
Tarneit	905.020000	56370	Wyndham (City)	62.290000
Rosebud West	902.270000	5246	Mornington Peninsula (Shire)	5.810000
Kilsyth South	891.140000	2862	Maroondah (City)	3.210000
Williamstown North	887.470000	1622	Hobsons Bay (City)	1.830000
Tullamarine	881.840000	6733	Brimbank (City)	7.640000
Altona North	871.490000	12962	Hobsons Bay (City)	14.870000
Junction Village	856.780000	1051	Casey (City)	1.230000
Brookfield	839.190000	10782	Melton (City)	12.850000
West Melbourne	837.890000	8025	Melbourne (City)	9.580000
Spotswood	823.270000	2820	Hobsons Bay (City)	3.430000
Tootgarook	822.530000	3178	Mornington Peninsula (Shire)	3.860000
Keilor Park	811.640000	2684	Brimbank (City)	3.310000
Safety Beach	810.660000	6328	Mornington Peninsula (Shire)	7.810000
Langwarrin	783.080000	23588	Frankston (City)	30.120000
Mount Eliza	770.770000	18734	Mornington Peninsula (Shire)	24.310000
The Basin	767.470000	4497	Knox (City)	5.860000
Lyndhurst	722.110000	8926	Casey (City)	12.360000
Scoresby	692.980000	6066	Knox (City)	8.750000
Mernda	690.840000	23369	Whittlesea (City)	33.830000
Attwood	675.830000	3309	Hume (City)	4.900000
Melton West	671.540000	12463	Melton (City)	18.560000
Doreen	660.690000	27122	Nillumbik (Shire)	41.050000
McCrae	658.040000	3311	Mornington Peninsula (Shire)	5.030000
Diamond Creek	657.830000	12503	Nillumbik (Shire)	19.010000
Altona	643.010000	11490	Hobsons Bay (City)	17.870000
Botanic Ridge	635.890000	6739	Casey (City)	10.600000
Derrimut	634.610000	8651	Brimbank (City)	13.630000
Beaconsfield	620.920000	7267	Cardinia (Shire)	11.700000
Mount Martha	613.990000	19846	Mornington Peninsula (Shire)	32.320000
Montrose	612.960000	6900	Yarra Ranges (Shire)	11.260000

Continued on next page

Table 14: Melbourne suburbs with area and population

Suburb	Population Density	Population	LGA	Area (km2)
Bacchus Marsh	583.980000	7808	Moorabool (Shire)	13.370000
Belgrave Heights	577.250000	1398	Yarra Ranges (Shire)	2.420000
Mount Evelyn	571.080000	9799	Yarra Ranges (Shire)	17.160000
Lower Plenty	570.360000	3962	Banyule (City)	6.950000
Lilydale	566.630000	17348	Yarra Ranges (Shire)	30.620000
Wyndham Vale	552.790000	12675	Wyndham (City)	22.930000
Keilor	546.140000	5906	Brimbank (City)	10.810000
Pakenham	543.480000	54118	Cardinia (Shire)	99.580000
Greenvale	506.040000	21274	Hume (City)	42.040000
Skye	486.480000	8088	Frankston (City)	16.630000
Crib Point	484.990000	3343	Mornington Peninsula (Shire)	6.890000
Rye	472.170000	9438	Mornington Peninsula (Shire)	19.990000
Chirnside Park	444.640000	11779	Yarra Ranges (Shire)	26.490000
Truganina	442.160000	36305	Melton (City)	82.110000
Campbellfield	412.840000	4977	Hume (City)	12.060000
Heatherton	408.460000	2826	Kingston (City)	6.920000
Park Orchards	403.380000	3835	Manningham (City)	9.510000
Melton	396.060000	7953	Melton (City)	20.080000
Melton South	377.720000	3601	Melton (City)	9.530000
Hastings	370.920000	10369	Mornington Peninsula (Shire)	27.950000
Blairgowrie	367.960000	2786	Mornington Peninsula (Shire)	7.570000
Narre Warren North	348.470000	8033	Casey (City)	23.050000
Brooklyn	339.000000	1979	Brimbank (City)	5.840000
North Warrandyte	337.210000	3027	Nillumbik (Shire)	8.980000
Ferny Creek	336.210000	1524	Yarra Ranges (Shire)	4.530000
Warrandyte	317.250000	5541	Manningham (City)	17.470000
Darley	310.710000	9190	Moorabool (Shire)	29.580000
Somerville	293.290000	11767	Mornington Peninsula (Shire)	40.120000
Clyde North	277.570000	31681	Casey (City)	114.140000
Research	275.650000	2695	Nillumbik (Shire)	9.780000
Sunbury	272.900000	38851	Hume (City)	142.360000
The Patch	267.860000	1046	Yarra Ranges (Shire)	3.910000
Selby	251.910000	1626	Yarra Ranges (Shire)	6.450000
Officer	250.410000	18503	Cardinia (Shire)	73.890000
Hurstbridge	232.450000	3554	Nillumbik (Shire)	15.290000
Sorrento	226.970000	2013	Mornington Peninsula (Shire)	8.870000
Wattle Glen	218.160000	1911	Nillumbik (Shire)	8.760000
Baxter	218.050000	2166	Mornington Peninsula (Shire)	9.930000
Plenty	215.400000	2575	Nillumbik (Shire)	11.950000

Continued on next page

Table 14: Melbourne suburbs with area and population

Suburb	Population Density	Population	LGA	Area (km2)
Bittern	215.210000	4276	Mornington Peninsula (Shire)	19.870000
Lysterfield	210.960000	6681	Knox (City)	31.670000
Blind Bight	207.220000	1290	Casey (City)	6.230000
Dromana	191.550000	6626	Mornington Peninsula (Shire)	34.590000
Wandin North	183.530000	3132	Yarra Ranges (Shire)	17.070000
Monbulk	179.880000	3651	Yarra Ranges (Shire)	20.300000
Millgrove	176.530000	1666	Yarra Ranges (Shire)	9.440000
Badger Creek	174.150000	1610	Yarra Ranges (Shire)	9.240000
Wollert	168.110000	24407	Whittlesea (City)	145.180000
Wonga Park	163.500000	3843	Manningham (City)	23.500000
Wallan	159.090000	15004	Mitchell (Shire)	94.310000
Mount Dandenong	157.640000	1271	Yarra Ranges (Shire)	8.060000
Cockatoo	150.830000	4408	Cardinia (Shire)	29.220000
Kalorama	146.350000	1277	Yarra Ranges (Shire)	8.730000
Yarra Junction	145.510000	2875	Yarra Ranges (Shire)	19.760000
Langwarrin South	142.220000	1346	Frankston (City)	9.460000
Tyabb	141.340000	3449	Mornington Peninsula (Shire)	24.400000
Maddingley	135.080000	5491	Moorabool (Shire)	40.650000
Belgrave South	129.550000	1670	Yarra Ranges (Shire)	12.890000
Kallista	119.220000	1418	Yarra Ranges (Shire)	11.890000
Emerald	114.590000	5890	Cardinia (Shire)	51.400000
Pearcedale	113.460000	3867	Casey (City)	34.080000
Somers	111.800000	1857	Mornington Peninsula (Shire)	16.610000
Seville	111.240000	2559	Yarra Ranges (Shire)	23.000000
Woori Yallock	107.680000	2964	Yarra Ranges (Shire)	27.530000
Yarrambat	103.490000	1602	Nillumbik (Shire)	15.480000
Bunyip	101.830000	3131	Cardinia (Shire)	30.750000
Beaconsfield Upper	100.400000	2997	Cardinia (Shire)	29.850000
Olinda	97.900000	1773	Yarra Ranges (Shire)	18.110000
Gisborne	93.100000	10142	Macedon Ranges (Shire)	108.940000
New Gisborne	91.020000	2509	Macedon Ranges (Shire)	27.570000
Ravenhall	84.760000	2295	Melton (City)	27.080000
Cranbourne South	83.710000	3241	Casey (City)	38.720000
Balnarring	82.660000	2371	Mornington Peninsula (Shire)	28.680000
Yarra Glen	81.560000	3012	Yarra Ranges (Shire)	36.930000
Garfield	67.600000	2114	Cardinia (Shire)	31.270000
Harkaway	67.530000	1011	Casey (City)	14.970000
Hmas Cerberus	67.520000	1124	Mornington Peninsula (Shire)	16.650000
Launching Place	66.280000	2495	Yarra Ranges (Shire)	37.640000

Continued on next page

Table 14: Melbourne suburbs with area and population

Suburb	Population Density	Population	LGA	Area (km2)
Devon Meadows	65.540000	1551	Casey (City)	23.660000
Koo Wee Rup	60.680000	4047	Cardinia (Shire)	66.690000
Werribee South	58.490000	2392	Wyndham (City)	40.900000
Romsey	58.430000	5797	Macedon Ranges (Shire)	99.210000
Mickleham	57.410000	17452	Hume (City)	303.990000
Tooradin	56.550000	1722	Cardinia (Shire)	30.450000
Riddells Creek	54.370000	4390	Macedon Ranges (Shire)	80.740000
Clyde	53.650000	11177	Casey (City)	208.330000
Whittlesea	52.810000	6117	Whittlesea (City)	115.830000
Healesville	52.640000	7589	Yarra Ranges (Shire)	144.170000
Macedon	52.340000	2073	Macedon Ranges (Shire)	39.610000
Panton Hill	50.360000	1063	Nillumbik (Shire)	21.110000
Eden Park	49.230000	1194	Whittlesea (City)	24.250000
Eynesbury	42.290000	2838	Melton (City)	67.110000
Silvan	41.290000	1323	Yarra Ranges (Shire)	32.040000
Diggers Rest	40.780000	5669	Hume (City)	139.010000
Wandong	39.560000	1477	Mitchell (Shire)	37.340000
Mount Macedon	39.250000	1450	Macedon Ranges (Shire)	36.940000
Red Hill	39.170000	1009	Mornington Peninsula (Shire)	25.760000
Coldstream	38.910000	2199	Yarra Ranges (Shire)	56.520000
Pakenham Upper	36.610000	1196	Cardinia (Shire)	32.670000
Rockbank	36.570000	7982	Melton (City)	218.270000
Kangaroo Ground	34.850000	1208	Nillumbik (Shire)	34.660000
St Andrews	30.810000	1186	Nillumbik (Shire)	38.490000
Moorooduc	25.610000	1004	Mornington Peninsula (Shire)	39.200000
Wesburn	24.690000	1052	Yarra Ranges (Shire)	42.610000
Beveridge	20.860000	4642	Whittlesea (City)	222.530000
Lancefield	19.830000	2743	Macedon Ranges (Shire)	138.330000
Nar Nar Goon	19.470000	1023	Cardinia (Shire)	52.540000
Kinglake West	17.860000	1305	Murrindindi (Shire)	73.070000
Flinders	16.420000	1130	Mornington Peninsula (Shire)	68.820000
Warburton	15.180000	2020	Yarra Ranges (Shire)	133.070000
Kalkallo	14.950000	5548	Hume (City)	371.100000
Kinglake	13.340000	1662	Murrindindi (Shire)	124.590000
Gembrook	11.610000	2559	Cardinia (Shire)	220.410000