Government of **Western Australia**
Department of Mines, Industry Regulation and Safety
Plumbers Licensing Board

Plumbing Performance Solution case study

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1. Plumbing Performance Solutions

The majority of plumbing and drainage installations in Western Australia are constructed under deemed-to-Satisfy (DTS) provisions and therefore designed to standards listed in the Plumbing Code of Australia (PCA). The main DTS standard used for plumbing work in Australia is the AS/NZS 3500 series.

However, that does not mean that a solution outside the DTS provision will fail. It is essential that all licensed plumbing contractors and designers have an understanding of the process involved in using a performance-based design under the PCA.

By utilising a performance-based code such as the PCA, a degree of flexibility is provided as well as ensuring acceptable plumbing and drainage solutions are achieved within a licensed and regulated trade such as the plumbing industry. It is mandatory for all plumbing and drainage solutions to meet the Performance Requirements listed in the PCA. However, there can be a dual approach to ensuring that Performance Requirements of the PCA are met:

- Deemed-to-Satisfy – Where a plumbing or drainage solution follows a PCA referenced document, then it is a deemed-to-satisfy solution and therefore complies with the PCA's Performance Requirements.

- Performance Solutions – There are often design situations that current standards or other referenced documents may not have envisaged. Alternatively, a designer or licensed plumbing contractor may envisage a new or innovative way to design a plumbing or drainage solution that provides important benefits. It must be understood that their proposal must still achieve the Performance Requirements of the PCA. This alternative approach is referred to as the Performance Solution approach.

Below is an extract of the Performance Requirements listed in the PCA 2019 for drainage plumbing work. These requirements must be met by the plumbing installation that is the subject of a Performance Solution.

Performance Requirements

CP2.1 design, construction and installation

(1) A sanitary *drainage* system must ensure the following:

(a) Sewage is transferred from a sanitary *plumbing* system to an *approved disposal system*.

(b) Access for maintenance and clearing *blockages*.

(c) Ventilation to avoid foul air and gases accumulating in the sanitary *drainage* and sewerage system

(d) Protection against internal contamination.

(2) A sanitary *drainage* system must avoid the following:

(a) *Blockage* and *uncontrolled discharge*.

(b) Damage from root penetration, superimposed loads or ground movement.

(c) Entry of water, foul air and gases from the system into buildings.

(d) Entry of surface water, subsurface water and stormwater into the system.

(e) Damage to existing buildings or *site* works.

(f) Damage to the *Network Utility Operator's* sewerage system or other *approved disposal system*.

1.1 Process for the development of a performance solution

The recommended process for the development of the performance solution as set out by the Australian Building Codes Board is as follows:

1. Prepare a performance based design brief.
2. Carry out analysis, modelling, calculations or testing.
3. Collate and evaluate results.
4. Prepare a final report.

2. Performance Solution case study

The case study below shows a process of developing a Performance Solution as a means of compliance with the Performance Requirements of the PCA.

The project is a Class 2 and 7b building consisting of a basement car park with ground floor and a further four levels totalling 145 sole occupancy residential apartments, mostly set out with 2 bedrooms, 2 bathrooms a kitchen sink and laundry trough.

The Performance Solution formulated for this project was necessary because the existing main sewer and property connection is DN 150 and the preliminary calculations show that the fixture unit loading will require a main drain size of DN 225. This performance based solution must demonstrate that as an acceptable solution the main drain from the building to the sewer connection can be reduced in size from DN 225 to DN 150.

The Performance Solution must also provide sufficient evidence to show that by reducing the size of the main drain the installation will still meet the Performance Requirements of the PCA. This solution is based on the fact that the current fixture unit ratings listed in AS/NZS 3500.2:2018 are out of date. They are based on flows and discharges that have been reduced by water saving initiatives such as the Water Efficiency Labelling Scheme and by other factors. For example, changes in lifestyle and flexible work hours meaning flows in drains are not subject to the same peak flow rates as in years gone by.

2.1 Developing the performance solution

The first step in developing the Performance Solution is calculating the drain size in accordance with AS/NZS 3500.2:2018, using the fixture unit ratings as specified in table 6.2(A). The total fixture unit loading for this development is calculated at 2,400 fixture units. Using table 3.2.1 of AS/NZS 3500.2:2018, the minimum drainage pipe size required to convey 2,400 fixture units at a gradient of 1.00% or 1:100 would be DN 225.

The maximum number of fixture units a DN 150 drain can convey if installed at a grade of 1.00% or 1:100 would be 855 fixture units. It is possible to discharge 2,400 fixture units through a DN 150 drain but only if laid at a grade of 5.00% or 1:20. This is not achievable on this site due to the invert level of the existing main sewer connection point.

2.2 Evaluation of the performance

Using the British and European plumbing design standards BS EN 12056 – 2:2000, Gravity drainage systems, the sizing and grades of plumbing pipes are determined by the discharge unit method. This method is based on the evaluation of a probable system loading from flow rates stated in litres per second (L/s), from water saving outlets and sanitary fixtures. The tables below show the discharge values given for sanitary fixtures expressed in litres per second taken from the BS EN 12056 – 2:2000 standard compared to the current fixture units given to sanitary fixtures in AS/NZS 3500.2:2018, table 6.2(A).

2.3 Analysis of standards

An analysis of the current BS EN 12056-2:2000 standard was carried out and a calculation using table 2 from this standard was used to show whether a Performance Solution using a DN 150 main drain installed at a grade was possible and acceptable for this project.

Using the discharge unit values for fixtures, on the left hand side below (table 2), it was calculated that the total connected discharge loading for the main drain is 1,528 discharge units in litres per second.

Common fixture discharge units from BS EN 12056-2:2000 table 2		**Fixture unit ratings from AS/NZS 3500.2:2018 table 6.2(A)**	
Sanitary appliance	**Discharge unit value (L/s)**	**Sanitary fixture**	**Fixture unit rating**
Washbasin or bidet	0.5	Basin or bidet	1
Bath	0.8	Bath	4
Dishwasher (household)	0.8	Dishwasher	3
Kitchen Sink	0.8	Sink	3
Shower without a plug	0.6	Shower	2
Trough	0.4	Trough	5
Washing machine (domestic)	0.8	Clothes washing machine	5
WC with 4.5/3 litre cistern	1.8	Water closet	4

Table 3 from BS EN 12056 – 2:2000 below shows a frequency factor (K) that is applied to the calculation, which allows for the frequency use of sanitary fixtures/appliances and for buildings that serve different functions in order to determine the maximum flow rate in the drainage pipework system.

Frequency factors from BS EN 12056-2:2000, table 3		
Usage of appliances (type of building)		**K factor**
Intermittent use	Dwellings, guest-house, offices	0.5
Frequent use	Hospital, school, restaurant, hotel	0.7
Congested use	Toilets/showers open to the public	1.0
Special use	Laboratories, processing plants etc.	1.2

2.4 Calculation

Using a frequency factor (K) of 0.5 for dwellings the following formula is used to ascertain the maximum peak flow rate. The resulting figures can then be used to determine the required main drain pipe size and acceptable grade.

Formula: Q = K x (√ TCL)

Where:

Q - Designed flow in litres/second = ?

K - Frequency factor = 0.5

TCL - Total connected load = 1,528 L/s

Q = 0.5 x (√ 1,528)

Q = 0.5 x 39.1

Q = 19.55 litres per second

The result from the calculation above shows that 19.55 litres per second will be the maximum load on the drain at any one time. To determine the most suitable pipe size and grade the Australian Standard, AS 2200 Design charts for water supply and sewerage are used as shown on the next page.

The charts in AS 2200 list both the Colebrook-White and Manning formulas, but for this example, the Colebrook-White chart for thermoplastics will be used. The AS 2200 standard gives a list of coefficients in table 2 for different materials as a *K* factor or smoothness factor, for PVC-U that is chart 3 where *K* = 0.015.

From the charts in AS 2200, sizes, grades and velocities can be found for calculated flows in pipes running at **full or 100% capacity**, see example below. The procedure in this case was to project a line from the DN 150 on the right hand side of the chart to intersect with the desired grade, say 1.0% or 1:100.

As shown, from the intersection of the DN 150 and 1.0% lines, a line is transposed down the sloped litres per second line to the left to find the discharge rate. In this case the discharge (Q) value is 24 L/s in a DN 150 pipe grading at 1.0% at a velocity of 1.38 metres per second.

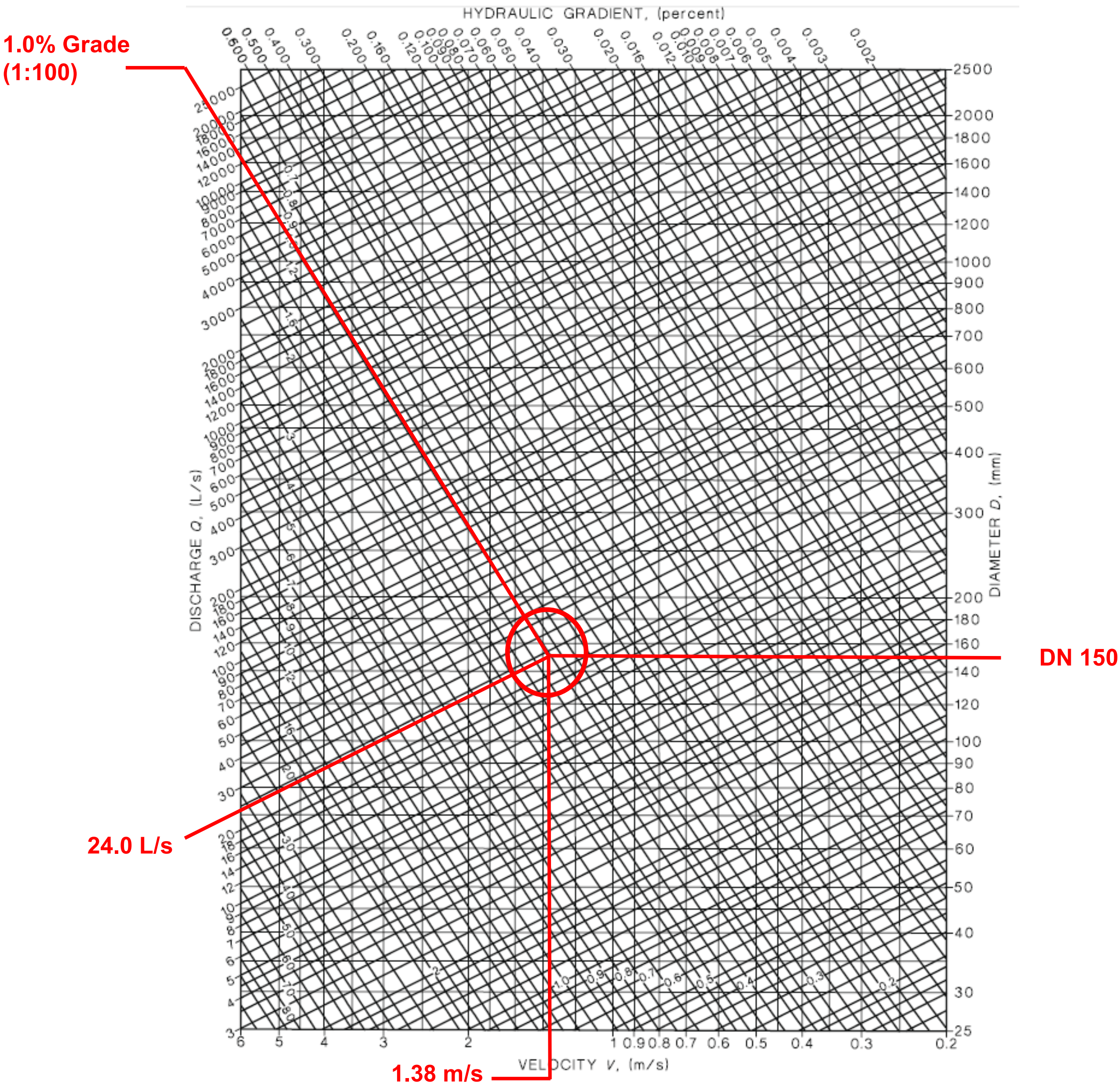
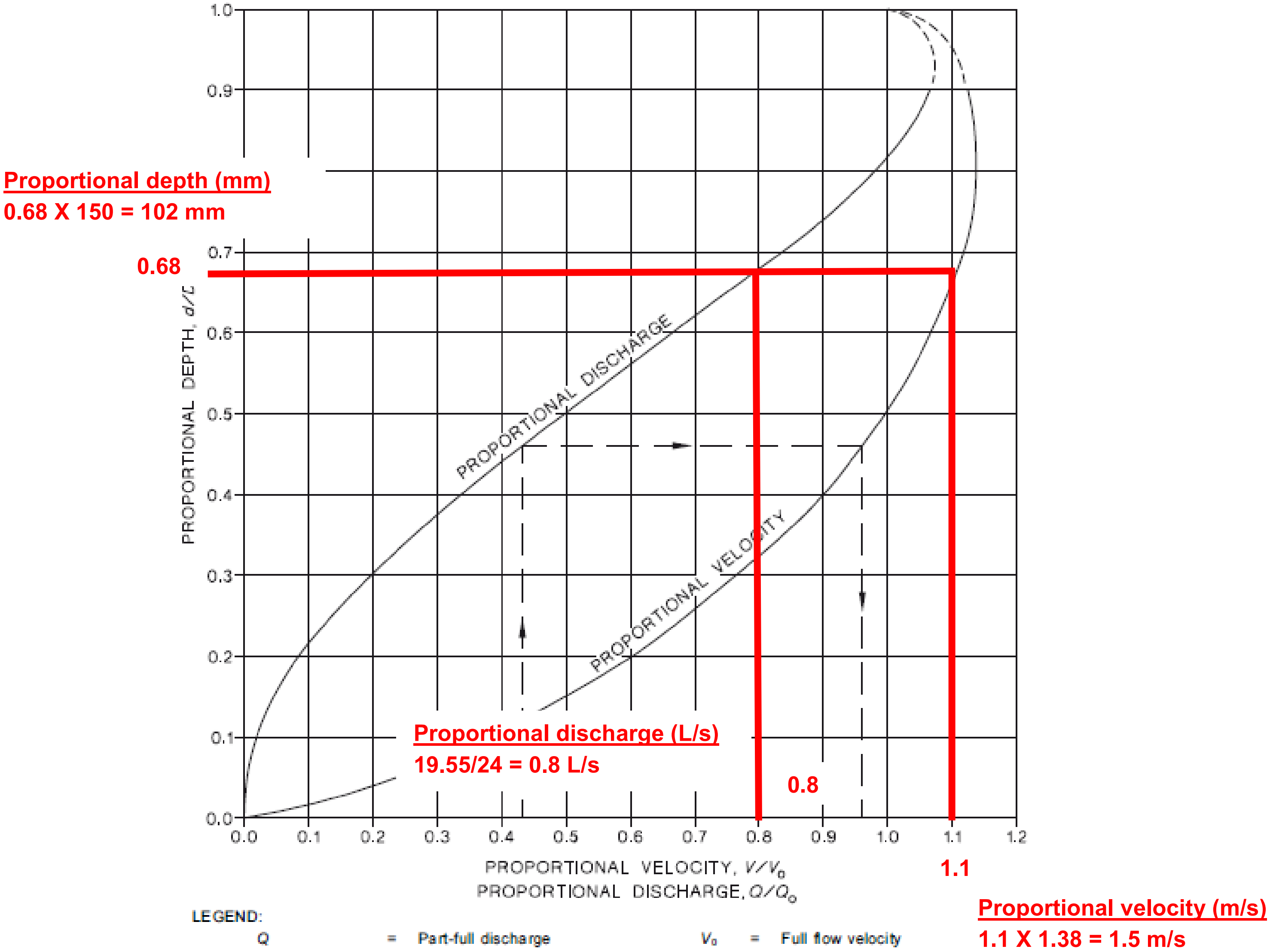


CHART 3 COLEBROOK-WHITE FORMULA WITH k = 0.015 mm

The charts are calculated for pipes running at 100% which may be suitable for stormwater applications but not for waste water in plumbing systems. To avoid the negative effects of pressure fluctuation, these systems should not exceed a maximum depth of 70% wastewater with 30% air in the drain as per accepted international standards. Therefore, chart 13 from AS 2200 for proportional velocity and discharge in part full pipes is required to be used as shown on the next page.

Our calculated flow rate of 19.55 L/s is divided by 24 L/s to give us a proportional discharge factor of 0.8. The factor, 0.8 is found on the chart 13 in the bottom row of figures as Q/Q_0 and projected up to the proportional discharge curve. This is projected to the right until intersecting with the proportional velocity curve and then vertically downward to a new proportional velocity reading of 1.1 on the bottom of the chart. To find the true velocity and check to see if a minimum cleansing velocity of 0.7 m/s is achieved we multiply the reading of 1.1 by the full pipe velocity from chart 3: 1.1 x 1.38 = 1.5 m/s. This will meet the minimum cleansing velocity of 0.7 m/s required for drains carrying wastewater containing solids as stated in BS EN 12056 – 2:2000.

Proportional depth in the DN 150 pipe can be found by projecting a horizontal line from the proportional discharge curve to the figures on the left side of the chart which is 0.68. This means the ratio of 70% wastewater in the DN 150 pipe is not exceeded. To find proportional depth in millimetres we multiply 0.68 x 150 = 102 mm deep.



LEGEND:

Q	=	Part-full discharge	V_0	=	Full flow velocity
Q_0	=	Full flow discharge	d	=	Depth of flow
V	=	Part-full velocity	D	=	Internal pipe diameter

Example:

Given: Q_0 = 100 L/s
Hydraulic gradient = 0.8 percent
k = 0.6 mm

From Chart 8:
D = 300 mm
V_0 = 1.41 m/s.

Also given Q = 43 L/s
Q/Q_0 = 0.43

Then from above chart
Proportional depth = 0.46
d = 0.46 × 300
d = 138 mm

Also:
Proportional velocity = 0.96
$\therefore V$ = 0.96 × 1.41
V = 1.35 m/s

CHART 13 PROPORTIONAL VELOCITY AND DISCHARGE IN PART-FULL CIRCULAR SECTIONS

3 Conclusion

The fixture unit ratings as specified in table 6.2A of AS/NZS 3500.2:2018 are now overstated due to the introduction of reduced flow fixtures and tapware complying with the Water Efficiency Labelling Scheme. This may result in oversized plumbing and drainage systems with reduced flows, increasing the risk of stranding solids/blockages in sanitary and drainage systems. The British and European plumbing design standards better reflect modern water efficient and sustainable plumbing systems.

This report has demonstrated that when the total fixture discharge unit values for this development are calculated using BS EN 12056-2:2000, a DN 150 main drainage pipe installed at a minimum grade of 1:100 is adequate and that the drainage plumbing meets the Performance Requirements of the PCA.

4 Application process

Where it is proposed that a Performance Solution be included in an installation, the Plumbing Regulations require that the licensed plumbing contractor who is responsible for the installation must:

- Submit a Notice of Intention particular to a Performance Solution.
- Submit the application form with all the relevant fields completed.
- Provide all evidence that the Performance Solution for plumbing work meets the performance requirements of the Plumbing Code of Australia.
- Ensure the owner is aware and notified of the Performance Solution.
- Pay the relevant notification fee listed in Schedule 1 of the Plumbers Licensing and Plumbing Standards Regulations 2000.

A guidance note detailing all information for submitting a Performance Solution can be found as Appendix A on the following link:

www.commerce.wa.gov.au/building-and-energy/plumbing-performance-solutions

5 Water services provider conditions

The relevant water services provider should be consulted as they may have certain conditions of connection, including maximum discharge flow rates that must not be exceeded.