SA Water

Engineering

Technical Standard

TS 0854 – Odour and Corrosion

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Documents superseded by this standard

The following documents are superseded by TS 0854:

a. Not applicable

Significant/major changes incorporated in this edition

Not applicable – this is the first edition of TS 0854.

Document controls

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1 Introduction

1.1 Background

The connection of new sewerage infrastructure, augmentation, and / or modification of SA Water's existing sewer network can result in elevated odour and corrosion (O&C) risks, causing odour complaints from the community, increased safety risks for workers and accelerated deterioration of corrodible assets (and failures in some cases). O&C risks are often high for new developments due to the sewage flows being relatively low initially (low number of connections), causing long sewage residence times, significant sulphide generation and consequent elevated sewer gas space hydrogen sulphide (H_2S) concentrations resulting in biogenic corrosion of corrodible assets and potential for unacceptable fugitive odour emissions. Additionally, there may be cumulative impacts to be considered where the sewer outlet from the new development discharges to an existing sewer, which itself contains sewage having substantial upstream residence times and significant sewage sulphide concentrations when it reaches the junction of the sewers.

Where the new assets are located within or adjacent to residential areas, this can lead to significant operating and maintenance issues post construction, including community odour complaints and health and safety risks for workers, where the designs of new infrastructure do not adequately provide for the effective management of potential odour and corrosion risks. Further to this, there may be new odour nuisance risks arising as a result of the encroachment of new residential development areas on existing sewerage infrastructure. This has historically been a significant issue and requires careful attention by the developer to avoid odour issues which could adversely impact local communities.

1.2 Purpose

SA Water's existing sewer network is to be managed to adequately address odour and corrosion risks by, as a minimum, meeting SA Water's specified target O&C performance levels, specifically for odour complaints and asset reliability targets. The purpose of the Odour and Corrosion Technical Standard (this document) is to provide the mandatory design and construction requirements that developers, designers and constructors are to apply when connecting new sewerage infrastructure to SA Water's existing sewer network. More specifically, the Odour and Corrosion Technical Standard provides a set of clear and pragmatic design and other rules to achieve this.

It is anticipated that the Odour and Corrosion Technical Standard (hereinafter the 'Standard') will be used primarily by third parties to provide requirements which are in line with, and complement, SA Water's existing approach to the orderly and sequential development of its sewer networks. The Standard will also provide guidance to SA Water as part of its own in-house Master Planning for, and the design and development of, new sewerage networks. In addition, the Standard, and specifically the embedded risk assessment framework, can be used by designers of new residential properties to understand the potential for new odour risks at these premises which may result from encroachment on existing sewerage infrastructure.

This Standard is not intended to replace existing sewerage system hydraulic design and construction requirements which must still be in accordance with relevant SA Water standards and guidelines, e.g. Sewer Construction Manual (SCM, SA Water Standard Drawing Set), TS 0109 for Infrastructure Design. It is expected that hydraulic design requirements would need to be met as a mandatory or threshold requirement before application of the Standard.

1.3 Glossary

Terms and Abbreviations utilised in this Standard are included in the following sections. The definitions presented below are to be used when interpreting this Standard and actions undertaken in relation to this Standard. Where a conflict exists, clarification is to be sought from SA Water.

1.3.1 Terms and Definitions

The following is a list of Terms applicable to this document:

Term	Description
AC filter, active	Activated carbon treatment system with forced ventilation, with air flow driven by mechanical fan.
AC filter, passive	Activated carbon treatment system with natural ventilation (no mechanical fan).
Constructor	The organisation responsible for constructing and installing infrastructure for SA Water whether it be a third party under contract to SA Water or an in-house entity.
Daisy chain	Two or more sewage pumping stations (SPS) are connected (with or without gravity sewer sections between the two SPS) and operated in series.
Designer	The organisation responsible for designing infrastructure for SA Water whether it be a third party under contract to SA Water or a Constructor, or an in-house entity. A Designer is a person who effects design, produces designs or undertakes design activities as defined in the *Work Health and Safety Act 2012 (SA).*
Green Dome	Low pressure activated carbon (AC) filter installed at ground level designed to capture odours and volatile gases from vented pump stations, air release valves, sewers and tanks. Includes both active and passive AC systems.
Hydraulic Jump	A jump or standing wave formed when the depth of flow of water changes from supercritical to subcritical state.
Responsible Discipline Lead	The engineering discipline expert identified in the 'Approvers' table (via SA Water's Representative).
SA Water Representative	The SA Water representative with delegated authority under a Contract or engagement, including (as applicable): • Superintendent's Representative (e.g. AS 4300 and AS 2124 etc.) • SA Water Project Manager • SA Water nominated contact person

Term	Description
Sensitive Receptor	Any land that is occupied or facilities used temporarily or permanently where people might be adversely affected (in this instance) by fugitive odour emissions from SA Water's sewer network is designated a sensitive receptor. In such instances, a focus on protecting human health and wellbeing, local amenity and aesthetic enjoyment is required. Examples of such sensitive receptors include, but are not limited to: • dwellings and private open space (including detached dwellings, multiple dwellings, flat/apartment buildings, row dwellings and semi-detached dwellings) • accommodation (excluding caretaker's residence) • childcare centres • education centres • informal outdoor recreation that is adjacent to residential zones • camping and caravan parks • indoor recreation facility • medical centres • hospitals • residential aged care facility and retirement villages • outdoor recreation facility, open sports grounds, (regular public use, for example sporting fields) adjacent to residential zones • dining facilities (restaurants, cafes) • religious institution buildings
Supplier	A person, group or company that provides goods for use in SA Water infrastructure.
Technical Dispensation Request Form	This form is part of SA Water's Technical Dispensation Request Procedure which details the process by which those required to comply, or ensure compliance, with SA Water's technical requirements may seek dispensation from those requirements.

1.3.2 Abbreviations

The following is a list of Abbreviations, Acronyms and Initialisms used in this document:

Abbreviation	Description
AC	Activated Carbon
ADWF	Average Dry Weather Flows
ARV	Air Release Valve
BOD	Biochemical Oxygen Demand
BWL	Bottom Water Level
COD	Chemical Oxygen Demand
DS	Dissolved Sulphide
FIDOL	Frequency, intensity, duration, offensiveness and location (acronym for description of odour risk)
GM	Gravity Main
GRP	Glass reinforced plastic
H_2S	Hydrogen Sulphide
HDPE and PE	High density polyethylene and polyethylene
HRT	Hydraulic Retention Time
IFC	Issued for Construction

Abbreviation	Description
MCA	Multi-Criteria Assessment
MH	Maintenance Hole
MHL	Magnesium Hydroxide Liquid
O&C	Odour and Corrosion
O&M	Operations and Maintenance
ORP	Oxidation Reduction Potential
PM	Pressure Main
PP	Polypropylene
PVC	Polyvinyl chloride
SA Water	South Australian Water Corporation
SAPPA	South Australian Property and Planning Atlas
SCM	SA Water Sewer Construction Manual
SPS	Sewage Pumping Station
TDRF	Technical Dispensation Request Form
TG	SA Water Technical Guideline
TS	SA Water Technical Standard
TW	Trade Waste
WSAA	Water Services Association of Australia

1.3.3 Terminology

The following is a list of specific interpretations for Terminology used in this standard.

- Where an obligation is given and it is not stated who is to undertake these obligations, they are to be undertaken by the Designer.
- Directions, instructions and the like, whether or not they include the expression "the Designer shall" or equivalent, shall be directions to the Designer, unless otherwise specifically stated.
- Where a submission, request, proposal is required and it is not stated who the recipient should be, it is to be provided to SA Water's Representative for review.
- Each word imparting the plural shall be construed as if the said word were preceded by the word "all".
- "Authorised", "approval", "approved", "selected", "directed" and similar words shall be construed as referring to the authorisation, approval, selection or direction of SA Water's Representative in writing.
- "Submit" mean "submit to the SA Water Representative or their nominated delegate".
- Unless noted otherwise, submissions, requests, proposals are to be provided at least 10 business days prior to work commencing or material ordering (unless noted otherwise).

1.4 References

1.4.1 Australian and international

The following table identifies Australian and International standards and other similar documents referenced in this document:

Reference	Title
MMBWTG 0530, 1989	Hydrogen Sulphide Control Manual, 1989 – Technological Standing Committee on Hydrogen Sulphide Corrosion in Sewerage Works. Hydrogen Sulphide Control Manual: Septicity, Corrosion and Odour Control in Sewerage Systems. Volume 1. Melbourne and Metropolitan Board of Works.
WSA 02 2002-2.2	Water Services Association of Australia (WSAA), 2017. Sewerage Code of Australia, Sydney Water Edition, WSA 02 2002-2.2 Version 4
WSA 02 2014-3.3	Water Services Association of Australia (WSAA), Gravity Sewerage Code of Australia, WSA 02-2014, Version 3.3
WSA 04 2022-3.2	Water Services Association of Australia (WSAA), 2022. Sewage Pumping Station Code of Australia, WSA 04 2022, Version 3.2
WSA 06 2008-1.3	Water Services Association of Australia (WSAA), Vacuum Sewerage Code of Australia, WSA 06-2008, Version 1.3

1.4.2 SA Water documents

The following table identifies the SA Water standards and other similar documents referenced in this document:

Reference	Title
94-0163	SA Water standard drawing set 94-0163 for reticulation networks: Standard Submersible Sewage Pumping Stations (Jan 2023)
94-0163(TB)	Technical Bulletin for drawing set 94-0163: Technical Bulletin – WWPS Interim Design Requirements (Jan 2023)
SAW-ENG-ODO-MUL-TSB-001	Technical Specification for Ferrous Chloride Dosing Unit, version 1.0 (May 2021). Available on request from SA Water Engineering.
SAW-ENG-ODO-MUL-TSB-002	Technical Specification for Bio Trickling Filter, Biofilter and Activated Carbon Polishing Odour Control Unit, version 1.1 (June 2023). Available on request from SA Water Engineering.
SCM	SA Water Sewer Construction Manual drawings set, drawings 4005-20001 through to 4005-20008 (current editions)
TG 0103	SA Water Technical Guideline – Approach to Technical Governance, v1.0, November 2023
TG 0530	SA Water Technical Guideline – Sewer Network Hydraulic Design Considerations, v1.0, February 2021
TG 0531	SA Water Technical Guideline – Gravity Network Ventilation Design, v1.0, February 2021
TG 11a	SA Water Technical Guideline – The Design of Sewerage Systems, v1.0 March 2009
TS 0502	SA Water Technical Standard – Authorised Products – Gravity Sewer and Pressure Pumping Main Systems, version 6.2 (December 2023)
TS 0104	SA Water Technical Standard – Design quality management, v1.0, August 2024
TS 0109	SA Water Technical Standard – Infrastructure Design, v1.1 (Feb 2024)

2 Scope

2.1 Overview of Assessment Approach

An overview of the O&C risk assessment approach is shown in Figure 2-1 and involves the review of minimum design rules applied in the initial development design, followed by a semi-quantitative risk assessment using the O&C Risk Assessment Tool. The O&C Risk Assessment Tool is an integral part of the O&C Technical Standard.

The use of the Standard, and the Tool, will be initiated by SA Water's Planning group, either by direction from SA Water to third parties, e.g. developers, or as triggered within SA Water's internal planning or development application and approval procedures.

The outcomes from the Tool are used to inform appropriate O&C mitigations for the effective management of O&C risks.

Details of the assessment methodology to be undertaken by the Designer are described in Section 4.1.

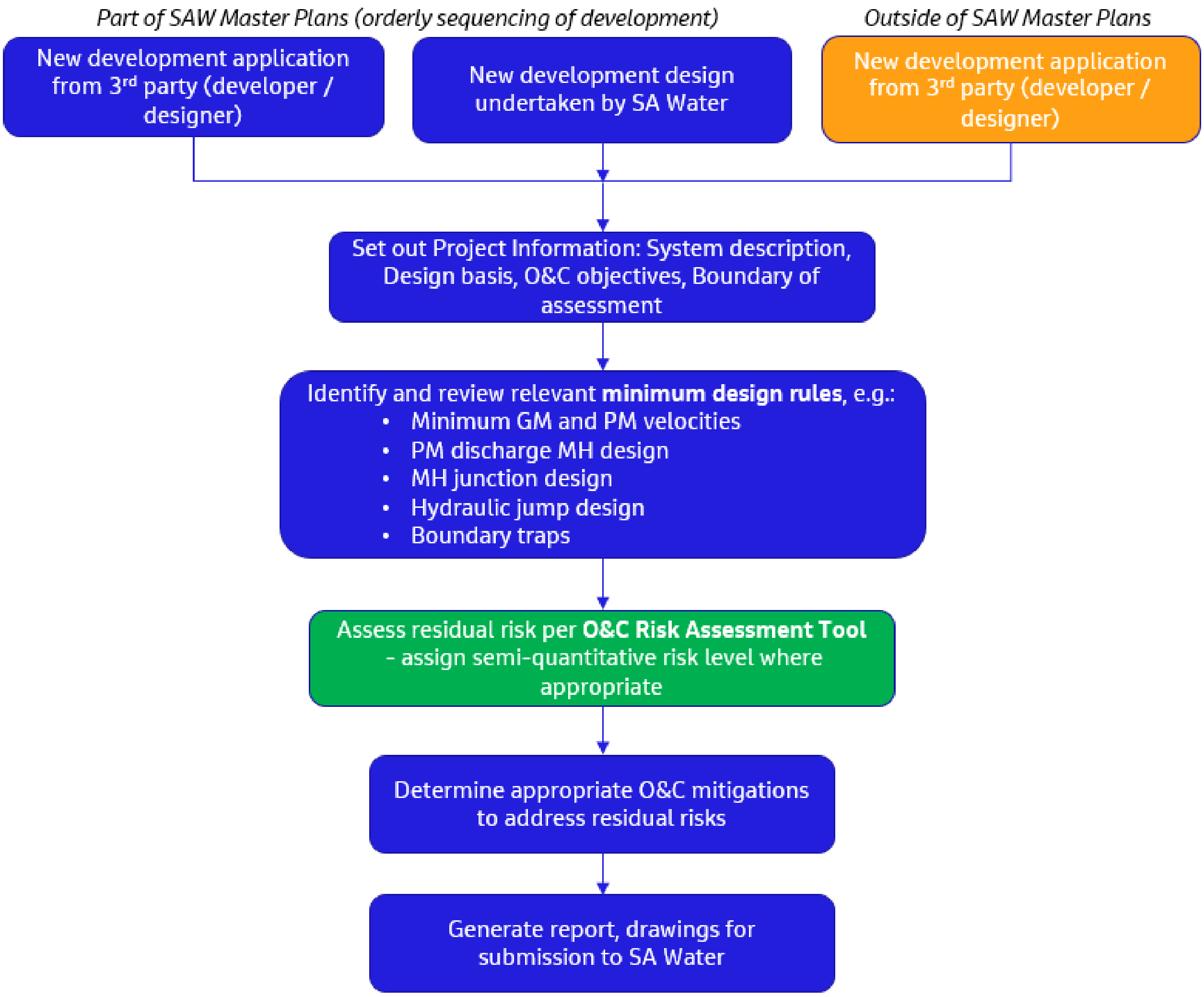


Figure 2-1: Overview of O&C assessment approach

2.2 Scope and application of this Technical Standard

This Technical Standard:

a. Establishes a consistent approach to assessing odour and corrosion risks for new (and existing) sewerage infrastructure and identifies appropriate mitigations.

b. Sets out the minimum design requirements for new sewerage assets to be connected to SA Water's existing infrastructure, to minimise the risk profile of odour and corrosion issues to acceptable levels.

c. Details steps to carry out a semi-quantitative assessment of O&C risks for new (or existing) sewerage infrastructure, and subsequent minimum types and extent of mitigations to be applied which are commensurate with the level of risk, and in meeting SA Water's target odour and corrosion performance objectives.

d. Incorporates an Odour and Corrosion Risk Assessment Tool, to be used in conjunction with this Technical Standard, for the semi-quantitative assessment of the O&C risks, without and with mitigative measures.

The focus of the Standard is to address the following applications:

1. New sewerage developments as set out within, and consistent with, SA Water's overarching Master Planning framework, for the orderly planning and implementation of sewerage infrastructure to accommodate future urban growth.
2. Development works which are within SA Water's Master Plan for orderly development but occur out of sequence.
3. Development requests which are outside of SA Water's Master Plans, received as enquiries by third parties.

The Technical Standard and the O&C Risk Assessment Tool complement the two Technical Guidelines addressing O&C management:

- TG 0530 Sewer Network Hydraulic Design Considerations, v1.0, February 2021
- TG 0531 Gravity Network Ventilation Design, v1.0, February 2021

These Guidelines provide information on best practices and principles that should be applied during the design and operation of sewerage assets for the effective management of O&C risks. Although there is some overlap of information, the Technical Standard sets out specific requirements for the design, construction, modification and performance of sewerage assets. SA Water's Technical Standards are compulsory and binding under all SA Water Contracts (TG 0103, Nov 2023).

The use of the Standard will be initiated by SA Water, either by direction from SA Water to third parties, e.g. developers, or as triggered within SA Water's internal planning or development application and approval procedures.

The primary intent is for the Standard to be used by the Designer; this may be a Developer, a Contractor, or a third party undertaking a design and construction project on SA Water's behalf. There may also be occasions where SA Water will apply the Standard in-house as part of the design of new developments undertaken internally.

The Standard is not intended to be used for development projects with a small number of property connections (less than 10). The Standard is expected to be useful for applications having 10 or more property connections, which include a new common sewer (or pump station) which collects and transfers sewage (either initially or in the future) from the properties to existing SA Water sewerage infrastructure. The O&C risks associated with these small development projects are expected to be low. Notwithstanding this, the information in the Standard can guide the design of connections to the existing sewerage network assets. [Note: Small numbers of dwellings/residential properties which are or ought to be considered as part of a larger development are not exempt but are to be considered on the whole of development basis.]

In addition to providing minimum requirements for new sewerage assets associated with the new development projects, the intent of the Standard is also to inform the risk assessment and appropriate mitigations where new residential developments (urban infill and new estates) encroaches on existing above ground sewerage infrastructure, including SPS and pressure main air release valves (ARVs).

2.3 Works not in scope

The Standard is focused on addressing risks for proposed new residential and commercial developments, including new residential estates and residential infill projects, as well as modification and upgrade work for existing sewerage networks. Assessment of O&C risks for broader parts of the sewerage system, e.g. including trunk sewers for transport of sewage to treatment facilities, is addressed separately by SA Water as part of its master planning processes, however elements of the Standard (including the minimum design requirements) may be used to guide design and risk assessment.

This Technical Standard defines in the Risk Assessment Tool three risk categories with respect to odour and corrosion issues – low, medium and high. It provides guidance in the selection of appropriate odour and corrosion mitigation facilities for low and medium risk applications. The focus of the mitigation facilities is activated carbon systems, however, examples where other mitigation facilities may be more appropriate are identified. The Standard is not intended to be prescriptive in the selection or design of odour and corrosion mitigation facilities.

Where ***high*** odour and corrosion risks are identified as part of the assessment approach, i.e. as defined by the Risk Assessment Tool, this Technical Standard provides high-level information and guidance for further and more detailed assessment of odour and corrosion risks. For example, it is not intended to provide detailed instructions for undertaking sulphide and ventilation modelling of gravity sewers for the purposes of estimating hydrogen sulphide (H_2S) gas concentrations in sewers.

The Standard does not stipulate the design of natural ventilation for new sewerage assets, including the location and sizing of vents. It is expected that the developer/designer will incorporate the design of the natural ventilation system as part of the broader system design for the new assets and in accordance with the technical guidance document SA Water TG 0531 and current WSAA codes.

2.4 Technical dispensation

Departure from any requirement of this Technical Standard shall require the submission of Technical Dispensation Request Form (TDRF) for the review and approval (or otherwise) of SA Water Principal Engineer (Manager Treatment Expertise) listed in Page 5, on a case-by-case basis.

The Designer shall not proceed to document/incorporate the non-conforming work before the Principal Engineer has approved of the proposed action in writing via the Technical Dispensation Request Form (TDRF).

SA Water requires sufficient information to assess dispensation requests and their potential impact. The onus is therefore on the proponent to justify dispensation request submissions and provide suitable evidence to support them.

Design works that are carried out without being appropriately sanctioned by SA Water shall be liable to rejection by SA Water and retrospective rectification by the Designer / Constructor.

3 Minimum Design Requirements

The minimum design rules are mandatory requirements which are to be implemented for all new sewerage infrastructure projects, including those designed and managed by SA Water. These requirements apply the 'hierarchy of controls' approach as described in Section 4.1 whereby the likelihood for sulphide generation is minimised as far as practicable. There may be cases where the adoption of some design rules is not cost effective, i.e. the costs of implementation outweigh the benefit of the measure. In this case, technical dispensation can be discussed with, and a suitable approach determined by, SA Water.

The minimum design requirements are consistent with the existing Technical Guidelines TG 0530 and TG 0531, and further background information can be found in these guidelines.

3.1 Pressure main design

Significant levels of sulphide generation can occur in pressure mains due to anaerobic conditions, i.e. absence of oxygen, which can occur with prolonged retention (while sewage is being pumped and while stagnant between pump cycles). In the first instance, detention periods are to be minimised by avoiding the use of SPS and pressure mains wherever practicable. Where adoption of an SPS and a PM is unavoidable, the following minimum design requirements are to be applied.

3.1.1 Minimum PM velocity

Pumps and PMs are to be designed to ensure minimum velocity requirements for slime control are satisfied according to Equation 1 below from WSA 04 2005 which provides the minimum pumping rate to ensure slime stripping. This formula aligns with the curve from the Hydrogen Sulphide Control Manual (MMBWTG 0530, 1989), as shown in Figure .

$$Qp\min = 325\,\pi\,\left(\frac{D}{1000}\right)^{2.15} \qquad \textit{Equation 1}$$

Where:

- **Qp_{min}** is the minimum pumping rate (L/sec)
- **D** is the pressure main pipe internal diameter (mm).

For pressure mains with a diameter less than DN300, an absolute minimum sewage velocity of 0.9m/s (at any point in time when pumping) is recommended for satisfactory transport of sewage solids through the pressure main, though the preferred minimum sewage velocity is 1.5m/s. Note that the minimum requirements for slime control as set out above require the velocities to be greater than the minimum of 0.9 m/s for transport of solids for all diameters of DN100 and larger, i.e. velocities are typically determined by slime control rather than solids transport.

For new wastewater networks which include both new gravity mains and new pressure mains in the scope of work, pump and pressure main systems must be designed to provide a minimum velocity of 0.7m/s in the new downstream gravity sewer at all times when pumping.

The above minimum design velocities specified herein are to be adopted noting that they are higher than those provided in latest edition of WSA Sewage Pumping Station Code. The WSA 04 2022-3.2 (i.e. latest edition) applies a different approach, with minimum velocities for slime control (and for prevention of solids deposition) significantly lower than for used in earlier edition, i.e. WSA 04 2005.

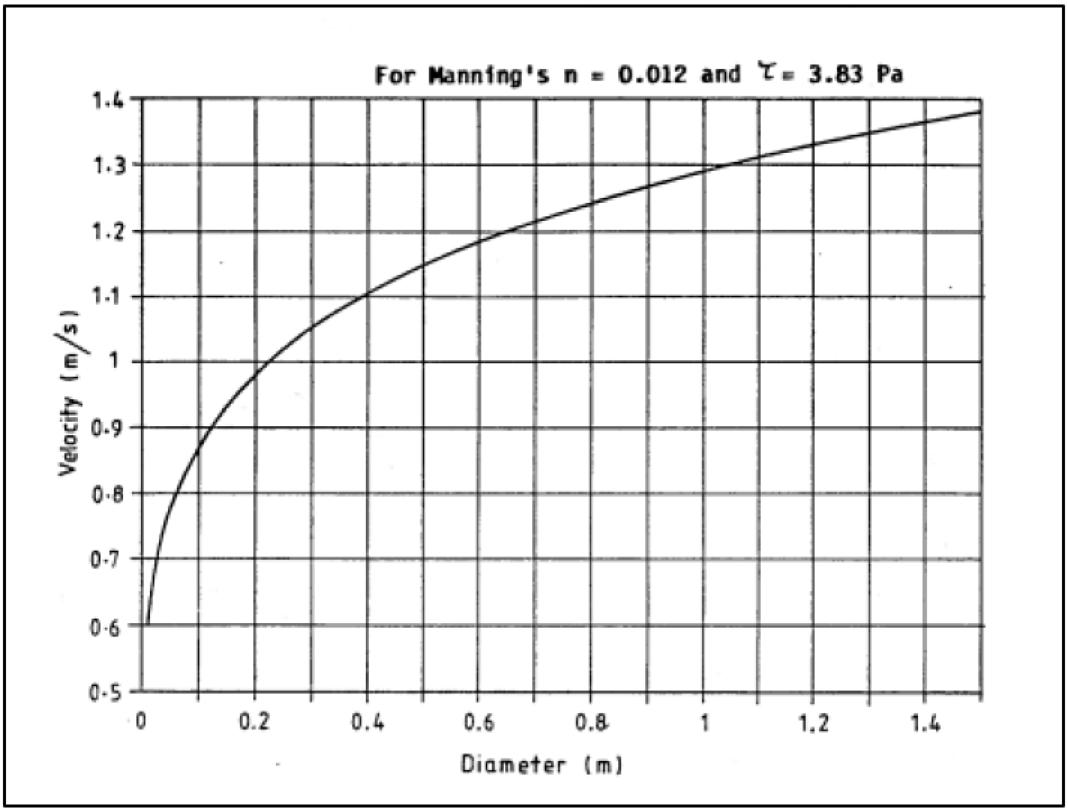


Figure 3-1: Minimum velocities for slime control in pressure mains (Hydrogen Sulphide Design Manual, 1989)

3.1.2 PM hydraulic retention times

Hydraulic retention times for ***aggregate SPS wet well and PMs*** are to be minimised as far as practicable with a target of less than 2 hours based on ADWFs (applied for all stages of development).

The PM residence time is to be calculated as the sum of the residence time when sewage is being pumped through the PM plus the sewage residence time when the sewage is stagnant in the PM between pump cycles.

The HRT (hours) for the PM can be calculated by dividing the total volume of the PM (m^3) by the average sewage flow rate (ADWF, m^3/hr), where the average sewage flow is the average flow rate of sewage entering the SPS (not the pump capacity flow rate). For aggregate PM and SPS wet well HRT, the combined volume of the wet well (working volume) and PM is divided by the ADWF. Details of HRT calculations are provided in Appendix A.

For applications where it is not possible to maintain an HRT of less than 2 hours, appropriate O&C mitigations may be required as determined by the O&C Risk Assessment Tool.

If designing a PM for a new development and the resulting detention time (HRT in the new PM) is greater than 4 hours at ADWF for the initial development sewage flow rate, apply the following where practical:

a. Design the PM to serve only the first stage of the development, thereby reducing the HRT (compared to that for PMs sized for ultimate development), or with the same objective.

b. Design for two (or more) PMs, with the first intended to serve the initial stage of development, and the second PM (and additional PMs) to serve the main stage (or later stages) of the development. It is expected that HRT will be assessed at each of the different development stages by the respective owner at the time. Where there is more than one PM installed and O&C risks are expected to be high for the future development scenario (e.g. as informed by sulphide modelling), the Designer should consider decommissioning the original PM. Operating a single PM (correctly sized for the flow rate to achieve HRT targets) can achieve improved O&C outcomes due to the overall lower surface area of the pipe internal walls compared to that for two (parallel) pipes.

3.1.3 PM discharge maintenance hole

Key features relating to the design of the PM discharge MH for the effective management of O&C risks include:

a. PM entry to a discharge MH at a low level to minimise turbulence.

b. As a minimum, the design shall be as set out in SA Water's SCM Section 8, drawing number 4005-20008-01; see Figure .

c. Where practicable, the PM entry to a MH chamber (within the development area and/or at the junction with the existing sewerage infrastructure) shall be submerged to minimise turbulence. The PM entry is to be as close to the flow line of the receiving MH as practicable.

   For PMs which include a downward sloping section where gravity flows can occur, a focused assessment of the downward sloping section should be undertaken to assess potential for air release from the gas space (can be pressurised on SPS pump start) along the PM at ARVs and/or at downstream vents, and potential for corrosion where there is a gas space. Minimising areas of turbulence for the gravity section, and review of potential gas release locations and selection of appropriate materials should be undertaken. In general, this arrangement, i.e. a downward sloping section of a pressurised main, should be avoided where possible.

d. Sufficient capacity of the channel within the MH chamber and within the downstream GM to avoid gas pressurisation of chamber. For new gravity mains proposed as part of the development project, the system design shall be such that the capacity of the new receiving gravity main does not exceed two thirds full (as set out in WSA 04-2022), when receiving the new SPS PM discharge and any other inflows to the gravity main, for all stages of development.

e. PM entry to the discharge MH to be angled at the minimum practicable angle to the horizontal alignment with the upstream Section of GM sewer to which the PM is joining (maximum of 45°) to minimise turbulence. This applies to the last, i.e. downstream end, 5 metres (or 10 times the PM diameter; whichever is greater) of the PM to have a straight alignment with the gravity pipe (as set out in SA Water's TG 0530).

f. Discharge MHs to be constructed from corrosion resistant material (e.g. plastic as listed in TS 0502) or lined with corrosion resistant material to minimise corrosion risk. The Designer is to refer to SA Water for approved and preferred products.

The minimum design requirements are as shown in SA Water's SCM Section 8, and reproduced in Figure here. However, note that this design will result in a 'medium risk' within the Risk Assessment Tool. Improvements on this design are to be applied by the Designer where practical, to reduce turbulence, and the associated risk level. A potential improved and preferred design configuration is shown in Figure . This shows the pressure main entering low within the MH chamber to limit turbulence. A further improvement on this is to ensure the PM discharge flow is submerged below liquid level in the PM discharge chamber under all operating conditions.

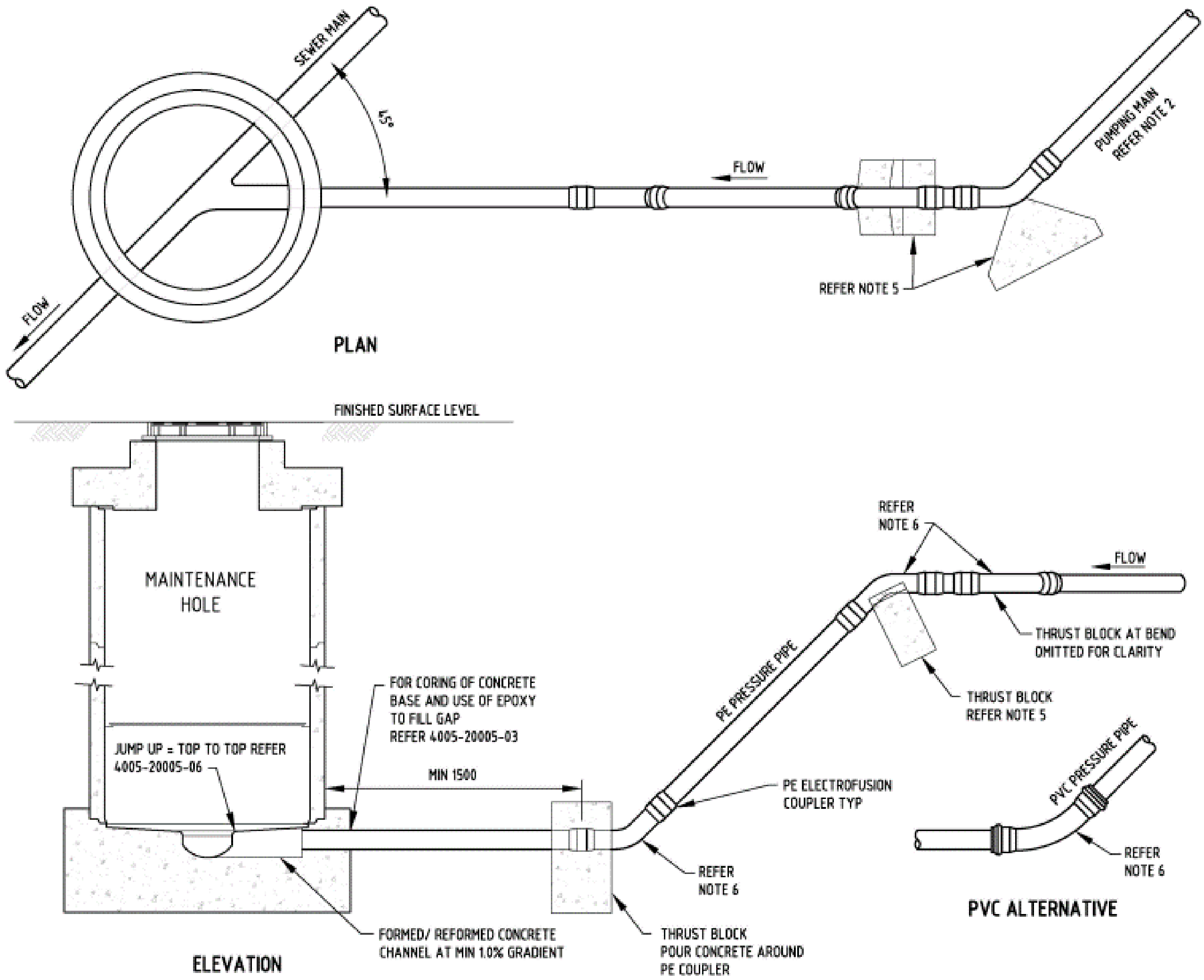


Figure 3-2: PM discharge MH arrangement (SA Water SCM, Section 8 drawing 4005-20008-01)

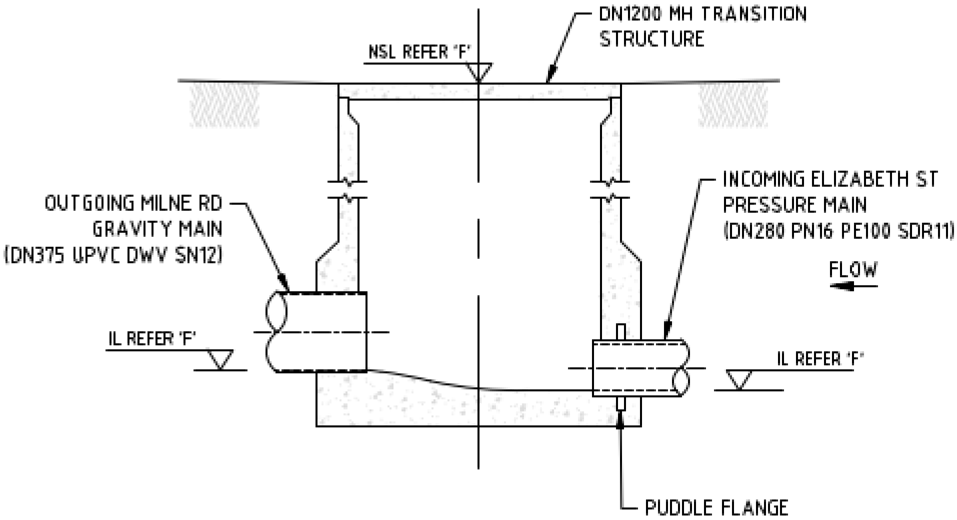


Figure 3-3: Example of PM discharge MH with low level PM discharge, for reduced turbulence

3.2 Gravity main design

3.2.1 GM velocity

The gradient of the GM is to be designed to achieve velocity targets as set out in Table 1. A minimum velocity target has been provided (rather than alternate guidance based on achieving minimum shear stress) to provide a simple approach which can be readily applied by Designers and Developers.

Key considerations to minimise sulphide generation are:

a. Achieving minimum self-cleaning and slime control velocities, with sulphide generated from accumulated solids being generally much less critical than generated from the slime layer, especially when the accumulated solids are flushed through the system on a daily basis.

b. Selection of pipe grades to avoid high sewage velocities is required to manage turbulence and H_2S release from the liquid to gas phase.

Table 1: Summary of GM minimum design requirements for sewage velocity

Criteria	Value	Notes	Reference (below table)
Minimum sewage velocity during average daily flow conditions	>0.6m/s	Minimum velocity to be achieved at all times to prevent deposition of solids, i.e. maintain a self-cleansing action in sewers.	2 and 3
Minimum sewage velocity for slime control	See Figure 3-4.	Dependent on sewer diameter. Applies to sewers with diameter of 300 mm and above[1]	3
Minimum velocity in an inverted siphon	>0.75m/s at ADWF >1.0m/s at max design flow	To ensure flow is capable of transporting solids against gravity	1
Maximum velocity for reticulation sewers >DN225	< 3m/s	For reticulation sewers greater than DN225[2]	1 [S5.5.9]
Maximum velocity for branch and trunk mains	< 3m/s	At PDWF.	1 [S5.5.9]

References:

1. Sewerage Code of Australia, WSA 02-2014-3.3, Version 3.3, Water Services Association of Australia (WSAA.)

2. US EPA Design Manual – Odour and Corrosion Control in Sanitary Sewerage Systems and Treatment Plants (1995)

3. Hydrogen Sulphide Control Manual: Septicity, Corrosion and Odour Control in Sewerage Systems. Volume 1, Technical Standing Committee on Hydrogen Sulphide Corrosion in Sewerage Works, Melbourne and Metropolitan Board of Works, 1989

[1] Minimum sewage velocity for slime control applies to sewers with diameter 300 mm and above. As per WSA 02-2014, the minimum self-cleansing velocity, i.e. > 0.6m/s shown in the first row of the above table, may not be sufficient to prevent the build-up of slimes for the larger sewers. For smaller sewers, these are typically reticulation sewers and entry of wastewater from connections are likely to maintain elevated DO levels and not subject to excessive slime growth as can occur in the larger sewers.
[2] Although the maximum velocity shown applies for reticulation sewers greater than DN225, as per WSA 02, it is recommended that the Designer also applies this maximum of 3m/s to DN150 and DN225 sewers wherever practical to minimise turbulence.

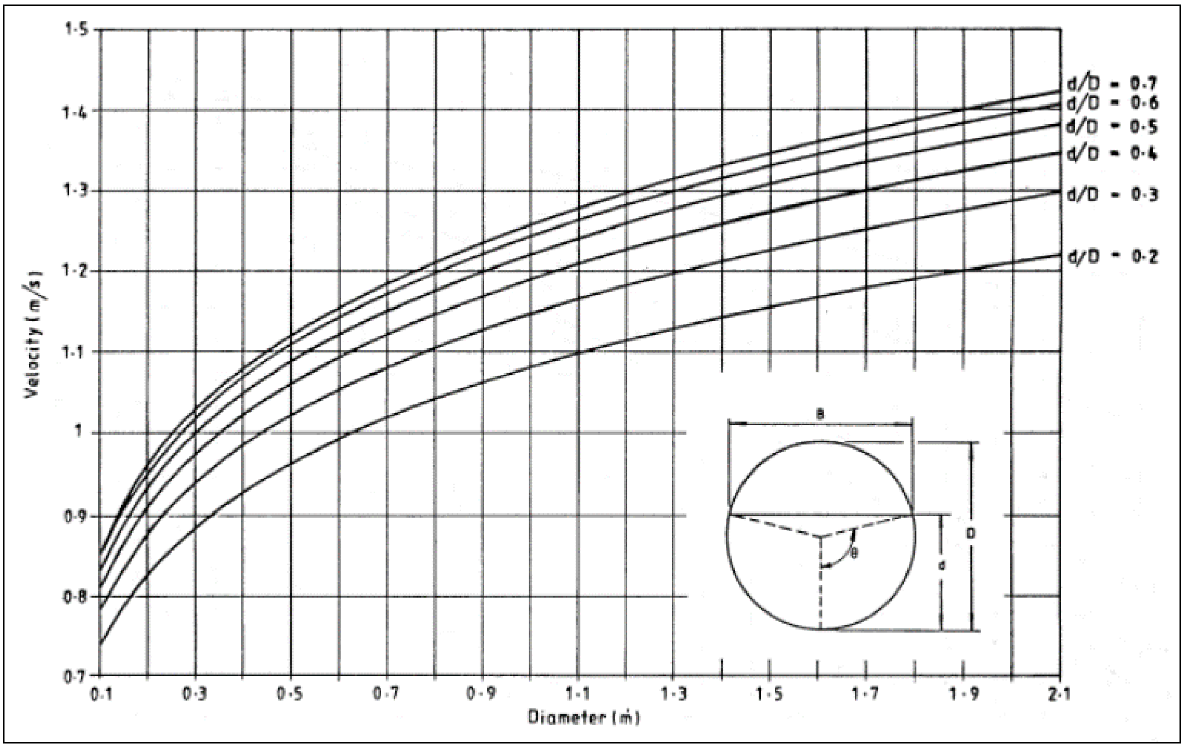


Figure 3-4: Minimum velocities for slime control (Hydrogen Sulphide Control Manual, 1989)

Notes:

d = depth of flow (m)

D = internal diameter of pipe (m)

3.2.2 GM hydraulic jumps

Hydraulic jumps along gravity mains, as occurs for surcharging of sewage at the bottom of sewers with a steep grade, are to be avoided wherever possible. Hydraulic jumps increase the likelihood of gas pressurisation along the gravity main and subsequent risk of fugitive odour emissions, as well as turbulence which exacerbates the release of H_2S to the gas phase.

Where hydraulic jumps cannot be avoided, the requirements as set out in WSA 02-2002-2.2 are to be applied. These requirements are replicated below.

For reticulation sewers of grade >7% and population loadings specified in Table 2 below, either a specialist review of the hydraulic performance shall be made and measures such as (a) and (b) immediately below incorporated, as appropriate, into the design:

a. Provide ventilation on either side of the possible hydraulic jump, i.e. an induct at the upstream end of the steep section, and an educt at the bottom of the steep section. Where there is a risk of odour complaints at the educt location (associated with elevated hydrogen sulphide concentrations due to turbulence), treatment of the gas at this location, e.g. by activated carbon, may be required.

b. Prevent the jump from occurring in a MH by providing horizontal and/or vertical curves in the sewer at changes of grade and/or direction. The curve should be located at sufficient distance from a MH such that the jump will not occur in the MH. The radius of the curvature should not be less than approximately 8 x the pipe diameter.

Or the following precautions shall be incorporated in the design:

1. For DN150 and DN225 sewers, the depth to invert of the MH shall exceed 1.5m
2. For DN300 sewers, the depth to invert of the MH shall exceed 2.0m
3. Change of direction at the MH shall not exceed 45°
4. Grade through the MH shall not be reduced
5. Any curvature radius of the channel inside the MH shall be greater than 6 x pipe OD.

Table 2: Summary of GM minimum design requirements for sewage velocity

Sewer Size DN (mm)	Equivalent Population (persons)
150	>200
225	>500
300	>1000

For branch and trunk sewers with a steep grade, i.e. >(1000 / DN in mm)%, requirements as set out in WSA 02:2002-2.2 apply.

3.2.3 GM drops and jump-up designs

Drops along GM routes, and for tributaries entering GM MHs, are to be avoided wherever possible. Where drops in MHs of greater than 300mm free fall depth are not avoidable, hydraulic jump up designs are to be as per SA Water drawing SCM 4005-20005-08; refer Figure below. The minimum 600 mm distance between incoming pipe and the pipe discharge invert level is incorporated for operational and constructability requirements.

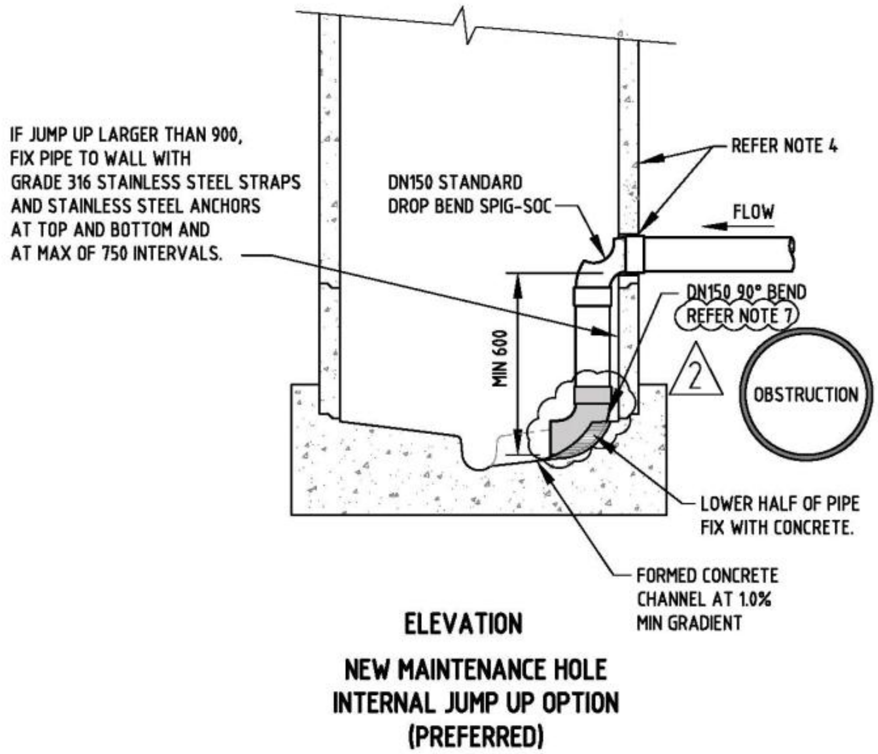


Figure 3-5: Gravity main jump up arrangement (SCM Section 5, drawing 4005-20005-08)

3.2.4 GM maintenance holes

Where there are junctions of GMs at MHs, the design shall be as set out in SA Water's SCM drawing numbers 4005-20005-07 and 4005-20005-08. The designs are to minimise turbulence as far as practicable.

3.3 Sewage pump stations

The design of any SPS is to be in accordance with TG 11a, and 94-0163 standard drawings and technical bulletin.

The Designer is to incorporate design features for an SPS to minimise O&C risks as far as practicable. These features are focused on addressing the following for the SPS wet well:

a. Reducing turbulence

b. Limiting hydraulic residence time (in the wet well and PM)

c. Eliminating or minimising the deposition and accumulation of solids and scum

d. Ensuring sufficient ventilation for the SPS wet well, and any emergency storage structure (refer Section 3.4.2)

e. Using non-corrodible materials where H_2S (g) levels above performance objectives (see Table 3) are expected. Consultation with SA Water is required for approval of materials and design recommended by the Designer.

Specific ***minimum requirements*** to be implemented at SPS for the effective management of O&C are:

1. There shall be a single inlet sewer to the SPS wet well, with the outlet submerged below the liquid surface (bottom liquid level) as shown in SA Water's standard drawing set 94-0163-07.

2. All lids and access covers shall be close fitting to contain all noise and odours (drawing set 94-0163-07).

3. A minimum 5m x 5m allowance shall be made when odour control devices are to be used. Where odour control is not required for initial operation, the design shall include and set aside, based on footprint provisions, for any future odour control device if practicable. Minimum footprint allowances are to be addressed in safety and design workshops to ensure sufficient space is provided.

4. SPS wet wells are to be designed to achieve the following HRT design requirements at ADWFs (refer SA Water TG 0530, 2021):

   a. Less than 30 minutes for SPS located in sensitive areas or with the nearest sensitive receptor located within 100 metres from the SPS.

   b. Less than 2 hours for SPS located in non-sensitive areas or with the nearest sensitive receptor located >500 metres from the SPS or where shorter times are impractical.

5. Wet well interiors to be lined with an approved H_2S corrosion resistant lining where H_2S(g) concentrations above performance objectives (see Table 3) are expected. Where there is uncertainty of H_2S(g) concentrations during operation (initial and/or future), the use of non-corrodible materials should be discussed and agreed with SA Water.

6. Minimum ventilation requirements as set out in Section 3.

3.3.1 Supplementary design features

Other key design features to be implemented for an SPS, as far as practicable, are:

1. Design to minimise potential for vortexing, swirling and excessive turbulence within the wet well. Set the lowest liquid level in the wet well above the sloping portion of the wet well. Include facilities to enable periodic wet well cleaning to remove accumulated fats, oils and greases.
2. Avoid drops of incoming sewer to the SPS wet well with respect to bottom water level (BWL). Where a drop cannot be avoided, design shall include an inlet drop pipe to BWL, i.e. a submerged entry provided to minimise turbulence.
3. Design of the SPS wet well to be such that backup of wastewater into influent lines does not occur, i.e. adequate pump start-stop cycles for constant speed pumps. Consider multiple pumps or multiple-speed pumps to accommodate range of incoming flow rates.
4. Avoid frequent starting of pumps, target less than 6 starts per hour or use variable drives. Although reducing the number of pump starts per hour will increase the residence time (and sulphide generation) in the wet well, the frequency of elevated H_2S (g) concentrations due to high turbulence at the PM discharge will reduce. Note that the aggregate HRT for the SPS wet well and the PM (combined) will not change with the reduced pump start frequency provided there is no change to the SPS influent average sewage flow rate (and no change to the working volume in the wet well).

3.4 Ventilation of key infrastructure items

General guidance for the design and implementation of both passive and forced ventilation of key infrastructure items is set out in SA Water's TG 0530 and TG 0531.

Minimum and mandatory requirements applicable for this Technical Standard are set out below.

3.4.1 PM air relief valves

Odour mitigation to be implemented for all ARVs where the following apply:

- Distance to sensitive receptor is <100 metres and sensitive receptor type is as defined in Section 1.3.1, **AND**
- HRT is >2 hours for the PM, at ADWF during any design development stage, at the ARV location.

For instances where monitoring (for existing systems) has indicated H_2S (g) concentrations at the ARV location are higher than the performance objectives stipulated in Table 3, then odour mitigation is likely to be required. The decision to implement odour mitigation for the existing system is to be based on assessment of odour risks (e.g. distance to sensitive receptors, and/or history of odour complaints) and corrosion risks for the PM.

See Section 6.2 for required odour mitigation details for ARVs.

3.4.2 SPS wet wells

Each SPS shall be fitted with an educt vent to facilitate natural ventilation of the wet well and the inlet MH, as a minimum. In addition, a vent line shall be provided from any emergency storage structure to the educt vent shaft to facilitate natural ventilation. The educt vent shall be located such that the distance of the vent lines between the wet well/inlet MH/emergency storage and the educt vent is to be less than 20 metres. If the distance from the wet well/inlet MH (or emergency storage structure) to the educt vent is greater than 20 metres, consider applying dedicated educt vents.

The use of an induct vent, fitted with a non-return damper, can improve natural ventilation and reduce O&C risks by providing fresh air dilution in the wet well (reducing H_2S concentration and gas space relative humidity). Where the Designer identifies a benefit in the use of a fresh air induct vent, the selection and design are to be discussed with SA Water.

The decision to implement forced ventilation with gas treatment at an SPS is site-specific and assessment should be undertaken on a case-by-case basis by the Designer, informed by outputs of the Risk Assessment Tool. Generally, SPS forced ventilation and treatment would be expected for systems with risks specifically associated with the SPS (e.g. relatively long HRTs in the upstream gravity network and at the SPS wet well, number of upstream daisy-chained SPSs, materials of construction) identified as 'medium' or 'high'. Where forced ventilation is applied and there is an emergency storage structure at the SPS site, a fresh air induct should be installed at the emergency storage as well as a vent line between the SPS wet well and the emergency storage. Air extraction would occur from the SPS wet well such that the two gas spaces are ventilated in series, thereby minimising the volumetric gas extraction rate.

Forced ventilation without treatment at a SPS is not preferred and would only be applicable to an SPS which is located at considerable distances from sensitive receptors, and H_2S (g) concentrations in the wet well are estimated to be lower than performance objectives (see Table 3). These systems require specific approval and endorsement by SA Water due to the associated risks. Where approved, adequate space at the SPS site for a treatment system, determined on a case-by-case basis, shall be included in the design.

Passive ventilation with treatment, e.g. with a Green Dome, is not acceptable for an SPS as it results in poor ventilation of the wet well (exacerbating corrosion risk) and a build-up of H_2S and odours in the gas space.

3.4.3 Gravity Mains

The design of educt and induct vents for natural ventilation of trunk sewers shall be as set out in SA Water's SCM drawings 4005-20007-04 through to 4005-20007-07. The drawing sets require induct and educt vents to be used on all trunk sewers DN450 and larger, unless otherwise directed by the SA Water Representative.

For smaller sewers (branch and reticulation), natural ventilation requirements and associated induct and educt arrangements are set out in SA Water's TG 0531. The following minimum requirements apply:

a. Where sewer grade changes significantly and includes a steep grade of 7% or more:

b. Install an induct at the upstream end of the sloped Section of the GM

c. Install an educt at the downstream end of the sloped Section of the GM

d. Vents should be located on high ground above the level of adjacent inhabited areas, and as far as practicable from residential areas, especially where buildings are more than one storey high. Appropriate distances from sensitive receptors are to be determined on a case-by-case basis. SA Water's standard vent height is 15 metres and diameter 300mm (SCM drawing 4005-20007-06).

In general, facilities for natural ventilation should be considered where there is turbulence and potential for H_2S gas release. This includes, for example, sewer bifurcations or weirs in gravity systems which can cause significant local turbulence.

3.4.4 PM discharge maintenance holes

PM discharge MHs are required to have a vent connected to the MH chamber. The vent ensures pressurisation of the MH and downstream gravity sewers is avoided and also allows ingress of fresh air as required. A common vent to facilitate both air induct and educt functions may be suitable or separate induct and educt vents may be more suitable. This is to be justified by the Designer and will be based on the level of O&C risk at the discharge MH. For example, where the discharge MH is located close to sensitive receptors, and has corrodible internals, the use of a short induct vent with non-return damper, in addition to a separate tall vent stack, may be warranted. An example of a PM discharge MH with induct and educt vents is shown in Figure .

The requirement for gas treatment of the vent emissions at the PM discharge MH will be dependent of the findings of the O&C risk assessment and output of the Risk Assessment Tool; see Section 5.

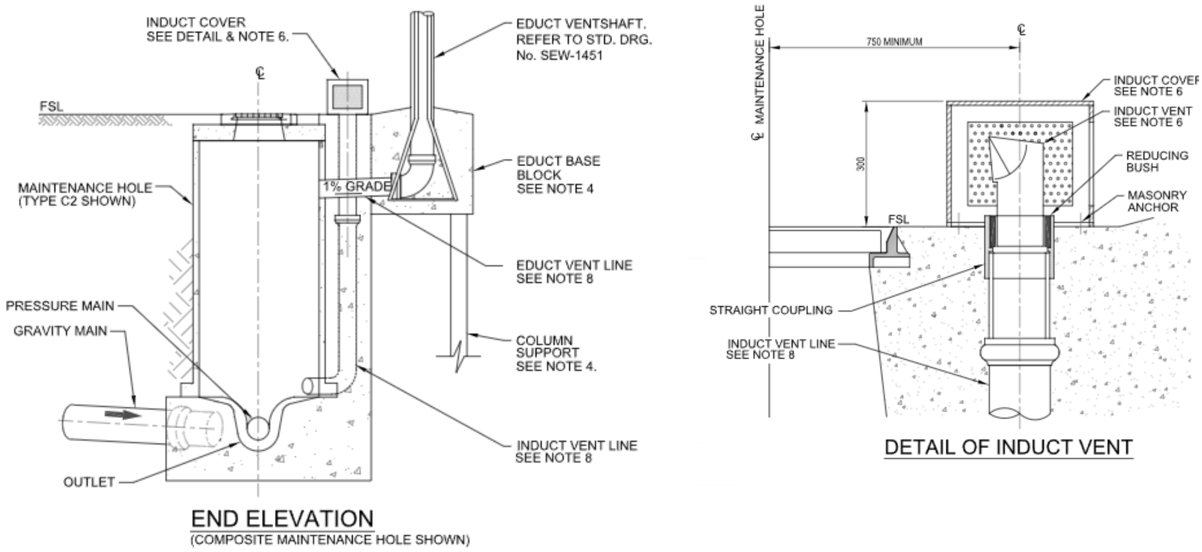


Figure 3-6: PM discharge MH with induct and educt vents (WSA 04-2022)

3.4.5 Siphons

Siphons are subject to gas pressurisation of the incoming sewer and/or MH at its upstream end which increases the risk of fugitive emissions. In addition, elevated H_2S (g) concentrations can occur at the entrance to and downstream of siphons due to the build-up of solids and biological material along the inverted siphon.

Wherever possible, the use of siphons should be avoided to prevent these associated odour (and corrosion) risks. In the case that a siphon cannot be avoided, the Designer is to justify the requirement for the siphon and request specific approval from SA Water.

Where a siphon is used, the following minimum ventilation rules apply:

- An educt shall be installed at the upstream end of a siphon, i.e. at the MH at its down-leg.
- An induct shall be installed in the MH to which the up-leg of the siphon discharges (or immediately downstream of the siphon).

4 Applying the Risk Assessment

4.1 Assessment Methodology

The O&C risk assessment approach involves the collection of relevant project design information, the review and application of minimum design rules as part of the design development, followed by a semi-quantitative risk assessment using the O&C Risk Assessment Tool. The O&C Risk Assessment Tool is fundamental to the O&C Technical Standard, and this is detailed in Section 5. The outcomes from the Tool are used to inform appropriate O&C mitigations for the effective management of O&C risks.

The key steps of the O&C risk assessment to be undertaken by the Designer, as shown in Figure 2-1, are described below.

Step 1: Define the boundary of assessment

- Define the boundary of the development infrastructure assets to be assessed; see **Section 4.3**.

Step 2: Collate design information

- Collate the project design basis information, including hydraulic operating scenarios to be assessed, proposed development infrastructure design (pipe lengths, sizes, locations, etc.); see **Section 4.4**.

Step 3: Review and apply minimum design rules

- Identify and apply the minimum design rules as set out in **Section 3** where appropriate, e.g. for PM discharge maintenance hole (MH) designs, minimum and maximum sewer pipe velocities.

Step 4: Use the O&C Risk Assessment Tool to establish risk levels for the scope of work

- An overview of the Risk Assessment Tool is provided in **Section 5**, with details for its application provided in **Section 5.1** and **Section 5.2**. The tool enables a semi-quantitative assessment of O&C risk levels for the sewerage assets within the scope boundary as defined in Step 1 and informs appropriate mitigations commensurate with the assessed risk level.
- The Tool is to be applied without pre-empting potential mitigations, e.g. in the absence of AC vessels for the treatment of vented gases, to avoid the likelihood of implementation of mitigations (beyond the minimum design rules) which are not warranted or commensurate with the O&C risk level.

Step 5: Determine appropriate design changes and/or mitigations

- For ‘medium’ or ‘high’ risks, appropriate design changes and/or mitigations are to be applied to the development designs to achieve either 'very low' or 'low' risk ratings (outputs from the Tool).
- Details of appropriate mitigations are set out in **Section 6**.

Step 6: Reassessment of risk level with design changes and/or mitigations applied

- Use the Risk Assessment Tool to re-assess risk levels with the implementation of proposed O&C mitigations, e.g. AC filters for gas releases at vents and the use of non-corrodible materials, to achieve either ‘very low’ or ‘low’ O&C risk ratings, or until an acceptable risk level is achieved as agreed with SA Water.

Step 7: Reporting

- Collate the project information as set out in **Section 7** and submit to SA Water.

Step 8: Performance assessment post implementation

- For some projects, it is anticipated that SA Water will elect to undertake or will require third parties to undertake (e.g. for projects with elevated O&C risks) performance assessments following implementation of the new infrastructure. Details of performance assessment requirements are set out in **Section 8**. The Contractor will be responsible for rectifying any performance non-compliance.

The assessment is to be undertaken at each critical design stage through the development of the project as set out in the projects agreed Design Management Plan, or nominally as indicated in TS 0104 Design quality management. The key design review stages are typically:

a. Concept design / 30% design

b. 60% design

c. 90% design

d. Issued for construction (IFC).

Where there are minimal changes to the O&C assessment from one design gate to the next, this is to be noted in the report submitted to SA Water (see Section 7). It is anticipated that following the initial O&C risk assessment undertaken and submitted at the concept design phase, the subsequent assessments will typically be minor updates to the initial assessment to reflect any changes in the design of the new development (residential, commercial or industrial). Where there are no changes to the development design which have potential to affect the O&C risks, this is to be documented and submitted to SA Water. In this case, re-assessment of O&C risks, i.e. as set out in the steps below, would not be required. SA Water may require additional gates during the design development phase if it considers that this is warranted based on the odour and corrosion risks to be managed.

An overarching theme of the O&C assessment approach and associated risk management shown in Figure 2-1 is to adopt design features for the proposed new sewerage infrastructure which minimise the risks of H_2S generation. This reduces the likelihood of requiring O&C mitigations to be installed, thereby avoiding unnecessary assets and associated costs (capital and ongoing). This approach is described by the 'hierarchy of controls', as depicted in Figure whereby O&C controls are implemented in the following hierarchical order where possible:

1. Limit input of precursors (conditions/constituents that promote sulphide generation mainly associated with trade waste), where within the development scope of works.
2. Limit sulphide generation in sewer networks (managing residence times where possible in GMs or PMs).
3. Limit H_2S transfer from the liquid phase to the gas phase (e.g. low sewage pH will accelerate the release of H_2S to head space as will turbulence associated with steep grades, drop structures or bends).
4. Management of gas phase H_2S concentration (e.g. diluted through forced ventilation with odorous gas treatment).
5. Management of Corrosion (e.g. corrosion resistant materials of construction).
6. Management of release of gas phase H_2S to atmosphere and sensitive environment (limit odours).

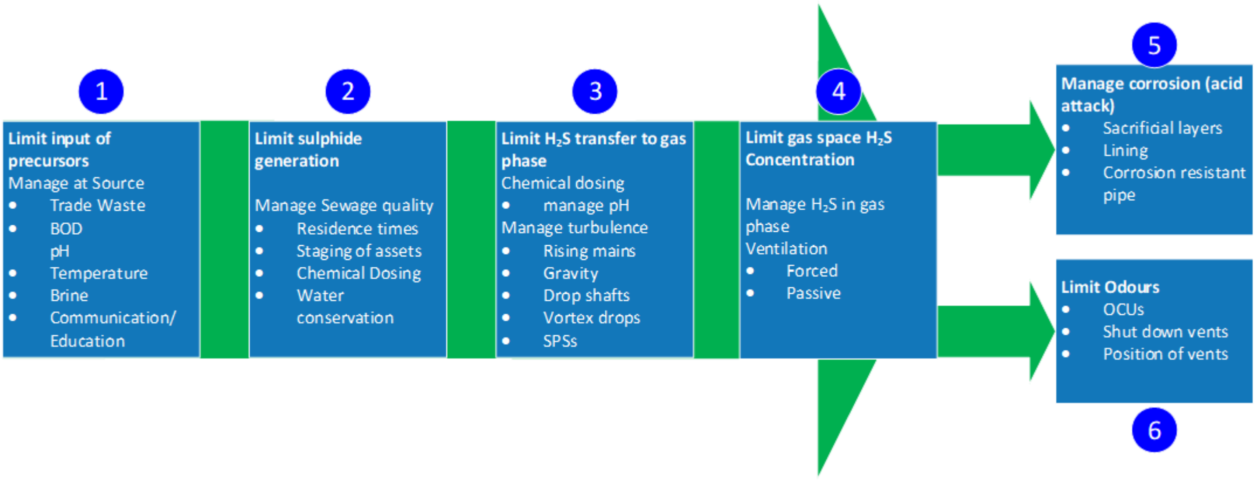


Figure 4-1: Hierarchy of Controls for Corrosion and Odour Management

Items 1, 2 and 3, i.e. limiting sulphide generation by managing sewage quality and managing turbulence, are described by the minimum design rules set out in Section 3.

4.2 Odour and Corrosion Performance Objectives

Defining targets for sewer gas and liquid phase qualities is important for the assessment of O&C risks for new and existing sewerage assets. The proposed lead indicators for O&C risks are summarised in Table 3. These represent thresholds for H_2S gas concentration in sewer gas spaces, e.g., in gravity mains, and dissolved sulphide (DS) concentrations in the sewage liquid phase, ***above which elevated O&C risks could be expected***.

The liquid and gas phase targets have been used to inform the minimum design rules and mitigations. For projects initially assessed as 'high' risk, the targets are to be applied as part of the performance assessment process (as determined by Level 2 assessment), involving collection of liquid and gas phase sampling data. The developer/designer may also use the values to guide their proposed infrastructure design, noting that the underlying requirements are compliance with the minimum design rules (as per Section 3) and mitigations as required by the O&C Risk Assessment Tool, as per Section 5.

Table 3: Odour and corrosion management targets

Parameter	H_2S gas concentration in sewer gas space (ppm)	Dissolved sulphide concentration in sewage (mg/L)
Odour	< 10 (peak / 90th percentile)	≤ 0.5
Corrosion	≤ 5 (average)	≤ 0.5

4.3 Establishing the Boundary of Assessment

Identifying the physical boundary of the sewerage infrastructure to be assessed is a critical initial step and is to be undertaken by the Designer. This sets the scope of work and defines all infrastructure/equipment to be included in the O&C risk assessment. To ensure impacts from existing infrastructure upstream of the development, and impacts to existing infrastructure downstream of the development, are considered the boundary of the assessment is to be defined to include:

- The new development infrastructure assets
- A minimum of 300 metres of the existing sewer downstream of the proposed connection point; and
- A minimum of 100 metres upstream of the proposed connection point (as appropriate).

An example of the selection of the boundary of assessment is shown in Figure .

The upstream aspects to be considered by the Designer are expected to include, as a minimum, aggregate hydraulic retention times (HRTs) under different operating scenarios (initial flows and ultimate flows). It is anticipated that high level estimates shall be made by the Designer using available information. This could include using publicly available SA Water asset maps to understand the extent of existing upstream infrastructure (sewer routes, sizes, and materials) and sewage flow data provided by SA Water. Undertaking of hydraulic modelling to obtain HRT data for upstream networks is not expected to be required.

Where available, sewer liquid phase and gas phase quality information (sewage dissolved sulphide concentration, sewer gas space H_2S concentration) at the proposed upstream and downstream connection points is to be reviewed by the Designer to gain an understanding of the potential extent of sewage septicity. This information is to be sourced from SA Water via 'Request for Information' process (see further details in Section 4.4 below).

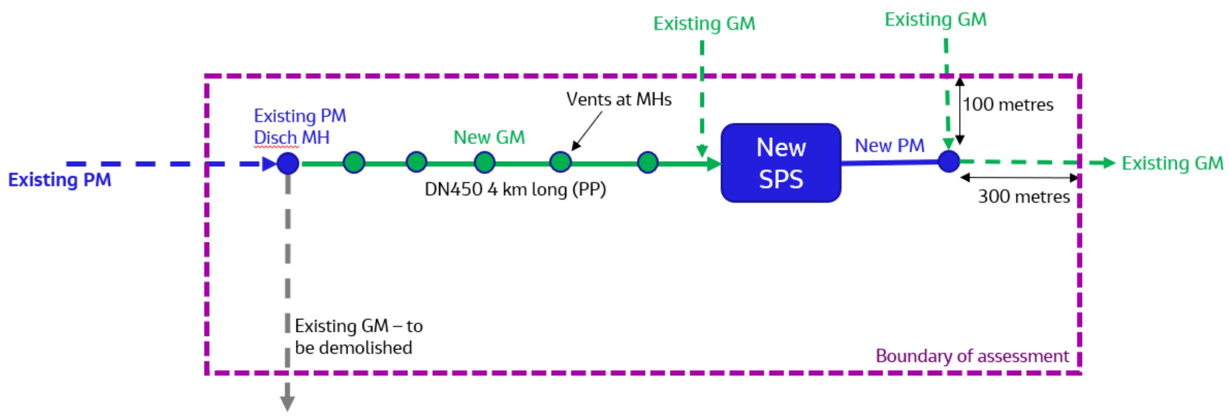


Figure 4-2: Example of selection of project boundary of assessment

4.4 System design basis

Following the definition of the boundary of assessment, the design basis information for the project scope of works, i.e. within the assessment boundary, is to be collated.

These information inputs are set out in Table 4.

Table 4: Design Basis Inputs and Information Sources

ID	Input Information	Source of Information
1	Key features of the new infrastructure, e.g. sewage pump stations (SPS), pressure mains, gravity mains, maintenance holes, and any special items (e.g. barometric loops, vacuum pump systems, low pressure sewer units).	Designer
2	Proposed development infrastructure design, i.e. pipe lengths, sizes, and materials.	Designer
3	Pipe route alignment and elevation profile, including extent and location of any drops.	Designer
4	Hydraulic information including average dry weather flows (ADWF), peak wet weather flows (PWWF) and pump rates for each of the operating scenarios to be assessed. It is expected that the initial development and ultimate development flow scenarios will be assessed, as a minimum.[3] Estimates of HRT (see Appendix A: Calculation of HRT for calculation guidance) for SPS wet wells, PMs (including stagnant periods when not pumping) and GMs, and sewer pipe velocities, for initial and ultimate development, will be required as inputs for the O&C risk assessment.	Designer (or the Designer's 3rd party contractor) To be consistent with SA Water's standard approach to hydraulic assessments for sewerage infrastructure (e.g. setting out requirements for estimating initial and future sewage flows based on populations serviced).
5	Details of upstream and downstream existing sewerage infrastructure connection points, including connecting pipe configurations and materials.[4] In addition, the Designer is to undertake estimates of aggregate HRT under different operating conditions for the upstream network, at the proposed connection point to the new development infrastructure. This information is to be applied by the Designer as an input to the O&C Risk Assessment Tool.	The upstream and downstream infrastructure details including sewer routes, sizes, and materials can be obtained by the Designer from SA Water's online asset mapping tool (AquaMap) and sewage flow data can be provided by SA Water (by submission of a 'Request for Information' to SA Water).
6	Details of any O&C issues/information for existing infrastructure up and/or downstream of proposed new infrastructure, including asset failures, odour complaints, H_2S (g) measurement data, sewage quality data. This information is to be used by the Designer as inputs to the O&C Risk Assessment Tool.	Sourced from SA Water Note that the availability of the information will be dependent on the application.

[3] Where the ultimate development flow rate is within 20% of the initial flow rates, only the lower flow rate of the two scenarios requires assessment.
[4] Understanding the materials of the upstream sewerage infrastructure is important because although non-corrodible sewers, e.g. plastic lined or GRP, can offer assets with long term high durability, they also readily transfer H_2S (g) and odour to downstream assets due to the low porosity of these materials. Similarly, understanding materials of the downstream network allows the Designer to consider risks which may be transferred to downstream assets from the implementation of the new development infrastructure.

ID	Input Information	Source of Information
7	Trade waste discharge information upstream and/or within the scope of works, including industry type and number of industrial discharges, quantity and quality (where available). Trade waste information, for both existing and new assets, where relevant, is an input to the O&C Risk Assessment Tool.	Trade waste information for discharges upstream of the proposed development works can be sourced from SA Water where available. Any trade waste discharges proposed as part of the development works within the boundary of assessment are to be provided by the Designer. Depending on the stage of the design, the Designer may also need to submit separate Trade Waste discharge application requests to SA Water.
8	Details of nearest sensitive receptors within the boundary of assessment – receptor type (residential, industrial, other as defined in SA Water's list of sensitive receptors), and distance from new assets. Applies to both existing and future receptors. Planning information within and adjacent to the boundary of assessment, e.g. from the South Australia Property and Planning Atlas (SAPPA).	Designer (from publicly available web-based mapping services, e.g. Google Maps). SAPPA website: https://sappa.plan.sa.gov.au/
9	Details of nearest sensitive receptors (as defined in Section 1.5) outside and adjacent to the boundary of assessment, and within 100 metres of newly installed assets, who could be impacted, e.g. where new assets will be located within 100 metres to existing and/or potential future sensitive receptors – receptor type (residential, industrial, etc.) and distance from new assets. This also applies to new sensitive receptors to be located as part of a proposed development, i.e. the scope of work, within 100 metres of existing sewerage infrastructure.	Designer (from publicly available web-based mapping services, e.g. Google Maps)

The Designer may need to source some of these inputs, where noted, from SA Water. This can be done by submission on a 'Request for Information' (RFI), emailed to SA Water's Representative.

5 O&C Risk Assessment Tool

The Odour and Corrosion (O&C) Risk Assessment Tool is a support tool for the semi-quantitative assessment of O&C risks for sewerage network infrastructure. The key objective of the Tool is to guide the selection of appropriate design features and mitigations, based on risk levels, to effectively manage O&C risks for new sewerage assets when connecting to SA Water's existing network. In addition, the Tool can be used by developers to assess odour risks for new residential properties (implemented as part of developments), which are in proximity to existing sewerage infrastructure.

The O&C Risk Assessment Tool is an integral component of the overall O&C risk assessment approach for SA Water's sewer networks. The process constitutes **three assessment 'gates'** (Level 1, Level 2 and Level 3) where specific information is collected and used to determine if further and more detailed assessment is required (in moving from the Level 1 gate assessment to the Level 2 or Level 3 gates assessments).

The outputs of the Tool for the Level 2 gate are assigned one of four risk levels, i.e. from 'very low' through to 'high', as per Figure 5-1. The resulting risk level informs the extent of O&C mitigation to be applied and/or adjustment of asset designs. Where there are elevated risks, i.e. for 'medium' and 'high' risks, mitigations and/or design adjustments are to be made and the assessment process repeated. Where the Level 2 risk assessment is and/or remains at a 'high' risk rating a detailed Level 3 gate assessment is required.

Only systems which are assigned a 'very low' or 'low' risk rating after this gated assessment process will be acceptable to SA Water.

An overview of the Risk Assessment Tool is shown in Figure 5-1, with details of the assessment gates set out in Sections 5.1, 5.2 and 5.3.

Examples of the application of the O&C Risk Assessment Tool are provided in **Appendix B**.

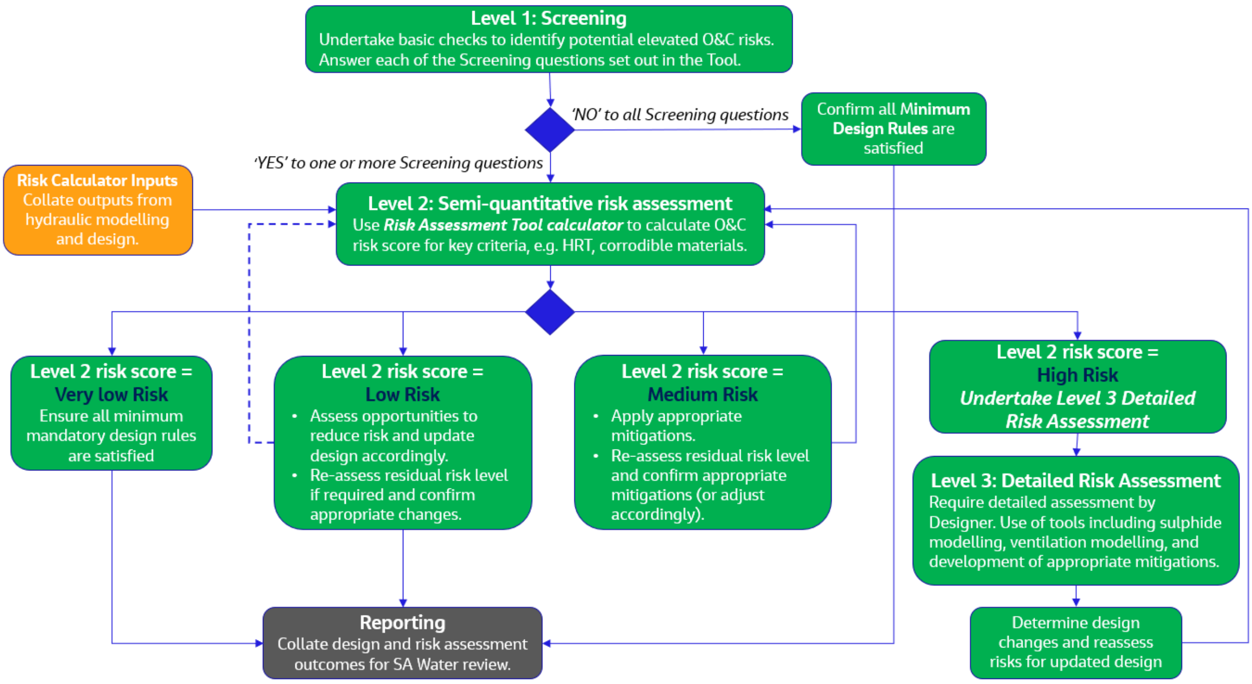


Figure 5-1: Overview of Risk Assessment Tool

5.1 Level 1 Assessment

The Level 1 assessment consists of basic screening and testing to identify any risk 'triggers' for the sewerage infrastructure within the scope of the development works. The testing involves answering a series of questions, as 'YES' or 'NO' which indicate whether there are materially elevated O&C risks that warrant more detailed assessment.

If no risk triggers are identified, there is no need to progress to a Level 2 assessment. In such cases prima facie, no special conditions related to the management of O&C issues are required for application approval by SA Water.

If risk triggers are identified in this Level 1 gate assessment, the user is to progress to a Level 2 assessment.

Examples of the questions include:

- Is the individual asset HRT greater than 2 hours for any of the PM/SPS, based on ADWF at any stage of development
- Are there any deviations to applicable minimum design rules as set out in the Odour and Corrosion Technical Standard (this Standard)?

If the information is not known or not available, an "Unknown" response is to be provided. If the screening question is not applicable to the project design, the response is "N/A". In such instances a Level 2 risk assessment is automatically triggered.

For some questions, the input information may need to be obtained from SA Water, as described in Section 4.4. The Designer is to instigate this by submission of a 'Request for Information' (RFI) to SA Water, noting that the availability of the information will be dependent on the application. The Designer is to use the information received to populate and complete the Level 1 screening assessment.

The outcomes from the Level 1 assessment are to be documented (as set out in Section 7) and submitted to SA Water for review and approval.

5.2 Level 2 Assessment

The Level 2 assessment is the major focus of the O&C Risk Assessment Tool and requires the collection and input of hydraulic and design data for the proposed new infrastructure into the Level 2 Calculator incorporated in the Tool. It is expected that this information will mostly be outputs from hydraulic design calculations undertaken by the Designer, however, as for the Level 1 Assessment, there will be inputs which the Designer will need to obtain from SA Water by submission of an RFI. These items are as indicated in the Tool Level 2 Assessment.

Where no information is available, the user is to enter 'N/A' (either text input or via the drop-down menus where relevant). Where information is not available, the Tool removes the parameter from the calculation such that the aggregate risk score is not influenced by the absence of data. However, where a minimum number of entries are not available, the Tool output will indicate 'Not enough data', and a Level 3 assessment is to be undertaken as a default position.

The Level 2 Tool calculator applies a risk score based on the input value for each of the risk criteria and determines an overall score and a subsequent O&C risk ranking. The risk rank output of the Tool informs the appropriate design features to be applied and/or minimum level of mitigations to be implemented, with guidance for the appropriate mitigations provided in Section 6 of this document.

For some input parameters, higher weightings are applied where those parameters are deemed to have a greater influence on overall potential O&C risk. These parameters are:

a. Hydraulic residence time (HRT) - for each of initial flow and ultimate development sewage flow scenarios.

b. Number of sewage pumping stations (SPS) upstream of the proposed development infrastructure, i.e. extent of daisy-chaining.

c. Distance from vent/release point to closest sensitive receptor.

This risk factor, with scores relating to the distance (in metres) between the emission point to the receptor site, applies a simplistic approach for the purposes of Tool. Other factors which would typically be considered in a detailed assessment include elements of 'a FIDOL' approach, i.e. considering *frequency* of exposure to odour emissions, *intensity*, *duration*, *offensiveness* and *location* of the odour emission (in relation to the sensitive receptor location).

In addition to the design of new sewerage infrastructure, this parameter is also important when considering potential odour risks for planned new residential properties which are in proximity to existing sewerage infrastructure, especially pump stations.

- Materials of system construction.
- Pressure main (PM) discharge maintenance hole configuration.

Although the focus of the Tool is new sewerage assets as part of a new development, consideration of upstream risks, which could act to worsen the risks at and downstream of the new development assets, will be important. The Tool incorporates a risk criterion for the Level 2 assessment which addresses HRT in upstream gravity systems on an aggregate basis. Where the input information for this criterion is not available the Designer should include a qualitative discussion of risks in the Report for SA Water to consider as part of the overall O&C risk assessment supporting the developer application.

The outputs of the Level 2 assessment provided in the Tool indicate the overall risk rating consistent with SA Water's risk categories as summarised in Table 5.

Table 5: Summary of Level 2 Risk Ranking and Actions

Level 2 Risk Rating	Required actions
Very low risk	No further assessment. Ensure all minimum mandatory design rules are satisfied and provide Summary report to SA Water (see Section 7).
Low risk	Assess opportunities to reduce risks by adjustments to design (or mitigations) and update design accordingly as informed by this Technical Standard. This is to be demonstrated and documented in the reporting. Re-assess residual risk level, confirm appropriate mitigations. See Section 6 of this Standard for appropriate mitigations to address risks for different assets.
Medium risk	Apply appropriate O&C mitigations, as set out in Section 6 of this Standard. Re-assess residual risk level, confirm appropriate mitigations. See Section 6 of this Standard for appropriate mitigations to address risks for different assets.
High risk	Further detailed assessment as set out in Level 3 (Section 5.3) is required.

Where the Level 2 assessment risk rating is 'Medium', further work and design revisions are required to reduce risk levels to either 'Very Low' or 'Low'.

Where the risk level is 'High', a Level 3 assessment and further detailed investigation is required to be undertaken in conjunction with SA Water, including selection of appropriate mitigations and/or design changes, to reduce the risk level to an acceptable level as determined by SA Water.

Only sewerage infrastructure for new developments with a Level 2 risk rating of 'Very Low' or 'Low' will be acceptable to SA Water, i.e. in the absence of plans for design improvements and/or implementation of mitigations. For some applications, ‘Low’ risk rankings may require some additional or changed design parameters to further reduce risk where practical to do so and as determined by SA Water.

5.3 Level 3 Assessment

Level 3 assessments are to be undertaken where the risk ranking output from the Level 2 O&C Risk Tool calculator indicates a 'High' risk rating.

These applications typically occur where there are extended sewage residence times, turbulence and/or contribution of significant flows to downstream assets. They can also involve more complex issues such as atypical sewage quality, e.g. due to significant seawater ingress, trade waste impacts.

Level 3 assessments may also be required where there is insufficient data available to reliably establish the O&C risk level.

The Level 3 assessment is a detailed assessment and should be undertaken on a more systemic basis (or at least linked with sewerage system-based planning undertaken by SA Water). It could involve one or more of the activities shown in Table 6.

The overarching aims of the Level 3 assessment is to obtain sufficient detailed understanding of the potential impacts of the proposed new development, within the development scope of work, and for downstream existing assets, such that 'fit for purpose' mitigations and necessary design changes can be implemented for the continuous effective management of O&C risks introduced by the proposed new development.

The Designer is to develop a plan for the Level 3 assessment for submission to SA Water for approval. The plan is to set out (in addition to the information collected in Section 4.3 and 4.4):

a. The O&C objectives of the Level 3 detailed assessment.

b. The Level 3 activities to be undertaken as part of the detailed assessment, i.e. informed by Table 6, to address information gaps and/or identified high risk aspects of the proposed development. Other activities can be nominated and detailed by the Designer where relevant and justified.

c. Proposed methodology for each of the Level 3 assessment activities to be undertaken, e.g. boundary of the detailed assessment, modelling software to be applied and scenarios to be tested, and any engagement of odour specialists.

d. Details of how the findings of the Level 3 assessment activities will be used to ultimately reduce the O&C risk level for the proposed development to 'low' or 'very low' as defined in the Level 2 assessment.

Table 6: Level 3 assessment activities

Level 3 assessment activity	Description	Examples of application and tools
Gas and liquid phase monitoring	Monitoring of gas and liquid data in upstream and downstream networks, i.e. up and downstream of proposed new connections. This information assists in understanding the existing O&C risks, thereby informing potential changes with implementation of new development, as well as providing baseline data. It is expected that this will be the responsibility of SA Water.	Installation of H_2S gas sensors for continuous monitoring of H_2S (g) concentration at upstream and downstream connection points (for proposed new assets). Spot sampling of liquid at upstream and downstream connection points for testing of dissolved sulphide, pH, BOD, ORP and sulphates.

Level 3 assessment activity	Description	Examples of application and tools
Sulphide modelling	Septicity assessment using sulphide modelling, to estimate key liquid quality parameters (DS, pH, etc.) and sewer gas quality (H_2S gas, relative humidity) for the new development assets. This information provides an indication of potential H_2S (g) concentrations for various locations within the proposed new development, and subsequent potential for odour impact and corrosion risks. Modelling is particularly useful for scopes of works with potential for extended HRTs, e.g. long PMs combined with extended up or downstream gravity networks, or complex systems involving changing sewage quality (trade waste, etc.)	There are various tools for sulphide modelling ranging from basic spreadsheet calculations through to detailed modelling using proprietary software/tools including WATS (Wastewater Aerobic / Anaerobic Transformations in Sewers) and SeweX. This could include assessment of extended regions downstream of the proposed new development infrastructure to consider broader impacts. Modelling can be carried out for various scenarios, e.g. with and without proposed chemical dosing (e.g. ferrous chloride and MHL dosing) mitigations.
Ventilation modelling	Use of software (or spreadsheet tools for simple systems) to estimate sewer gas conditions (gas velocities, pressures, relative humidity, temperature) under natural ventilation and forced ventilation conditions. This allows assessment of potential for fugitive emissions and estimates of dilution of H_2S and odours in the gas phase, for different locations within the proposed new development, and existing downstream assets.	Various tools are available for ventilation modelling, ranging from basic spreadsheet calculations, through to detailed proprietary software such as AFT Arrow. Modelling can be carried out for various scenarios, e.g. with and without proposed forced ventilation and treatment mitigations.
Identification of appropriate mitigation facilities	Optioneering, including financial and whole of life assessments, of identified mitigation options. Potential options include: • Non-corrodible sewer materials • Forced ventilation and treatment of SPSs, gravity sewers, etc. • Chemical dosing, including magnesium hydroxide liquid (MHL), ferrous/ferric chloride dosing, caustic shock dosing Combinations of the above options may also be appropriate.	Involves initial generation of potential mitigation options, e.g. chemical dosing, forced ventilation and odorous air treatment, followed by preliminary design of key features and O&M costs of each mitigation. Semi-qualitative comparison of advantages and disadvantages can be undertaken, e.g. using multi-criteria analysis tools, to identify preferred option(s). Requires financial assessment of whole of life costs using net present cost (NPC) calculations for each short-listed option. Spreadsheet calculations , e.g. chemical dosing at SPS (or gravity mains), forced ventilation of sewers with extracted odorous gas treatment, renewal/rehabilitation of sewers with non-corrodible materials.

Level 3 assessment activity	Description	Examples of application and tools
Air dispersion modelling	Air dispersion modelling to assess impacts of different mitigation options.	Air dispersion modelling of odour (and H_2S) emissions to estimate ambient odour impact (OU at ground level). To be undertaken as set out in SA EPA's 'Ambient air quality assessment' guideline (August 2016). Suitable modelling software includes AERMOD and CALPUFF (with meteorological modelling using WRF, TAPM, CALMET).
Comparison with similar applications	Use examples of existing sewerage infrastructure in SA Water's network, which has comparable design and operating conditions to the proposed new development assets, to assist in informing potential risks and appropriate mitigations. This information is to be sought from SA Water by the Designer. In assessing extent of comparable design and operating conditions, the following attributes as a minimum should be considered: • Sewer pipe surface area to volume ratios and HRT • Sewer elevation profiles and extent of ventilation • Extent of areas with potential turbulence • Influent sewage qualities: COD/BOD, temperature, pH, DS, sulphates • Proximity of infrastructure to sensitive receptors	Information collected from existing and operational sewerage infrastructure which has similar key features to the proposed new development can be useful in understanding likely sewage and sewer gas qualities under different operating conditions, and associated risks. Valuable data includes: • Monitoring data (sewage and sewer gas phase) • Odour complaint history (where available), noting that the absence of odour complaint history does not mean that there is no odour risk. • Asset condition information (condition assessment findings, failure data) • Operator observations (odour, general condition, operability) This information can then be used to develop and justify appropriate mitigations and/or ensure specific design features are adopted to achieve low O&C risk outcomes.

6 Odour and Corrosion Mitigations

6.1 Overview of O&C Mitigations

For the purposes of this Technical Standard, the mitigations are focused on:

1. Activated carbon (AC) gas treatment systems suited to relatively small diameter sewers and assets and/or those with low to medium O&C risks (as identified using the O&C Risk Assessment Tool) and low to moderate H_2S (g) concentrations to be managed, and
2. The use of non-corrodible materials for corrosion protection of key assets.

Although there are many other types of O&C mitigation options available, e.g. chemical dosing, biological gas treatment, these are typically only warranted for the applications with risk assessment outcome of 'high risk'. Selection and development of these more substantial O&C mitigations would be undertaken on a case-by-case basis, in collaboration with SA Water, and in accordance with SA Water's Technical Specification for Bio Trickling Filter, Biofilter and Activated Carbon Polishing Odour Control Unit (SAW-ENG-ODO-MUL-TSB-002).

Where there are larger branch or trunk sewers, or key SPS(s) within SA Water's overall sewerage network, a broad set of mitigation options would be considered by SA Water as part of its overarching master planning and asset management systems.

6.1.1 Activated carbon systems

Activated carbon treatment systems include:

1. Active (or forced) ventilation and treatment – incorporating a mechanical fan to drive air through the activated carbon vessel and vent stack for discharge of treated air to atmosphere, and
2. Passive ventilation and treatment – relying on air movement through the AC vessel by natural ventilation, with the AC bed designed to manage pressure and avoid pressurisation of the sewer. Passive ventilation and treatment systems are **not preferred** and only to be used under a limited set of circumstances, as discussed in Section 6.2.1. The use of a passive ventilation systems requires submission of a Technical Dispensation Request Form (see Section 2.4) and approval by SA Water for all applications except for the treatment of gas from ARVs on pressure mains.

6.1.2 Non-corrodible materials

This mitigation option applies the use of non-corrodible materials, including GRP, PVC, HDPE (structural, lining) in sewer pipes and for key infrastructure items (e.g. SPS wet wells, PM discharge MHs) to minimise the risk of corrosion by H_2S (g) attack.

6.2 Application of O&C Mitigations

O&C mitigations are to be applied when the minimum sewerage infrastructure design requirements have been implemented as far as practicable, and the residual risks for the system within the project boundary have been identified in a Level 2 assessment (from the Risk Assessment Tool) as 'medium' or 'high'. The selection, location and design of the O&C mitigation facility is the responsibility of the Designer/Developer, and this is to be documented for approval by SA Water.

For projects identified as having a Level 2 risk assessment O&C rating as 'low' or 'very low', implementation of O&C mitigations is not specifically required, provided the Designer has ensured that there are no further practical changes that can be made to further reduce and minimise O&C risks. The Designer is to provide justification of any O&C mitigation included in the project scope where risks have been evaluated as 'low' or 'very low' (as per the Risk Assessment Tool output of Level 2 assessment).

For systems identified as having a Level 2 assessment of 'high' risk rating, the appropriate mitigations are to be informed from a detailed assessment as set out under Section 5.3 'Level 3 Assessment' and as agreed with SA Water.

For sewerage infrastructure with Level 2 assessment overall outcomes of ***'medium' (or 'low') risk rating, mitigations are to be applied as informed by the assigned risk level for the individual risk factors set out in the Tool***. For example, where the potential for release of (untreated) sewer gas to atmosphere (risk factor #14 in the Tool) is deemed to be 'medium' or 'high' due to the release of sewer gas via a natural vent at a SPS, an AC treatment system could be applied to effectively manage this risk.

For overall assessment outcomes of 'high' risk, appropriate mitigations may involve more complex designs and infrastructure beyond AC treatment systems, including chemical dosing and forced ventilation with biological treatment vessels. The design and selection of mitigations for these applications is to be undertaken in conjunction with SA Water.

Following the identification of appropriate mitigations (and design changes where necessary), the Tool is to be used again to re-assess the O&C risk level for the project.

The overall intent of applying the mitigations is to reduce the residual risks for the overall system to a Level 2 assessment risk rating of 'very low' or 'low'.

6.2.1 AC Treatment Systems application

AC treatment systems can be applied to reduce the O&C risk levels for the following applications:

1. PM discharge MHs
2. ARV vents
3. SPS wet well, inlet (control) chambers and emergency storage tanks
4. At MH sites which are used to store sewage for collection and transport to treatment plants by trucks, known as tankered waste
5. GM vents
6. Inverted siphons, at upstream leg
7. Barometric legs

Note that minimum design requirements apply to each of these items (as set out in Section 3) and the Designer is to ensure that these have been implemented prior to inclusion of AC treatment systems in the design. For vacuum sewage pump stations, AC treatment systems are not likely to be suitable due to the relatively large volumes of air (often with a high H_2S concentration) which typically occur from these systems. Biological treatment systems, specifically biofilters, are more suited to treat the exhaust gas from vacuum pump stations, noting that the high temperature of the vacuum pump exhaust needs to be suitably managed (e.g. with pre-cooling and/or use of specialised media). As set out in WSA 06-2008, all vacuum pump stations shall have an odour control system installed constituting a soil bed biofilter.

Passive ventilation with treatment systems are not preferred by SA Water. The use of passive AC filters typically results in the sewer air inlet/outlet point acting as a cap due to insufficient driving force to overcome the gas pressure loss across the AC media. The consequence of this is often elevated H_2S and odour concentrations in the sewer gas space at and downstream of the AC filter location, worsening O&C risks.

Passive AC treatment systems are only applicable when there is sufficient gas driving force, e.g. as for ARV vents when pumps are operating. All other applications require active (forced) ventilation. An exception to this may occur where one or more of the following apply:

a. Active ventilation systems are not practical due to power at site not being available and/or insufficient space is available at the site.

b. A feasible location for the vent stack for release of gas from the active treatment system is not available, e.g. due to being adjacent multi-storey residential areas
c. Only temporary O&C mitigation is required, e.g. for a 12-month construction period of a new residential area, after which the sewage flows will be at ultimate (development) design levels.
d. Alternative locations and technology types (e.g. upstream chemical dosing) for treatment are not feasible.

The use of a passive AC filter on top of a vent stack is not considered an effective odour treatment and shall be avoided. Similarly, AC filters with wind assisted fans mounted on top of vent stacks are to be avoided due to poor accessibility for maintenance activities.

Passive AC filters may be suitable for PM discharge MHs with low risks, i.e. where H_2S (g) concentrations are expected to be less than the O&C Performance Objectives as defined in Table 3: Odour and corrosion management targets, and where there is sufficient pressurisation in the discharge MH to overcome the pressure loss across the passive AC filter. With the exception of passive AC filters for ARVs on pressure mains, the Designer is to request specific approval from SA Water for the proposed implementation of passive AC treatment systems.

SA Water's TG 0531 provides guidance for estimating activated carbon service life and this should be used by the Designer to support the documented expected AC vessel media replacement frequency.

Where the H_2S gas concentration at the extraction point is likely to be greater than 10ppm on an average basis, AC systems, either passive or active, may not be suitable, unless the gas flow is low (e.g. for a PM ARV). For these higher H_2S (g) concentrations, the size of the AC vessel and cost of ongoing media replacements often mean the AC systems become uneconomical. For these situations, a case-by-case basis assessment which compares whole of life costs and advantages/ disadvantages for different treatment options is warranted and is to be provided by the Designer.

6.2.2 AC Treatment System Details

This Section sets out key features, design parameters and a list of potential vendors for AC treatment systems.

Active AC treatment

Active AC treatment systems typically include the following key elements:

1. One or more AC vessels containing AC media
2. Fans(s) – duty or duty/standby.
3. Pre-filter (optional)
4. Dehumidifier – electrical inline heater to reduce the humidity of the gas stream prior to entering the AC vessel. Requirement for a dehumidifier will be dependent on the humidity of the gas to be treated, and the type and supplier of the AC treatment unit selected. However typically sewer gas spaces are at or near saturation and dehumidification is required to avoid reduced AC media life expectancy.
5. Vent stack
6. Ductwork from the sewer infrastructure (e.g. from the MH) to the air treatment facility, and that integral to the air treatment facility, including isolation dampers, flexible expansion joints, AC vessel bypass ductwork (if required), and sampling and testing ports (for collection and testing of gas samples and duct flow/velocity measurement).
7. Drainage pipework from AC vessel, fan, vent stack, duct low points to the sewerage infrastructure (e.g. MH or SPS wet well)
8. Instrumentation and controls

9. Sample ports for gas and AC media samples, and for breakthrough (saturation) indicators.

Passive AC treatment

As described in Section 6.2.1, passive AC treatment systems are only suitable for specific and limited applications; they are not to be installed without the review and approval by SA Water.

Passive AC treatment systems include the same elements as for active AC systems, however, will have no fan and typically no vent stack. The required footprint is typically less than that required for an active AC treatment system.

The air path through the AC vessel(s) is driven via natural ventilation and relies on sufficient gas pressure at the sewerage infrastructure extraction point to overcome the pressure loss across the AC treatment system.

Passive AC treatment systems can be installed partially below ground level to minimise adverse visual impacts.

AC air treatment system design parameters

SA Water's internal standard SAW-ENG-ODO-MUL-TSB-002 Technical Specification for Bio Trickling Filter, Biofilter and Activated Carbon Polishing Odour Control Unit, version 1.1 (June 2023), sets out design requirements for AC treatment systems. Any proposed deviations to the Technical Specification shall be justified and documented by the Designer for SA Water review and approval.

The WSAA guideline for potentially explosive atmospheres should also be consulted in the design of an AC air treatment system.

Key design parameters which will typically be requested by the supplier of the AC treatment system to the Designer for selection and sizing include:

1. Details of the asset to be ventilated, e.g. sizing and configuration of the SPS wet well, PM discharge MH, ARV.
2. Estimated H_2S (g) concentration for the extracted gas – average and typical diurnal profile (minimum and maximum concentrations). This is to be estimated by the Designer based on their experience and/or information from other similar applications. The H_2S (g) concentrations at the point of extraction will be dependent on various factors specific to the application, including aggregate upstream HRT (and relative HRTs for gravity and pressure sewers), extent of ventilation (upstream and at the extraction point), sewage quality (domestic, industrial) and extent of liquid turbulence. As a general guide, the indicative H_2S (g) concentrations could be expected in the asset gas space (in the absence of forced ventilation) are provided in Table 7.

Table 7: Indicative H_2S gas concentrations, based on HRT and turbulence

Aggregate upstream HRT (hours)	H_2S gas concentration (ppm)	
	Average	Peak
0 – 2	3 - 4	20
2 – 4	10	40
>4	20	>70

Note that for the figures presented in Table 7:

a) The H_2S concentration values are provided **for general guidance and design checks only**.

b) The H_2S concentration values are estimates based on selected ratio of HRT for the GM and PM systems. Increasing the ratio of the length of the PM to the aggregate GM length, for example, would increase the H_2S values shown. The majority of the sulphide is generated in the PM. For the values provided, the PM length varies from approximately 100 metres for the 0 – 2 hours HRT category, up to approximately 1200 metres. Similarly, changing diameter of the sewer (and maintaining the same HRT) will impact the estimated H_2S concentrations, with larger diameters resulting in lower H_2S concentration, and vice versa.

c) The values represent H_2S concentrations for quiescent flow. With turbulence, the concentrations may be up to 2 to 2.5 times these values.

d) The H_2S concentrations represent those in gas spaces with no/little ventilation. The Designer is to allow for impacts of forced ventilation (both dilution and stripping) and incorporate adequate factors of safety to address the level of uncertainty.

e) The H_2S concentrations are representative of domestic sewage. Values may be different where the sewage quality is influenced by industrial sewage inputs.

f) The values assume that there are no upstream odour mitigations, e.g. chemical dosing.

3. Gas flow rate, relative humidity and temperature of gas in the sewer at the extraction point. This should be provided by the Designer for different operating conditions, e.g. average and peak sewage flows/levels in the sewerage asset.

   Guidance for suitable ventilation design rates for different assets is provided in SA Water's TG 0531. There are different approaches which can be used for the establishment of suitable ventilation gas flow rates. These include gas flow rates based on a target number of air changes per hour under different wet well operating levels, and/or target gas flux rates (i.e. air flowrate per m^2 of liquid surface area), or based on pumping rate for the PM discharge MH. The treatment system vendor may also provide guidance where required.

4. Gas target pressure in the sewer at the extraction point. Gas pressure targets for active AC systems must be clearly specified by the Designer to ensure the AC fan and system design is sufficient to maintain a continuous vacuum in the sewerage asset to be ventilated. Typically, a target pressure of lower (more negative) than -20Pa (gauge) is required to ensure effective capture of foul air (and avoidance of fugitive leaks).

   For passive AC systems, the supply gas pressure specified at the sewerage asset is important such that the supplier can design the AC media bed to ensure the design target gas flow rate can be met, i.e. so that the pressure loss across the AC media bed and other equipment can be accommodated at the design gas flow rate. Where the pressure loss across the AC treatment unit is higher than anticipated (at any stage of the design life of the AC unit), the gas flow will be less than target. In some cases, the gas flow can be at or near zero, e.g. due to fouling of the AC media; the AC unit acts essentially as a 'cap' and foul air transfers further downstream in the sewer network.

5. Minimum requirements for the AC treatment system outlet gas quality, e.g. maximum allowable $H_2S(g)$ concentration and OU levels. This will typically be set at 0.05ppm H_2S and 500 OU. For Level 2 'high' O&C risk rating applications, the outlet gas quality limits can be determined by odour dispersion modelling (see Table 6).

6. Indication of presence of other odorous gas compounds, i.e. other reduced sulphides (especially methyl mercaptan concentration), VOCs, ammonia. This is to be estimated by the Designer, based on experience and/or information from other similar applications. Where necessary, gas sampling and testing at existing sewerage infrastructure sites may be warranted. Where the Designer is working on behalf of a Developer, requests can be submitted to SA Water (with 4 to 6 weeks' notice) to undertake the sampling. Elevated levels of VOCs (e.g. ketones) and methane can indicate the potential for fire/explosion risks, and a hazardous area assessment may need to be undertaken.

7. Required minimum life of the AC media, i.e. minimum acceptable media replacement period. This is typically 2 years, to avoid excessive maintenance requirements (and community disruption). Media life periods less than 24 months may be allowable, at the discretion of SA Water, where the size of the AC treatment system is limited due to available footprint at the site.
8. Available space for the AC treatment system.
9. Availability and location of power and water supply.
10. Requirements for extent of monitoring and telemetry integration.
11. Preferred arrangement for capture and handling of the condensate (low pH liquid from ducts, fan, vessels, etc.).
12. Any limits on noise at the site. For active AC systems, acoustic enclosures and/or inlet and outlet silencers may be required where there are limits on fan noise, e.g. due to adjacent sensitive receptors.
13. Vent stack requirements. Design to be according to SA Water's standard SCM drawing 4005-20007-06. Educt vent stacks are to be 15 metres tall (above finished ground level), free standing (i.e. no guy wires) with a minimum diameter of 300mm, exit velocity of not less than 15m/s (i.e. stack cone exit velocity), and constructed from either GRP or stainless steel.
14. Hazardous area information for the protection of the proposed AC treatment facility, e.g. in the case of the potential for presence of elevated methane gas concentrations in the sewer gas, to inform the specification of electrical equipment (fans and instrumentation). Note: AC treatment is not an effective means of removing methane from sewer gas.

The vendor will use this information to select and design the appropriate AC treatment system. Key design parameters which are typically applied by the vendor to select the appropriate media type, configuration and size of the AC treatment system include:

a. Inlet gas design basis which sets out gas flow rate, H_2S levels, supply gas pressure, etc., as informed by design parameters provided by the Designer listed above.
b. Outlet gas quality requirements.
c. Empty bed residence time for the AC media.
d. This is typically a minimum of 4 seconds for stand-alone AC vessels, i.e. no upstream treatment stage (not acting as a 'polisher'). The SA Water Specification SAW-ENG-ODO-MUL-TSB-002 specifies a minimum of 3 seconds for a polishing AC unit, i.e. for an AC unit having one or more treatment stages upstream of the AC vessel(s).
e. AC media superficial gas velocity.
f. The diameter of the AC vessel will be set such that the gas velocity should be less than 0.25m/s to prevent excessive pressure loss and to avoid carry-over of the media with the gas stream.
g. Pressure loss per metre of AC media.
h. Different AC media types will have different pressure loss profiles (i.e. pressure loss and gas flow rate). This will affect the sizing of the fan for active AC treatment systems or will affect the achievable gas flow rate through the AC treatment system for the natural ventilation case.
i. Minimum AC media life, as informed by design parameters provided by the Designer (listed above).
j. AC media type and adsorption capacity for different gas phase contaminants. The vendor will select the AC media type based on the inlet gas phase contaminant concentrations. Different media types are available and can include virgin carbon (non-impregnated) and chemically impregnated activated carbon (e.g. impregnated with NaOH, KOH, KI).

AC treatment system service providers

There are numerous vendors which can provide AC treatment systems, ranging from small 'off the shelf' package units complete with all mechanical elements and I&C for monitoring, through to bespoke systems with design tailored to the specific application. Services typically include detailed design, construction, commissioning and performance testing.

A list of potential suppliers for AC treatment systems is included in TG 0531. Many of these suppliers also offer other O&C mitigation technologies, both gas phase and liquid phase treatment.

The Designer is to identify appropriate vendor(s) and system design based on consideration of:

1. Technical performance.
2. Reliability and operability.
3. OH&S.
4. Sustainability.
5. Whole of life costs.

6.2.3 Non-Corrodible Materials

Where elevated H_2S (g) concentration in sewer gas spaces is expected to occur (i.e. higher than 5ppm average as set out in the O&C Performance objectives), assets should be designed with non-corrodible materials to reduce asset corrosion risk levels. There are various corrosion resistant materials and methods available, each with different advantages and disadvantages. The more common non-corrodible materials include:

1. Fibreglass (GRP / FRP) – for gravity sewer infrastructure only (not permitted for pressurised systems)
2. PVC, HDPE, PP and PE
3. Polyurea (EUH), vinyl ester or epoxy lined equipment / infrastructure

The Designer is to select the appropriate material based on suitability for the specific application and provide details in documentation for SA Water review.

Where new gravity mains are plastic and materials with low porosity are selected, there is likely to be an increased risk of transfer of H_2S/odour to downstream assets. The adsorption of H_2S (g) by these materials is significantly less than would occur for conventional concrete pipelines, and instead the H_2S (g) is more readily transferred to downstream assets. Potential O&C impacts for these downstream assets will need to be considered and the Designer is to highlight any changes to risks for existing infrastructure in its reporting.

6.2.4 Other O&C Mitigation Technologies

Other mitigation technologies which are typically used for larger systems and/or for systems with high risks include:

Gas phase technologies

1. Chemical scrubbing systems
2. Biotrickling filter systems
3. Biofilters

The above systems are typically combined with activated carbon treatment for polishing, i.e. as a final treatment stage.

Liquid phase technologies

Chemical dosing systems which can apply dosing of a selected chemical:

1. Magnesium hydroxide liquid (MHL)
2. Ferric or ferrous chloride
3. Calcium nitrate
4. Sodium hydroxide – continuous or shock dosing

The above gas and liquid phase technology lists represent the more typical treatments applied. There are other technologies available which are not as widely applied, e.g. ozone injection for the gas phase, and chemical dosing using biocide shock dosing or oxygen injection for the liquid phase. These less common technologies would not be recommended for implementation as part of new developments without SA Water's specific direction.

The selection of the preferred O&C mitigation technology for the larger systems and/or those with high O&C risks is dependent on the application. Typically, an options assessment would be undertaken, with assessment of technical performance, operability, health, safety and environment, and whole of life costs, to determine the preferred mitigation approach. This preferred approach would need to be reviewed by SA Water and necessary approval obtained.

7 Reporting

The Designer shall submit an 'Odour and Corrosion Risk Assessment Report' as part of the initial concept design of the network development project to SA Water for review and approval (or otherwise).

For every key update to the design through the project development, the Designer shall update the Odour and Corrosion Risk Assessment Report to reflect any changes to the proposed O&C odour risk assessment and associated mitigations as outlined in Section 4.1.

The 'Odour and Corrosion Risk Assessment Report' shall provide a brief summary of the following key items for SA Water review and approval:

1. Project overview, including location and objectives (overall project objectives, and specific O&C design objectives) of the sewerage system development project and the relevant design phase (concept, 90% design, etc.).
2. Boundary of assessment – physical boundary of scope of work (refer Section 4.3).
3. System design basis – elements as described in Section 4.4. Include details of key infrastructure and identified O&C risk areas.
4. Overview of outcomes from application of the O&C risk assessment Tool, i.e. provide summary tables for Level 1 risk assessment and Level 2 risk assessment (copied from the spreadsheet).
5. Where O&C mitigations are proposed for development projects by the Designer, i.e. to reduce O&C risks as informed by the O&C Risk Assessment Tool to 'low' or 'very low', the Designer shall document the proposed mitigation(s) for SA Water approval. This is to include details of risk levels before and after implementation of the mitigations. For all O&C mitigations proposed, the Designer shall provide details of the mitigations including, for example:
6. Details of new active AC treatment system at a PM discharge MH, including: AC vessel size, media type and volume, design media replacement frequency, fan capacity, target suction pressure at the point of air extraction from the relevant MH, fan power draw, vent stack height, materials of construction, and other data as set out in Section 6.2.2.
7. AC vessel sizing calculations (where relevant), including design adsorption capacity for H_2S, other reduced sulphides and VOCs.
8. Details of proposed new sewerage asset materials, e.g. PM material, SPS wet well materials, GM and MH materials.
9. Where the O&C Risk Assessment Tool has identified the project has a Level 2 'high' risk rating , the report shall document the proposed plan for the Level 3 assessment activities to be undertaken, as set out in Section 5.3. Subsequent implementation and documentation of the Level 3 assessment plan will be done as part of a separate report, as agreed with SA Water.
10. Provided as an Attachment to the O&C Risk Assessment report: Copy of completed O&C risk assessment tool spreadsheet (MS Excel), indicating the results of the Level 1 screening test, and if applicable, inputs and outputs for the Level 2 risk assessment.
11. Any supporting information, e.g. sulphide generation calculations, odour complaints data and available monitoring data (for relevant existing sewerage infrastructure), design drawings, hydraulic reports, MCA outcomes, cost reports, to be provided as attachments to the 'O&C Risk Assessment' report.

8 Performance Assessment Post Implementation

Following the commissioning of the new sewerage development infrastructure and associated O&C mitigations (where relevant), SA Water will undertake performance assessment of the new assets. The extent of the testing undertaken as part of the performance assessment shall be determined by SA Water, however, the general approach to the performance assessment and application of the O&C targets is set out below.

For projects identified as having 'medium' O&C risks or lower (from Level 2 risk assessment) – No monitoring is proposed to be undertaken for assessment of installed infrastructure performance in this case, unless specifically identified by SA Water as part of the approval process. Rather performance assessment will be against compliance with the minimum O&C design requirements, as set out in Section 3. The minimum design rules and minimum mitigation requirements established within this Technical Standard have been developed with the network H_2S (g) and DS concentration targets shown in Table 3 forming the underlying design basis.

For projects identified as having 'high' O&C risks (from Level 2 risk assessment) – For these projects field monitoring will be required as stipulated in SA Water's approvals. The threshold H_2S (g) and DS concentration values shown in Table 3 are to be applied to the performance testing assessment of the installed sewerage infrastructure. SA Water will determine the extent of the performance testing, e.g. sampling period, location and number of samples required, and analysis to be undertaken for the liquid and gas phases. The Contractor will be responsible for rectifying any performance non-compliance with the threshold values.

A Calculation of HRT

A1 Single SPS and Pressure Mains

The total HRT (HRT_TOT) for a single SPS with a single PM can be calculated by summing the HRT of the PM (HRT_PM) and the HRT of the SPS wet well (HRT_WW), as follows:

HRT_TOT = HRT_PM + HRT_WW

Where:

- HRT_PM (hours) = Volume of PM (m^3) / ADWF (m^3/hr)
- HRT_WW (hours) = Volume of wet well (m^3) / ADWF (m^3/hr)

The ADWF is the average sewage flow rate entering the SPS (and PM), i.e. on a daily average basis (not the pump rate).

A2 Daisy Chained SPS and Pressure Mains

Where there is more than one SPS in series, i.e. daisy-chained, the total HRT can be calculated by summing the weighted HRTs for the upstream assets. An example of this is set out below.

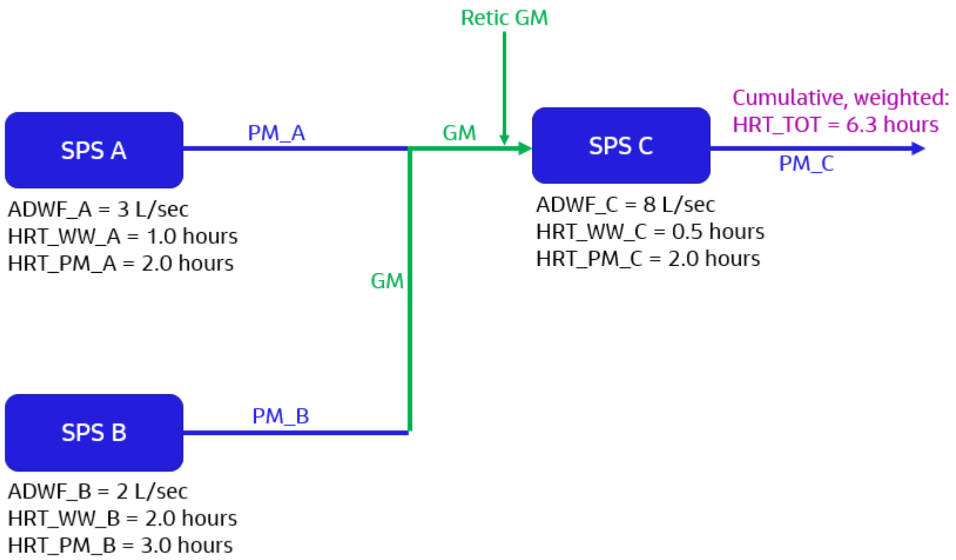


Figure A-1: Example of HRT calculation for daisy chained SPS and PM

The formula for calculation of the total weighted HRT at the discharge of the SPS PM is:

$$\text{HRT\_TOT} = \text{HRT\_C} + \frac{(\text{HRT\_A x ADWF\_A}) + (\text{HRT\_B x ADWF\_B})}{\text{ADWF\_A} + \text{ADWF\_B}}$$

Where

- HRT_A is the sum of the PM HRT and the wet well HRT for SPS A, i.e. HRT_A = HRT_WW_A + HRT_PM_A. Similarly, for SPS B and C.

B Examples of Application of the O&C Risk Assessment Tool

B1 Case Study 1

New sewerage infrastructure required as part of a residential development project in metropolitan Adelaide. The development is a new estate, located adjacent other residential areas, and represents a planned project as set out in SA Water's master plans, i.e. part of a sequenced orderly development plan to accommodate population growth.

A schematic of the development project scope is shown in Figure B-1.

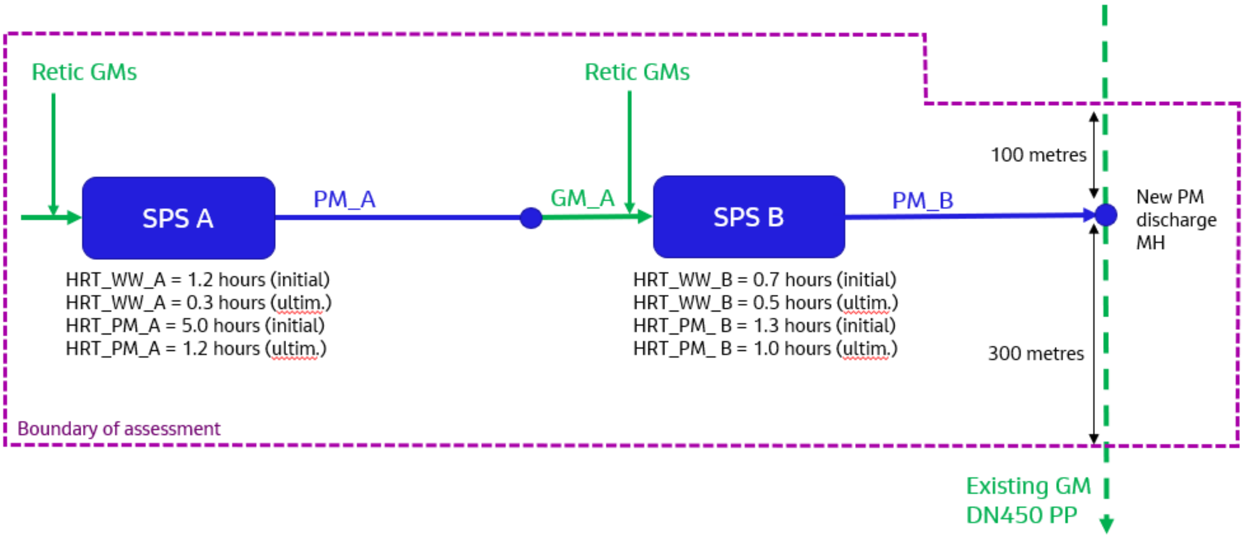


Figure B-1: Case Study 1 schematic

Key project data for the proposed design includes:

- Key infrastructure includes 2 new SPSs, SPS_A and SPS_B, in new residential area, to operate in series. Retention time summary data estimated for the proposed design is shown in Table B-1.
  - SPS_A will service the new residential area only, i.e. receiving influent from a limited reticulated gravity network. It is expected to have very low flows initially, i.e. on commissioning, and then ramping up to ultimate flow rate progressively over the following 5 years.
  - SPS_B will service the new residential area however will also receive some sewage influent from existing adjacent residential areas and therefore changes in HRT are relatively minor between initial and ultimate development.
- The scope of work includes 300 metres of existing GM downstream of the SPS_B PM discharge MH. This is a DN450 GM constructed in polypropylene (PP). The flow rate from the SPS_B PM will be approximately 2% of the total flow along the existing GM to which the new development will discharge.
- The Designer has estimated H_2S (g) levels of up to 40ppm at times from basic sulphide retention time calculations, and from experience from other similar applications.
- The two proposed new PM discharge MHs will be constructed in non-corrodible materials (as agreed with SA Water) with arrangement as per SA Water standard drawing (Figure). There will be a vent stack located on each of the discharge MHs. The vent for SPS_B PM discharge MH will be located within an existing residential area and will be within 70 metres of a new multi-storey apartment complex.
- The two proposed new SPS wet wells, including lids, will be constructed in concrete. All other SPS internal infrastructure and equipment will be non-corrodible.

- There is no TW discharge within or upstream of the scope of work, and no likelihood of seawater ingress.
- The new GM sections downstream of SPS_A and SPS-B will be constructed in PP. Flows at ADWF will be between 1.0 and 1.5m/s. There are no drops along the new GM sections.
- There are no special items with increased O&C risks, e.g. barometric loops, tankered waste.

Table B-1: Case Study 1 SPS and PM HRT information

Parameter	Units	SPS_A and PM	SPS_B and PM
PM and wet well HRT (at ADWF), initial development	hours	6	2
PM and wet well HRT (at ADWF), ultimate development	hours	1.5	1.5

Use of the 'Level 1' inputs indicated that a 'YES' response was provided for at least one of the screening questions, e.g. the first screening question, i.e. 'Is there any daisy chaining of SPS within or upstream of the scope of works?'. As a result, a 'Level 2' assessment is required.

The O&C Risk Assessment Tool inputs for 'Level 2' are shown below. The Level 2 assessment results indicate a 'medium' O&C risk rating for this proposed infrastructure development.

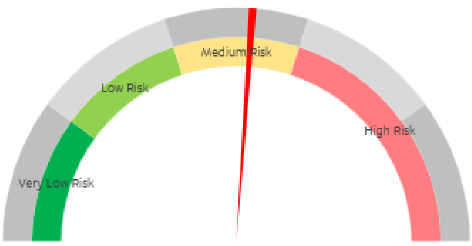
Item No.	Risk Criteria	Units	Inputs
1	Pressure main and SPS wet well HRT (hours), at ultimate development	hours	< 2 hours
2	Pressure main and SPS wet well HRT (hours), at initial development	hours	>= 4 hours
3	Time between pump starts at minimum flow	hours	2.0
4	Number of daisy-chained SPS	no.	2
5	Flow contribution to downstream assets (at connection point with existing assets)	%	2.0
6	Trade waste inputs for new development	-	None
7	Distance from vent/release point to closest sensitive receptor	metres	50 – 100 m
8	Depth of drops for gravity assets	-	No drops
9	Gravity main sewage velocity - maximum	m/s	1.5
10	Gravity main sewage velocity – minimum	m/s	1.0
11	Materials of construction	-	One or more key infrastructure items corrodible, e.g. wet wells, PMs, GMs, MHs
12	Pressure main discharge maintenance hole configuration	-	Compliant with SAW standard drawing 4005-20008-01
13	Potential for sea water ingress to assets within and/or upstream of scope of works	-	No potential for SWI, > 5 km from coast
14	Potential for sewer gas release (untreated) to atmosphere	-	At least one vent with no mitigation and/or an asset known to be poorly sealed.
15	Are there special items with potential for increased O&C risks, e.g. barometric loops, siphons, vacuum sewer units, low pressure sewer units, tankered waste inputs, etc.		No
16	Where available, estimate of sewage DS concentration at downstream end of scope of works	mg/L	2.0
17	Where available, estimate of H_2S (g) concentration of gas at downstream end of scope of works (90th percentile / peak)	ppm	40

Figure B-2: Case Study 1 – Level 2 inputs to O&C Risk Assessment Tool

The Tool Level 2 outputs are shown in Figure B-3. This shows the individual risk rating for each of the risk factors. The overall risk rating for the proposed development is 'medium'.

Item No.	Risk Factor	Units	Inputs	Assigned Risk Level
1	Pressure main and SPS wet well HRT (hours), at ultimate development	hours	< 2 hours	Low
2	Pressure main and SPS wet well HRT (hours), at initial development	hours	>= 4 hours	High
3	Time between pump starts at minimum flow	hours	2.0	Medium
4	Number of daisy-chained SPS	no.	2	Medium
5	Flow contribution to downstream assets (at connection point with existing assets)	%	2	Low
6	Trade waste inputs for new development	-	None	Very low
7	Distance from vent/release point to closest sensitive receptor	metres	50 – 100 m	Medium
8	Depth of drops for gravity assets	-	No drops	Very low
9	Gravity main sewage velocity - maximum	m/s	1.50	Very low
10	Gravity main sewage velocity – minimum	m/s	1.00	Low
11	Materials of construction	-	One or more key infrastructure items corrodible, e.g. wet wells, PMs, GMs, MHs	High
12	Pressure main discharge maintenance hole configuration	-	Compliant with SAW standard drawing 4005-20008-01	Medium
13	Potential for sea water ingress to assets within and/or upstream of scope of works	-	No potential for SWI, > 5 km from coast	Very low
14	Potential for sewer gas release (untreated) to atmosphere	-	At least one vent with no mitigation and/or an asset known to be poorly sealed.	Medium
15	Are there special items with potential for increased O&C risks, e.g., barometric loops, siphons, vacuum sewer units, low pressure sewer units, tankered waste inputs, etc.	-	No	Very low
16	Where available, estimate of sewage DS concentration at downstream end of scope of works	mg/L	2.0	Medium
17	Where available, estimate of H_2S (g) concentration of gas at downstream end of scope of works (90th percentile / peak)	ppm	40	High

Overall Risk Level:	Medium Risk



Odour and Corrosion Risk Score

Figure B-3: O&C Risk Assessment Tool Level 2 outputs for Case Study 1

The Standard requires changes to the proposed development infrastructure design (where practicable in the first instance), and the addition of mitigations where necessary to reduce the risk level below 'medium'.

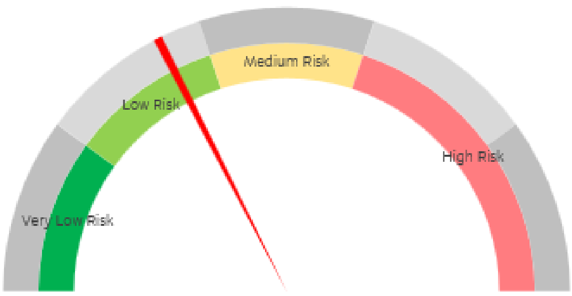
To reduce risk levels to below 'medium', the following changes could be made:

- Include a second (dual) PM for SPS-A with smaller diameter to better cater for the initial low sewage flows, targeting total HRT of less than 2 hours. The original PM would continue to be sized for the ultimate sewage flows.
- Include a corrosion resistant lining for the internals of the SPS wet wells (SPS_A and SPS_B) for corrosion resistance.
- Include active AC treatment systems to extract and treat the gas from each of the PM discharge MH chambers, i.e. for SPS_A PM discharge MH and at SPS_B PM discharge MH.
- Improve the design of the PM discharge MH to reduce turbulence (see Section 3.1.3).

With the implementation of the design modifications and mitigations described above, re-assessment of the O&C risks using the Tool indicates the risk level would be reduced from 'medium' to 'low'. Copies of the outputs of the Tool are shown in Figure B-4 below.

Item No.	Risk Factor	Units	Inputs	Assigned Risk Level
1	Pressure main and SPS wet well HRT (hours), at ultimate development	hours	< 2 hours	Low
2	Pressure main and SPS wet well HRT (hours), at initial development	hours	< 2 hours	Low
3	Time between pump starts at minimum flow	hours	2.0	Medium
4	Number of daisy-chained SPS	no.	2	Medium
5	Flow contribution to downstream assets (at connection point with existing assets)	%	2	Low
6	Trade waste inputs for new development	-	None	Very low
7	Distance from vent/release point to closest sensitive receptor	metres	50 – 100 m	Medium
8	Depth of drops for gravity assets	-	No drops	Very low
9	Gravity main sewage velocity - maximum	m/s	1.50	Very low
10	Gravity main sewage velocity – minimum	m/s	1.00	Low
11	Materials of construction	-	Protective coatings applied to at risk items	Low
12	Pressure main discharge maintenance hole configuration	-	Low risk of turbulence. Designed with part submerged inlet (per Fig 3-6 in Tech Standard)	Low
13	Potential for sea water ingress to assets within and/or upstream of scope of works	-	No potential for SWI, > 5 km from coast	Very low
14	Potential for sewer gas release (untreated) to atmosphere	-	Well sealed MHs. Well sealed SPS wet wells. Any releases have effective treatment installed.	Low
15	Are there special items with potential for increased O&C risks, e.g., barometric loops, siphons, vacuum sewer units, low pressure sewer units, tankered waste inputs, etc.	-	No	Very low
16	Where available, estimate of sewage DS concentration at downstream end of scope of works	mg/L	2.0	Medium
17	Where available, estimate of H_2S (g) concentration of gas at downstream end of scope of works (90th percentile / peak)	ppm	40	High

Overall Risk Level:	Low Risk



Odour and Corrosion Risk Score

Figure B-4: Risk Assessment Tool Level 2 outputs for Case Study 1 WITH O&C mitigations implemented

B2 Case Study 2

New sewerage infrastructure required as part of a residential infill development project in metropolitan Adelaide. A new residential area and industrial area is to be implemented within an existing built up urban area, i.e. with surrounding residential and commercial/ industrial properties. A key feature of the new sewerage infrastructure required to service the development is a significant gravity main and a single SPS. The development represents a planned project as set out in SA Water's master plans, i.e. part of a sequenced orderly development plan to accommodate population growth.

A schematic of the development project scope is shown in Figure B-5.

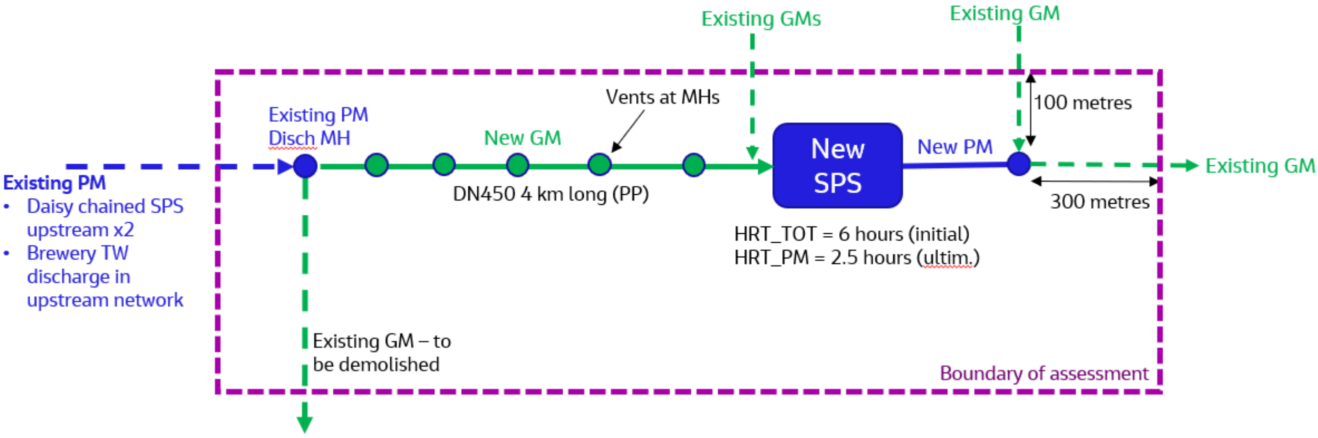


Figure B-5: Case Study 2 schematic

Key project data for the proposed project design includes:

- A new gravity main constructed in polypropylene (PP), with diameter DN450 and 4 km long.
  - The MHs along the GM will be concrete, i.e. corrodible.
  - The sewer will be naturally ventilated via tall educt vents and short fresh air inducts. At least one of the educt vents will be within 50 metres of future proposed residential properties.
  - The design includes one drop of approximately 5 metres depth along the new GM due to undulating terrain in the area.
- There are at least two existing SPS located upstream of the scope of work, which will transfer sewage to the upstream end of the new DN450 GM. H_2S (g) measured at the proposed connection point, at the upstream end of the new GM, indicated peaks up to 100ppm.
- New infrastructure proposed includes a single new SPS. Retention time summary data for the SPS and PM is shown in Figure B-5. This SPS will receive sewage from an established upstream gravity network.
- At the downstream end, the new SPS PM discharge is proposed to transfer sewage to an existing non-corrodible branch GM.
- The scope of work includes 300 metres of existing GM downstream of the SPS PM discharge MH. The flow rate from the SPS PM will be approximately 10% of the total flow along the existing GM to which the new development will discharge.
- There are no estimates available from the Designer for H_2S (g) or DS concentrations at the downstream end of the new scope of works.
- The proposed new PM discharge MH will be constructed in non-corrodible materials with part submerged inlet as shown in in Figure . There is no vent stack proposed for the PM discharge MHs.
- The proposed new SPS wet well will be constructed in non-corrodible materials.
- There is a single TW discharge from a large industrial brewery upstream of the scope of work which will be received by the new GM.
- There is no likelihood of seawater ingress as the development is far from the coast.
- There are no special items with increased O&C risks, e.g. barometric loops, tankered waste.

Use of the 'Level 1' inputs indicated that a 'YES' response was provided for at least one of the screening questions, e.g. the first screening question, i.e. 'Is there any daisy chaining of SPS within or upstream of the scope of works?'. As a result, a 'Level 2' assessment is required.

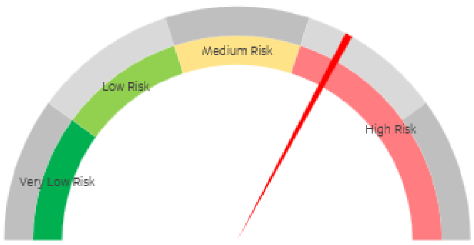
The O&C Risk Assessment Tool inputs and outputs for 'Level 2' are shown below in Figure B-6 and B-7, respectively.

Item No.	Risk Criteria	Units	Inputs
1	Pressure main and SPS wet well HRT (hours), at ultimate development	hours	2 – 4 hours
2	Pressure main and SPS wet well HRT (hours), at initial development	hours	>= 4 hours
3	Time between pump starts at minimum flow	hours	3.0
4	Number of daisy-chained SPS	no.	3
5	Flow contribution to downstream assets (at connection point with existing assets)	%	10.0
6	Trade waste inputs for new development	-	Single TW discharge of high risk
7	Distance from vent/release point to closest sensitive receptor	metres	< 50 metres
8	Depth of drops for gravity assets	-	One or more drops > 3 metres
9	Gravity main sewage velocity - maximum	m/s	1.5
10	Gravity main sewage velocity – minimum	m/s	1.0
11	Materials of construction	-	Minor equipment items only with corrodible materials
12	Pressure main discharge maintenance hole configuration	-	Low risk of turbulence. Designed with part submerged inlet (per Fig 3-6 in Tech Standard)
13	Potential for sea water ingress to assets within and/or upstream of scope of works	-	No potential for SWI, > 5 km from coast
14	Potential for sewer gas release (untreated) to atmosphere	-	Several opportunities for sewer gas release to atmosphere.
15	Are there special items with potential for increased O&C risks, e.g., barometric loops, siphons, vacuum sewer units, low pressure sewer units, tankered waste inputs, etc.		No
16	Where available, estimate of sewage DS concentration at downstream end of scope of works	mg/L	N/A
17	Where available, estimate of H_2S (g) concentration of gas at downstream end of scope of works (90th percentile / peak)	ppm	N/A

Figure B-6: Case Study 2 – Level 2 inputs to O&C Risk Assessment Tool

Item No.	Risk Factor	Units	Inputs	Assigned Risk Level
1	Pressure main and SPS wet well HRT (hours), at ultimate development	hours	2 – 4 hours	Medium
2	Pressure main and SPS wet well HRT (hours), at initial development	hours	>= 4 hours	High
3	Time between pump starts at minimum flow	hours	3.0	High
4	Number of daisy-chained SPS	no.	3	High
5	Flow contribution to downstream assets (at connection point with existing assets)	%	10	Medium
6	Trade waste inputs for new development	-	Single TW discharge of high risk	Medium
7	Distance from vent/release point to closest sensitive receptor	metres	< 50 metres	High
8	Depth of drops for gravity assets	-	One or more drops > 3 metres	High
9	Gravity main sewage velocity - maximum	m/s	1.50	Very low
10	Gravity main sewage velocity – minimum	m/s	1.00	Low
11	Materials of construction	-	Minor equipment items only with corrodible materials	Medium
12	Pressure main discharge maintenance hole configuration	-	Low risk of turbulence. Designed with part submerged inlet (per Fig 3-6 in Tech Standard)	Low
13	Potential for sea water ingress to assets within and/or upstream of scope of works	-	No potential for SWI, > 5 km from coast	Very low
14	Potential for sewer gas release (untreated) to atmosphere	-	Several opportunities for sewer gas release to atmosphere.	High
15	Are there special items with potential for increased O&C risks, e.g., barometric loops, siphons, vacuum sewer units, low pressure sewer units, tankered waste inputs, etc.	-	No	Very low
16	Where available, estimate of sewage DS concentration at downstream end of scope of works	mg/L	N/A	N/A
17	Where available, estimate of H_2S (g) concentration of gas at downstream end of scope of works (90th percentile / peak)	ppm	N/A	N/A

Overall Risk Level:	High Risk



Odour and Corrosion Risk Score

Figure B-7: O&C Risk Assessment Tool Level 2 outputs for Case Study 2

The Level 2 assessment results indicate a 'high' O&C risk rating for this proposed infrastructure development. This is mainly due to the following features:

- Transfer of O&C risks (expect septic sewage) from the upstream connected existing infrastructure, i.e. with daisy-chained SPS upstream, into the new GM. Polypropylene materials for the new GM will limit adsorption of H_2S (g) in to the sewer pipe walls, and the H_2S (g) will be readily transferred along the GM and in to the downstream existing infrastructure, i.e. further transferring risks downstream.
- Proposed vent stacks along the new GM in proximity to sensitive receptors. High H_2S (g) concentrations are expected along the GM (based on monitoring at existing upstream infrastructure) and therefore odour impact from these vent stacks is likely.
- Significant drop (5 metres) along the new GM. This is likely to cause significant turbulence and exacerbate the H_2S (g) along the new GM (and downstream), further increasing odour impact risks.
- In addition, the high risk TW discharge upstream of the development may cause elevated COD and is most likely contributing to the generation of sulphide, and subsequent high H_2S (g), which will be transferred to the new GM.

Overall, there are many factors which contribute to an overall high O&C risk for the new system which are complex and largely systemic. This type of application would require the Designer to develop a plan for the Level 3 assessment, applying Level 3 assessment tools as set out in Section 5.3. The plan would be referred to SA Water for discussion and agreement of the investigation and assessment steps to be undertaken. For example, an appropriate course of action to be undertaken by the Designer/Developer (or third party) could be:

- Undertaken sulphide modelling for the new development infrastructure, including the upstream network, to assess/confirm causes of sulphide generation.
- Investigate risk areas for the existing upstream network and identify modifications to improve designs to reduce risks, e.g. reducing aggregate HRT for the daisy-chained SPS, treatment of brewery TW discharge to avoid elevated COD.
- Investigate opportunities to improve the design for the proposed new development infrastructure, e.g. realignment of the GM to avoid the 5 metre drop.
- When the appropriate design changes for the existing upstream and new infrastructure have been applied, as far as practicable, identify and assess potential mitigations. This could involve optioneering of forced ventilation and treatment options for the gravity sewer, or application of chemical dosing for the existing upstream SPS(s).

C Alternate low turbulence structure designs

PM discharge MH

An alternate PM discharge MH arrangement is shown in Figure C-1. This arrangement is expected to result in low turbulence when SPS pumps are operating and there is liquid level in the discharge chamber. However, it may be susceptible to turbulence at the start of the pump cycle with sewage being splashed across the chamber and this would need to be taken in to account in selection of the preferred MH arrangement.

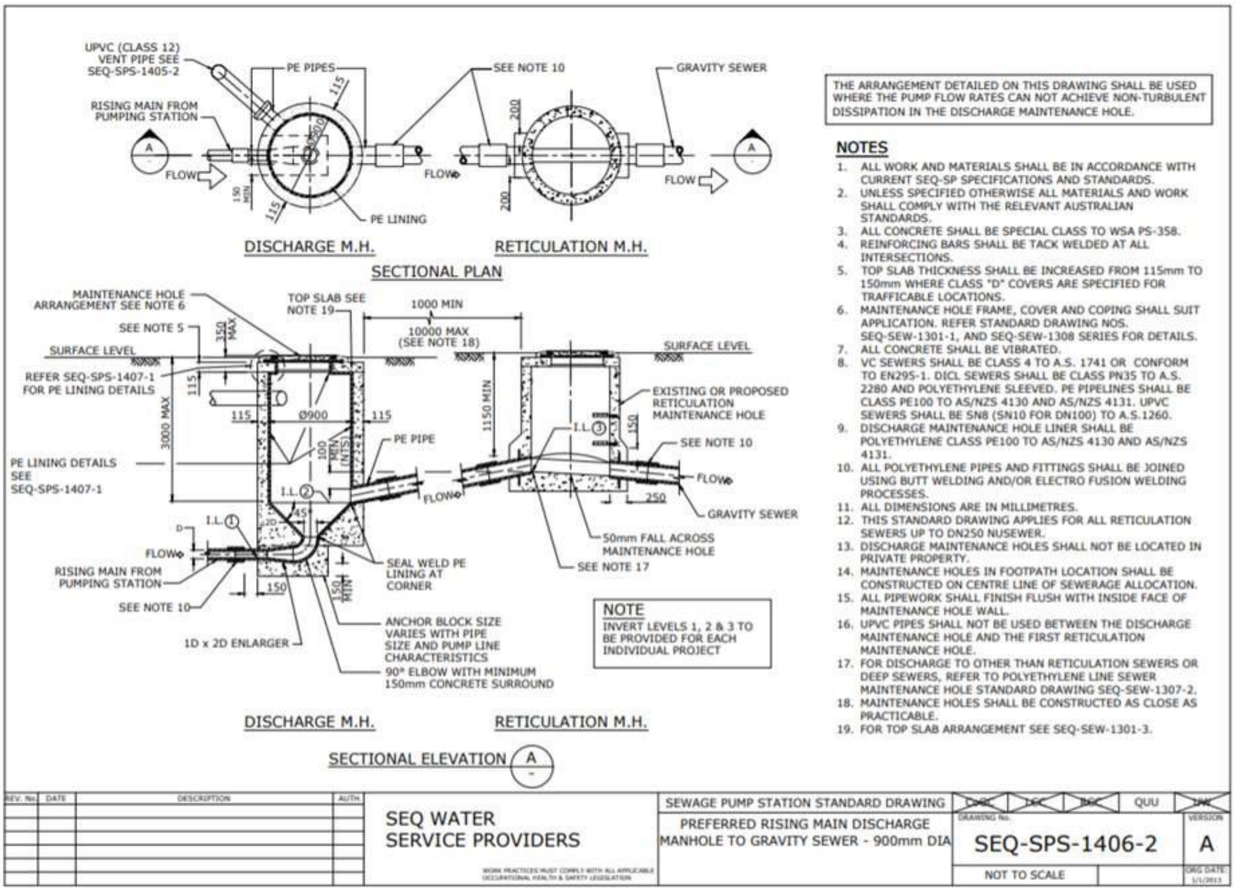


Figure C-1: Alternate PM discharge MH configuration (source: SEQ Water)