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Engineering

Technical Standard

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Documents superseded by this standard

The following documents are superseded by TS 0721:

a. TG 106 Above Ground Circular Concrete Tanks.

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1 Introduction

SA Water is responsible for the construction, commissioning, operation and maintenance of an extensive portfolio of engineering infrastructure such that it is functional, reliable and safe.

Tanks in SA Water's water supply system provide the storage to balance the difference between inflow and outflow over a sequence of high-water demand.

Tanks may also:

a. Provide water at an elevated level to provide pressure suitable for distribution.

b. Break pressure in a main.

c. Act as a one-way surge mitigation tank.

d. Store water prior to and after water treatment.

e. Provide reserve storage of water for use during system maintenance or failures.

1.1 Purpose

The purpose of this standard is to detail SA Water minimum requirements to enable assets covered by the scope of this standard to be designed, constructed, operated and maintained to consistent standards and attain the required asset life.

1.2 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.

1.2.1 Terms and Definitions

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

Term	Description
Accepted	Determined to be satisfactory by SA Water's Representative.
Allow	Means that the cost of the item referred to is the responsibility of the Constructor
Anchor Block	A reinforced concrete block which is cast around a straight piece of pipe (fitted with a thrust collar or puddle flange) and which is designed to restrain the pipe against longitudinal movement.
Asset	Structure, facility, plant, operating system/equipment.
Autogenous healing	Self-generated healing of cracks in the concrete tank structure by the reaction of tank-stored water and the concrete paste.
Balance Pipe	The pipe between tanks to equalise water levels.
Component	Any part of the structure or non-structural part or mechanical/electrical components that may affect the durability of the structure.
Concept Design	The initial level of design undertaken to identify and address the major and/or critical elements of the asset being designed.
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.
Contract	A set of documents supplied to Constructor as the basis for construction; these documents contain contract forms, contract conditions, specifications, drawings, addenda, and contract changes.

Term	Description
Convective Load	The load of water sloshing inside the tank during an earthquake.
Design Lead/Design Manager	The person identified as responsible for the SiD process. They will have experience in line with the scale, scope and complexity of the package of work to be carried out. E.g. Senior Designer, Principal Designer, and Head Designer.
Design Life	The specified/assumed period for which infrastructure (or its constituent components) is expected to be used for its intended purpose, and under the expected conditions, without major repair or replacement being necessary.
Designer	The organisation responsible for designing infrastructure for SA Water, whether it be a third party under contract to SA Water 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).
Designer and/or constructor	The entities that undertake the design, specification, vendor negotiations, purchasing, construction installation and/or operational testing of the tank (can be either external or internal to SA Water).
Detailed Design	The level of design undertaken to develop a concept design to a level of detail necessary to enable construction, modification or installation of the work.
Durability	Capability of a structure or any component to satisfy, with planned maintenance, the design performance requirements over a specified period of time under the influence of the environmental actions or as a result of self-aging. Reference shall be made to TS 0110 for more information.
Elevated Tank	A water storage structure constructed with the floor above ground level, either supported on a stand or an integral support structure.
Facility Design Life	The Design Life of an entire facility (for example, a Water Treatment Plant, Wastewater Pump Station etc.).
Ground Level Tank (or Surface Level Tank)	A water storage structure constructed with the floor at ground level.
Hazard	A situation or thing that has the potential to harm.
Impulsive load	The load of water inside the tank moves in unison with the structure during an earthquake.
Inflow rate	Inflow rate through the inlet into the tank.
Inflow temperature range	The difference between the temperature of the inlet water and the ambient temperature in the tank.
Informative	Means “provided for information and guidance”.
Inlet Inclination plane	The inclination of the inlet jet in degrees is measured from the horizontal.
Lifecycle	All phases in the life of an asset. The specific phases present in an asset lifecycle will depend upon the type of asset but may include design, development, manufacture, construction, assembly, import, supply, distribution, sale, hire, lease, storage, transport, installation, erection, commissioning, use or operation, consumption, maintenance, servicing, cleaning, adjustment, inspection, repair, modification, refurbishment, renovation, recycling, resale, decommissioning, dismantling, demolition, discontinuance, disposal.
Maintenance	A combination of all technical and associated administrative actions during infrastructure (or its constituent components) Service Life with the aim of retaining it in a state in which it can perform its required functions.
Manufacturer	A person, group, or company that owns and operates a manufacturing facility that provides materials for use in SA Water infrastructure.

Term	Description
Must	Indicates a requirement that is to be adopted in order to comply with the Standard.
Non-Conformance Report (NCR)	A quality-related document that addresses specification deviation or work that fails to meet quality standards.
Person/s	Each word implying a person, or persons shall, where appropriate, also be construed as including corporations.
Precast Shop Drawings	Comprehensive precast manufacture drawings showing all relevant details, including the panel dimensions, set out of cast-in elements and pockets, reinforcement size and layout including cog lengths, cover and surface finishes.
Principal	The term "Principal" shall mean SA Water's Representative.
Prolonged Service Life	The period comprising of both the Design Life and Residual Life.
Provide	Means "supply and install".
Repair	Repair is the restoration of a structure or components to an acceptable condition by the renewal or replacement of worn, damaged or deteriorated components. It should be noted that repair activities normally fall outside the scope of maintenance activities.
Request For Information (RFI)	The process of requesting clarifying information for drawings, specifications or scope.
Reserve + Unusable Storage	The minimum volume of water that must always be in the tank for use in an emergency situation.
Residual Life	The duration for which an asset shall remain operational and serviceable after reaching its Design Life.
Principal Engineer	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
Safe Design	Safe design means the integration of control measures early in the design process to eliminate or, if this is not reasonably practicable, to minimise risks to health and safety throughout the life of the structure being designed.
Scour	Waste pipe provided to enable emptying and cleaning out of the tank.
Service Life	The **actual period** during which infrastructure (or its constituent components) satisfy the design performance requirements without unforeseen major repair or maintenance when used for its intended purpose and under the expected conditions of use.
Shall	Indicates a requirement that is to be adopted in order to comply with the Standard.
Should	Indicates practices which are advised or recommended, but is not required
Sloshing	Splashing of water inside the tank due to horizontal tank movement.
Steelwork Shop Drawings	Comprehensive steelwork fabrication and construction drawings showing all relevant details, including each assembly component and connection, together with information relative to cutting, welding, bolting, surface treatment and erection.
Supplier	A person, group or company that provides goods for use in SA Water infrastructure.

Term	Description
Survey – As-Constructed Survey	Surveys to record the location of new and existing network infrastructure created or impacted as the result of a Major Land Development or capital works.
Survey – Design Survey	Initial survey that includes the location of existing infrastructure that may be impacted by the project.
Survey – Site Survey	Survey to identify existing infrastructure at a site, including land boundary, buildings, overhead and underground services.
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.
Vendor	The supplier (re-seller) and/or factory manufacturer of an item to be incorporated into the tank and associated works construction (not always the same entity) – the information required of the vendor under this Technical Standard must be obtained from the supplier (re-seller) and/or factory manufacturer as "vendors" as required.
Verifier	A suitably qualified and experienced person, who: • Carries out design verification to ensure technical requirements are satisfied. • Possesses water industry experience specifically related to the subject area for which the verification is being undertaken.
Watertight	A tank is considered watertight when it passes the testing requirements of TS 0600 and this Technical Standard.
Work	Elements of a project which require design and/or construction.

1.2.2 Abbreviations

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

Abbreviation	Description
ACRS	Australian Certification Authority for Reinforcing Steel
ADWG	Australian Drinking Water Guidelines
AS	Australian Standard
BMT	Base Metal Thickness
CFD	Computational Fluid Dynamics
DAR	Durability Assessment Report
DBR	Design Basis Report
EPA	Environment Protection Authority
EWP	Elevated Working Platform,
FRP	Fibre Reinforced Polymer
GDA94	Geocentric Datum of Australia 1994
GPO	General Power Outlet
GRP	Glass Reinforced Polymer
IP&S	Infrastructure Planning and Strategy
ISO	International Standard Organisation
ITP	Inspection and Test Plan
JSEA	Job Safety and Environmental Analysis

Abbreviation	Description
kPa	Kilo Pascal
NATA	National Association of Testing Authorities, Australia
NDMA	N-Nitrosodimethylamine
NZS	New Zealand Standards
O&M	Operating and Maintenance
P&ID	Piping (Process) and Instrumentation Diagram
PCCP	Painting Contractor Certification Program
PE	Polyethylene
PLC	Programmable Logic Controller
PM	Project Manager
PN	Pressure Nominal
PPE	Personal protective equipment
PTFE	Polytetrafluoroethylene
PVC	Polyvinylchloride
QA/QC	Quality Assurance/Quality Control
QMS	Quality Management System
RTU	Remote Telemetry Unit
SA Water	South Australian Water Corporation
SCADA	Supervisory Control And Data Acquisition
SiD	Safety in Design
TDRF	Technical Dispensation Request Form
TG	SA Water Technical Guideline
THM	trihalomethane
TS	SA Water Technical Standard
TSO	Technical Services Officer
WQ&TS	Water Quality and Treatment Solutions

1.2.3 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 Constructor.
- Directions, instructions and the like, whether or not they include the expression “the Constructor shall” or equivalent, shall be directions to the Constructor, 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).

1.3 References

1.3.1 Australian and international

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

Reference	Title
-	Work Health and Safety Act 2012 (SA) Version 3.10.2019
AS 1281	Cement mortar lining of steel pipes and fittings
AS 1319	Safety signs for the occupational environment
AS 1345	Identification of the contents of pipes, conduits and ducts
AS 1397	Continuous hot-dip metallic coated steel sheet and strip — Coatings of zinc and zinc alloyed with aluminium and magnesium
AS 1562.1	Design and installation of metal roof and wall cladding Metal
AS 1579	Arc-welded steel pipes and fittings for water and wastewater
AS 1657	Fixed platforms, walkways, stairs and ladders
AS 1726	Geotechnical site investigations
AS 1768	Lightning protection
AS 2124	General conditions of contract
AS 2312.1	Guide to the protection of structural steel against atmospheric corrosion by the use of protective coatings -Paint coatings
AS 2832.4	Cathodic protection of metals Internal surfaces
AS 2870	Residential slabs and footings
AS 2890 (set)	Parking facilities
AS 3566.1	Self-drilling screws for the building and construction industries General requirements and mechanical properties
AS 3600	Concrete structures
AS 3610	Formwork for concrete
AS 3735	Concrete structures for retaining liquids
AS 3894.1	Site testing of protective coatings Non-conductive coatings - Continuity testing - High voltage (brush) method
AS 3959	Construction of buildings in bushfire prone areas
AS 4041	Pressure piping
AS 4100	Steel Structures
AS 4300	General conditions of contract for design and construct
AS 4312	Atmospheric Corrosivity Zones in Australia
AS 4321	Fusion-bonded medium-density polyethylene coating and lining for pipes and fittings
AS 4678	Earth-retaining structures
AS 5334	Climate change adaption for settlements and infrastructure – A risk-based approach

Reference	Title
AS 8501.3	Preparation of steel substrates before application of paints and related products - Visual assessment of surface cleanliness Treatment grades of welds, edges and other areas with surface imperfections
AS/NZS 5131	Structural steelwork - Fabrication and erection
AS/NZS 1170.0	Structural Design Actions: General Principles
AS/NZS 1170.1	Structural design actions: Permanent, imposed and other actions
AS/NZS 1170.2	Structural design actions: Wind actions
AS/NZS 1170.4	Structural design actions: Earthquake actions in Australia
AS/NZS 1252 (set)	High-strength steel fastener assemblies for structural engineering - Bolts, nuts and washers
AS/NZS 1314	Prestressing anchorages
AS/NZS 1664 (set)	Aluminium structures
AS/NZS 1665	Welding of aluminium structures
AS/NZS 1734	Aluminium and aluminium alloys - Flat sheet, coiled sheet and plate
AS/NZS 1865	Aluminium and aluminium alloys - Drawn wire, rod, bar and strip
AS/NZS 1866	Aluminium and aluminium alloys - Extruded rod, bar, solid and hollow shapes
AS/NZS 1867	Aluminium and aluminium alloys - Drawn tubes
AS/NZS 2312.2	Guide to the protection of structural steel against atmospheric corrosion by the use of protective coatings -Hot dip galvanising
AS/NZS 2566.1	Buried flexible pipelines – Structural design
AS/NZS 2566.2	Buried flexible pipelines – Installation
AS/NZS 3000	Electrical installations
AS/NZS 3008.1.1	Electrical installations – Selection of cables – Cables for alternating voltages up to and including 0.6/1 kV – Typical Australian installation conditions
AS/NZS 3500.3	Plumbing and drainage – Part 3: Stormwater drainage
AS/NZS 4020	Testing of products for use in contact with drinking water
AS/NZS 4087	Metallic flanges for waterworks purposes
AS/NZS 4600	Cold-formed steel structures
AS/NZS 4671	Steel for the reinforcement of concrete
AS/NZS 4672.1	Steel prestressing materials – General requirements
AS/NZS 4672.2	Steel prestressing materials – Testing requirements
AS/NZS 4680	Hot dip galvanized (zinc) coatings on fabricated ferrous articles
AS/NZS 4766	Rotationally moulded buried, partially buried and non-buried storage tanks for water and chemicals
AS/NZS ISO 9001	Quality management systems - Requirements
ASME RTP-1	Reinforced Thermoset Plastic Corrosion-Resistant Equipment
ASTM D 1238	Standard Test Method for Melt Flow Rates of Thermoplastics by Extrusion Plastometer
ASTM D 1693	Standard Test Method for Environmental Stress-Cracking of Ethylene Plastics
ASTM D 2563	Standard Practice for Classifying Visual Defects in Glass-Reinforced Plastic Laminate Parts

Reference	Title
ASTM D 2565	Standard Practice for Xenon-Arc Exposure of Plastics Intended for Outdoor Applications
ASTM D 2837	Standard Test Method for Obtaining Hydrostatic Design Basis for Thermoplastic Pipe Materials or Pressure Design Basis for Thermoplastic Pipe Products
ASTM D 2990	Standard Test Methods for Tensile, Compressive, and Flexural Creep and Creep-Rupture of Plastics
ASTM D 4703	Standard Practice for Compression Molding Thermoplastic Materials into Test Specimens, Plaques, or Sheets
AWWA D100-21	American Water Works Association Standard for welded carbon steel tanks for water storage.
AWWA D100-5	American Water Works Association Standard for the minimum inspection and quality requirements for steel tanks
AWWA D102-21	American Water Works Association Standard for Coating Steel Water-Storage Tanks
AWWA D103-19	American Water Works Association Standard for Factory-Coated Bolted Steel Tanks for Water Storage
AWWA D120-02	American Water Works Association Standard for Thermosetting Fiberglass-Reinforced Plastic Tanks
AWWA D130-02	American Water Works Association Standard for Flexible-Membrane Materials for Potable Water
BS EN 13121-1	GRP tanks and vessels for use above ground Raw materials. Specification conditions and acceptance criteria
BS EN 14015	Specification for the design and manufacture of site built, vertical, cylindrical, flat-bottomed, above ground, welded, steel tanks for the storage of liquids at ambient temperature and above
ISO 1133-1	Plastics Determination of the melt mass-flow rate (MFR) and melt volume-flow rate (MVR) of thermoplastics Part 1: Standard method
ISO 1133-2	Plastics Determination of the melt mass-flow rate (MFR) and melt volume-flow rate (MVR) of thermoplastics Part 2: Method for materials sensitive to time-temperature history and/or moisture
ISO 12944-5	Paints and varnishes — Corrosion protection of steel structures by protective paint systems — Part 5: Protective paint systems
ISO 18273	Welding consumables - Wire electrodes, wires and rods for welding of aluminium and aluminium alloys - Classification
ISO 28765	'Vitreous and porcelain enamels – Design of bolted steel tanks for the storage or treatment of water or municipal or industrial effluent and sludges
ISO 3506 (set)	Fasteners — Mechanical properties of corrosion-resistant stainless steel fasteners
NZS 3106	Design of concrete structures for the storage of liquids
NZS 4219	Seismic performance of engineering systems in buildings

1.3.2 SA Water documents

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

Reference	Title
4005-30001 to 10 (series)	Water supply construction manual drawings
94-0163-12	Sewer Construction Manual Page M12 – Sewage Pumping Station – Access Roadway Typical Cross Section and Drainage Details
SAWS-WQ-0004	New Assets – Water Quality and Monitoring Requirements for Commissioning
SAW-WQ-0003	New Asset Water Quality Requirements Checklist
SAW-WQ-0004	New Asset Water Quality Monitoring Requirements for Commissioning
SAW-WQ-0009	Storages – Water Quality Guideline for Operation and Maintenance
STD-04-00001	Standard Cathodic Protection Design
TG 0631	General Technical Information for Geotechnical Design - Earthworks
TG 0650	Tree Clearance and remediation in Earth Dams
TS 0100	Requirements for technical drawings
TS 0101	Safety in design
TS 0103	Survey requirements
TS 0104	Design quality management
TS 0105	Quality requirements
TS 0109	Infrastructure design
TS 0110	Durability
TS 0120	Installation standards for electronic security systems
TS 0121	Physical security site standards general definitions
TS 0132	Operations and maintenance manuals
TS 0133	Requirements for asset labelling
TS 0136	Pipework access and protection
TS 0204	Colour coding of pipework
TS 0300	Supply and installation of low voltage electrical equipment
TS 0302	Stand-alone solar power supply systems
TS 0350	SCADA Systems
TS 0400	SA Water Supplement to Manual for Selection and Application of Protective Coating: WSA201 (when published)
TS 0420	Welding Requirements (Metal)
TS 0421	Welding of thermoplastics (when published)
TS 0440	Cathodic Protection Part 1 – Pipelines
TS 0460	Floating covers and liners for earth bank storages
TS 0464	PVC waterstop
TS 0503	Authorised Products Water Systems
TS 0600	Water tightness testing of liquid retaining structures
TS 0700	(Formerly TS 0601) Design, assessment and retrofitting of SA Water assets in bushfire-prone areas

Reference	Title
TS 0630	Coarse aggregates for civil works
TS 0631	Fine materials for pipe embedment
TS 0632	Minimum requirements of geotechnical investigations and reports
TS 0710	Concrete
TS 0711	Concrete remedial works (series)
TS 0720	Safe access system for SA Water assets
TS 0730	Stainless steel durability, fabrication and erection
TS 0760	Pipeline design and installation (in progress)
TS 0800	Materials in contact with drinking water
TS 0900	Pressure testing of pipelines
TYP-07 Series	Tank Rehabilitation Program OP20 Typical Drawings

1.3.3 Use of Standards and Codes

Unless otherwise specified in the Contract, and where applicable, materials and workmanship are to be in accordance with the relevant Standard or Code.

Unless otherwise specified, use the most current published edition (prior to the commencement of detailed design works) of Standards and Codes applicable to the Works.

Use Standards and Codes consistently throughout the design, supply and installation process without interchanging between different Standards.

Overseas standards and other standard documents named in the Technical Standard are applicable in the same manner as Australian Standards to relevant materials and workmanship.

In cases where an applicable Australian Standard is not published, the applicable British Standard, European, New Zealand or American Standard shall be used.

2 Scope

2.1 Scope and application of this Technical Standard

This Technical Standard stipulates SA Waters' requirements for the design of tanks and their associated works that are to be operated by SA Water. The requirements are based on operation, safety, maintenance, water quality, durability and whole-of-life value for money considerations.

The structural design of tanks is not specifically addressed in this Standard. The structural design is to be in accordance with published Australian and International Standards.

This Standard shall be read in conjunction with all other Technical Standards referenced herein.

The objective of this Technical Standard is to provide clear and consistent requirements to enable:

a. Proper selection of tank materials with consideration of design life, durability, sustainability, bushfire, vandalism and water quality.

b. Consideration of water quality throughout the lifecycle of the structure.

c. Improved design, construction, operation and maintenance outcomes and thus minimization of the risk of service interruptions to customers.

d. Relevant factors are considered in site selection and site layout design.

e. Geotechnical investigations are undertaken with sufficient scope and detail.

f. Engagement with key internal/external stakeholders occurs to achieve project-specific objectives.

2.2 Works not in scope

The following items are excluded from the scope of this Technical Standard:

a. Tanks containing liquids other than water.

b. Tanks containing wastewater.

c. Tank repairs or refurbishment.

d. Tanks of a temporary nature.

2.3 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 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.

2.4 Hazards

SA Water has provided known hazards associated with the testing activities nominated in this Technical Standard below for reference by users of this document.

Specific hazards/risks and their proposed controls relating to testing shall be included within the project Quality Plan and Work Method Statement submission (refer section 3).

Hazards/risks may include, but are not limited to, the following:

a. For watertightness test of liquid retaining structures, refer TS 0600.

b. For pressure testing of pipelines, refer TS 0900.

2.5 Risks posed by large tanks

2.5.1 Background to risk posed by large tanks

Large tanks, typically 9ML and greater, are key components of SA Water's water supply systems. They typically have high stored energy being located on high ground, often close to housing or other developed property or land.

Large tanks could pose a risk to people and property if a sudden, uncontrolled release of stored water through tank failure occurred.

2.5.2 Defining the risk event and the possible consequences

If soils beneath tank foundations are susceptible to leakage water, possible foundation saturation, weakening, damage or dissolution may result. The foundation damage may be dissolution of the foundation rock or a softening, weakening or swelling of the clay foundation.

The potential consequences, in order of decreasing likelihood and increasing severity, could be:

1. Significant deformation of and damage to the tank structure (no uncontrolled release of stored water). This would necessitate the taking of the tank offline for weeks or months to enable foundation and structural repairs. The resulting operational incident would disrupt supply and generate adverse media, public and political reactions.
2. Significant deformation of and damage to the tank structure, resulting in the uncontrolled release of the stored water. This would necessitate the taking of the tank offline for weeks or months to enable foundation and structural repairs. The resulting operational incident would severely disrupt supply and generate adverse media, public and political reactions.
3. Failure of the tank structure due to major foundation collapse and/or slope instability, resulting in the uncontrolled release of the stored water and possibly fluidised foundation materials. Operational consequences as for Event 2.
4. The uncontrolled release of water and possibly fluidised foundation materials from Event 2 or 3 damaging property such as housing, roads and railways.
5. The uncontrolled release of water and possibly fluidised foundation materials from Event 2 or 3 resulting in injuries and deaths.

The risks posed by large tanks on foundations susceptible to leakage water damage therefore need to be appropriately managed.

3 Quality requirements

3.1 General

The quality management system requirements for the supply, construction, testing and commissioning activities undertaken on site in the delivery of water storage tank projects shall comply with TS 0105.

3.2 Hold points

Hold points applicable to this Technical Standard can be found in Appendix A. Please refer to TS 0105 for further detail on hold points.

3.3 Witness points

Witness points applicable to this Technical Standard can be found in Appendix A. Please refer to TS 0105 for further detail on witness points.

3.4 Non-conformance

Please refer to TS 0105 for the requirements relating to non-conformance.

4 Design and documentation

4.1 Design requirements

The tank and associated works shall be designed and constructed in such a way that it will, during its design working life and with appropriate degrees of reliability, sustain all design actions for strength, serviceability and stability limit states and meet the durability requirements as set out in the SA Water and Australian Standards.

It shall be designed to withstand extreme or frequently repeated actions, or both, occurring during its construction and anticipated use.

4.2 Competency of the structural design team

The structural design of water storage tanks is a specialised field requiring experience and in-depth knowledge. Design capability used for this infrastructure is to comply with the requirements of TS 0104 and be able to demonstrate relevant capability in:

1. Designing and detailing water storage tanks (and associated infrastructure, such as roof structures, columns, etc.)
2. Applying SA Water requirements, along with Australian and international standards
3. Supporting construction and troubleshooting or resolving construction issues.

4.3 Design loads

Tank structures shall be designed in accordance with the relevant standards and specifications.

Tank structures shall be designed for the following design loads:

a. Dead load.

b. Live load on roof structure.

c. Liquid load.

d. Temperature taking into consideration climate change (refer TS 0109).

e. Moisture variation.

f. Earthquake.

g. Wind.

h. Ground movement.

i. Construction loads.

j. Backfill.

k. Fatigue.

The tank shall also be designed for:

1. Global stability against seismic and wind loads whether full of water or empty.
2. Minimum durability requirements to achieve the project-specific design life (refer TS 0110).
3. Safe access requirements (refer to TS 0720 and associated safe access typical drawings).

In addition to the load cases and combinations required by the relevant design standards, the following conditions shall be addressed by the design:

i. Bushfire design events.

ii. Buoyancy/Flotation.

iii. Earthquake-induced soil pressure for buried tanks when empty (refer AS 4678).

iv. Impact of local flooding and flood levels (refer TS 0109).

All tanks and associated works shall be designed with a project-specific Asset Criticality Rating (ACR) and for a minimum Design Life that reflects the following:

A. Facility Design Life and its implications on the Design Life of constituent infrastructure or components.

B. Design Life of infrastructure and its components.

Ideally, the ACR would be evaluated and made available to the design team prior to the commencement of a given infrastructure project. However, it is recognised that this will not always be the case, and that some projects will commence without this information being immediately available. Where this occurs, direction shall be sought from the Project Sponsor as to the ACR classification.

4.3.1 Buried and partially buried tanks

For buried and partially buried tanks, the following load cases shall be considered:

a. Tank Full with no soil support/loads counteracting the hydrostatic pressure.

b. Tank Empty with soil pressure acting including earthquake effect to AS 4678.

4.3.2 Seismic loading considerations

The design shall consider the seismic performance of the tank and associated tank infrastructure in line with relevant Australian Standards.

Where the material of construction of the tank (for example, concrete, steel panel, FRP etc) falls outside of the scope of the Australian Standards, appropriate International Standards are to be adopted.

a. Hydrodynamic mass and structure mass:

   Design shall be undertaken to AS 1170.4 and international Standards, as accepted by SA Water, which are provided in subsequent sections of this Standard.

b. Earthquake induced soil pressure:

   Design shall be undertaken to AS 1170.4 and AS 4678.

4.3.3 Durability considerations

All tanks and associated works shall be designed for durability in accordance with the SA Water Technical Standards TS 0109 and TS 0110 and relevant material standards.

The durability parameters to be considered in the design include but not limited to:

a. Minimum design life of assets/materials broken down similarly to the assets/materials listed in the TS 0109 design life tables.

b. Minimum service life of assets/materials broken down similarly to the assets/materials listed in the TS 0109 design life tables.

c. Materials of each component.

d. Protective coating for both internal and external surfaces including estimated life to first major maintenance.

e. Repair and maintenance methodology.

f. Schedule and type of maintenance required over the life span of the tank structure.

4.3.4 Thermal considerations

For concrete tanks, thermal loads shall be considered and assessed using AS 3735. Further to this the design of tanks shall account for:

a. Thermal expansion and contraction.

b. Humidity of the tank interior as 100%.

c. Action effects arising from differential temperature gradients through walls and roofs.

d. Temperatures given in Table 1 where these cause a greater effect than the AS 3735 values.

e. Future climate change effects (refer to TS 0109).

Table 1: Thermal loads

Description	Temperatures (pre–Climate Change)
Metal roof cladding	-7 C min. to 70°C max.
Initial installation	12°C to 20°C
Design average roof cladding temperature range	-27°C to 58°C
Tank air space average temperature	55°C
Water average temperature	30°C

Refer also to section 5.14 Climate Change and incorporate outcomes of the climate change risk assessment using AS 5334 into the thermal design of the tank, tank roof, pipework and associated works which change the above temperatures.

4.4 Design reports

A Detailed Design Report shall be submitted with each Design Milestone and be in SA Water format. The intent of the Detailed Design Report shall be to demonstrate and record compliance with this Technical Standard and TS 0104.

For tanks less than or equal to 1ML in volume, a shortened version of the Design Report may be submitted as agreed with SA Water and include the following as a minimum and as appropriate for the project and design progression:

Table 2: Design report contents

Design report content	≤1 ML tank	>1 ML tank
Purpose	Y	Y
Scope of work	Y	Y
Design summary	Y	Y
Siteworks/Civil design	Y	Y
Structural design	Y	Y
Services design	N	Y
Water quality design	Y	Y
Security design	Y	Y
Landscaping design	N	Y
Construction methodology	Y	Y
Safety in Design	Y	Y
Sustainability in Design	Y	Y
Investigation reports and summary of findings	Y	Y

Design report content	≤1 ML tank	>1 ML tank
Early age thermal and shrinkage assessment taking into account the proposed construction method	N	Y
Data sheets	Y	Y
Concrete mix design	Y	Y
Commissioning plan	Y	Y

Reference shall be made to TS 0104 and TS 0105.

4.5 Design computations

A set of completed computations shall be provided to SA Water by the tank designers to show that the requirements of this technical standard and the material referenced within it have been adhered to.

The computations shall be clear and legible.

The computations shall include a design philosophy and contents page and be consistent with SA Water Project Requirements (as defined in TS 0104).

The computation pages shall be numbered and clearly define each element being designed, the design outcome and code references.

4.6 Design drawings

Documentation for the construction of the tank and its associated works shall be produced to convey all the necessary information to enable the works to be constructed in accordance with this Technical Standard and the material referenced within it.

All drawings shall be produced in accordance with TS 0100.

Unless required otherwise, the design drawings shall include, but are not limited to, the following elements:

1. Location plan.
2. Demolition plan.
3. Temporary access, constructor laydown, and constructor compound plan.
4. Existing site survey plan.
5. Site layout plan.
6. Earthworks design plan and cross sections.
7. Setout plan including site, pipework, columns, wall pockets for roof elements, etc.
8. Site hydraulic services plan.
9. Hydraulic services details.
10. Electrical services site plan.
11. Electrical services details.
12. Communications services site plan and details.
13. Mechanical services details.
14. Tank floor and column layout plan.
15. Wall and footing sections.
16. Tank floor reinforcement plan.
17. Wall, footing, floor joint and floor penetration details.
18. Floor and column sections and details.

19. Roof beam and purlin layout plan.
20. Roof beam details, connections and connection schedule.
21. Roof cladding plan.
22. Roof cladding, access hatch cladding and roof ventilation details.
23. Liner and floating cover plans, sections and details.
24. Safe access system and corresponding details.
25. Sampling pipework details (if required by SA Water).
26. Chlorination system details (if required by SA Water).
27. Inlet and outlet pipe details.
28. Internal overflow pipe details, fixings, bellmouth and pipe restraint.
29. Outlet pipe grating and mud ring details.
30. Details of all pipework (above and below ground) associated with the tank valve chamber and anchor blocks plan and details.
31. Pipe end dissipator, cover and scour protection plan, sections and details.
32. Site grading, drainage and pavement plan.
33. Civil works, stormwater, electrical, communications, security and pavement details.
34. Site fencing plan, security plan and fencing details.
35. Landscaping plan and details.
36. Environmental features such as trees, tree canopies and natural water courses.

The following information shall; as a minimum, be shown on the drawings:

a. Tank design code and year.
b. Design data and design details as listed in AS 3735.
c. Live loads used in design.
d. Design wind speed, basic and factored.
e. Earthquake design code and year.
f. Earthquake zone and site factor.
g. Earthquake probability and hazard factor.
h. Earthquake loads used in the design including base shear.
i. Corrosivity categories to AS 4312.
j. Exposure classification for durability.
k. Fire resistance level, if applicable.
l. Geotechnical conditions including site subsoil class to AS 1170.4 and soil reactivity class to AS 2870.
m. Earthworks engineering material and testing specifications, including inspections.
n. Asset lifecycle requirements.
o. Classes of concrete for different applications.
p. Grade and type of reinforcement or tendons Shape and size of each member.
q. Finish on unformed surfaces.
r. Class of formwork to AS 3610 to formed surfaces.

s. The size, quantity and location of all reinforcement, tendons and structural fixings and the minimum cover for each.

t. The curing procedure and duration.

u. The concrete mix design minimum requirements.

v. The force required in each tendon, the maximum jacking force to be applied, calculated tendon extension and the order in which tendons are to be stressed. The location and details of planned construction joints.

w. The minimum time before stripping forms.

x. Any constraint on construction assumed in the design.

y. Any special protective coatings.

z. Refer also to tank material design requirements in relevant sections of this standard.

4.7 Design stages

Unless varied by the contract, the stages of design submission and minimum submission requirements shall be as follows.

Table 3: Design stages

Stage	Minimum submission requirements
30% Design	• Design Basis Report (DBR) • Site layout • Tank dimensions and material • Tank main pipe sizing and materials • Earthworks • Structural systems for floor, walls and roofing including alternative systems worth considering. • Foundations, retaining walls, and site preparation works • Drainage, including the need for tank underdrains. • Access roads and parking areas • Desktop environmental checks and design considerations to avoid or minimise environmental and heritage impacts. • Identify potential stakeholders who may need to be consulted. • Roof hatch location • Bushfire risk assessment • Piping (Process) and Instrumentation Diagram (P&ID)

Stage	Minimum submission requirements
60% Design	Update the 30% submission to a 50% level of detail and submit in addition the following: • Detailed Design Report • Environmental and heritage considerations – avoiding/minimising impacts through design and assessment and approvals required. • Where precast wall panels are proposed to be used, the joint details shall be submitted. • External stairs, platforms, landings • Roof access, roof ventilation • Inlet, outlet, overflow, and scour pipework complete with flanges, valves, support brackets, anchor blocks, pipeline connectors and spigot bands as required. • Isolation valves, bypass valves, inlet control valves and air/vacuum breakers. • Electrical installation relating to power for equipment operation, instrumentation and control. • Site drainage and scour discharge arrangements. (including erosion protection, design of outlets for ease of operations and de-chlorination for controlled water discharges to the environment and opportunities for water sensitive urban design). • Dosing and sampling pipework • Vermin proofing • Stakeholder engagement • Landscaping requirements, especially whether aesthetics will be impacted next to sensitive receptors e.g. residents.

Stage	Minimum submission requirements
90% Design	Update the 60% submission to a 90% level of detail and submit in addition the following: • Roof cladding details • Roof structure details • Foundation details • Tank floor and wall details • Column details • Where precast wall panels are proposed, full details of the grouting operations, including materials, bleed control additive, mixing equipment, pumping equipment and grouting procedures. • Where post-tensioned systems are used, full details of all stressing operations, including cable type and size, sheath type and size, concrete strength at transfer, number of jacks required, cable stressing method (one or both ends), cable stressing order, stressing load, allowable draw in and calculated cable extensions. • All jointing, sealant and water stop details • Outlet screen • Cathodic protection • Lightning and earthing system • Protective coatings • Landscaping • Boundary fencing • Erosion and sediment control measures • Drainage details, including tank underdrains • Level sensing and alarms • Security • Specifications • Commissioning plan • All other works that may be necessary to construct and commission a fully functional reservoir and associated works • Quality control documents.
Issued for Acceptance	• All Owner's Engineer comments must be closed out/resolved prior to IFC • Quality control documents with all Verifier comments closed out. • Independent Verifier report and certificate.
Issued for Construction	Update the 90% submission to a 100% level of detail and submit in addition the following: • Final detailing • Final controls • Final security systems • Restoration of the site.

4.8 SA Water stakeholders

As part of design development, it is critical that SA Water stakeholders provide input in their areas of expertise such that location specific risks and conditions are considered and a fit for purpose design is produced.

SA Water stakeholders include, but are not limited to:

a. Operators.

b. Water Quality Specialists.

c. Security Specialists.

d. Network Analysis.

e. Asset Management.

f. Environmental and Heritage Team.

g. SA Water Stakeholder Team.

h. SA Property Team (easement/land acquisition matters).

i. SCADA systems.

j. System Planning Team.

k. Engineering.

l. Infrastructure Planning and Strategy.

4.9 External stakeholders

External stakeholders need to be consulted as part of design development to enable location specific risks and conditions to be taken into account and a fit for purpose design is produced.

External stakeholders include, but are not limited to:

a. Department for Infrastructure and Transport.

b. Department for Environment and Water.

c. Environment Protection Agency.

d. Local councils, businesses, residents and landowners.

e. Adjoining property owners.

f. SA Power Networks.

g. Telecommunications providers.

Where applicable, approvals or letters of agreement from stakeholders/regulatory bodies shall be included in the Detailed Design Report.

5 General requirements

5.1 Storage components

The **Total Volume** of a tank is calculated as the volume between the **High Water Level (HWL)** and the **Finished Floor Level**.

Overflow level is generally at the HWL. However, depending on system performance the design can allow the overflow to be slightly higher.

The **Effective Volume** of a tank is calculated as the volume between the **High Water Level (HWL)** and the **Low Water Level (LWL)**. It is equal to the total volume less any dead storage.

The Operational Storage is the volume of storage associated with source or booster pump normal cycling levels times under normal operating conditions and is a subset to the equalizing storage components.

The **Equalisation Storage** of a tank is the volume of storage needed to supplement supply to consumers when the peak hourly demand exceeds the total source (pumping) capacity.

The **Emergency Storage** of a tank is to provide a measure of reliability should inflows fail or when unusual conditions impose higher demands than anticipated, e.g. fire flows or pipe breaks.

The **Dead Storage** in a tank is the bottom layer of water that should not be supplied to customers.

The depth of **Dead Storage** is typically 150mm, in order to prevent sediments from being drawn into the tank outlet, and to prevent the formation of vortexes and resultant air entrainment in the supply system. Refer Section 9.3.8.

Figure 1 schematically shows the various tank levels and storages described above.

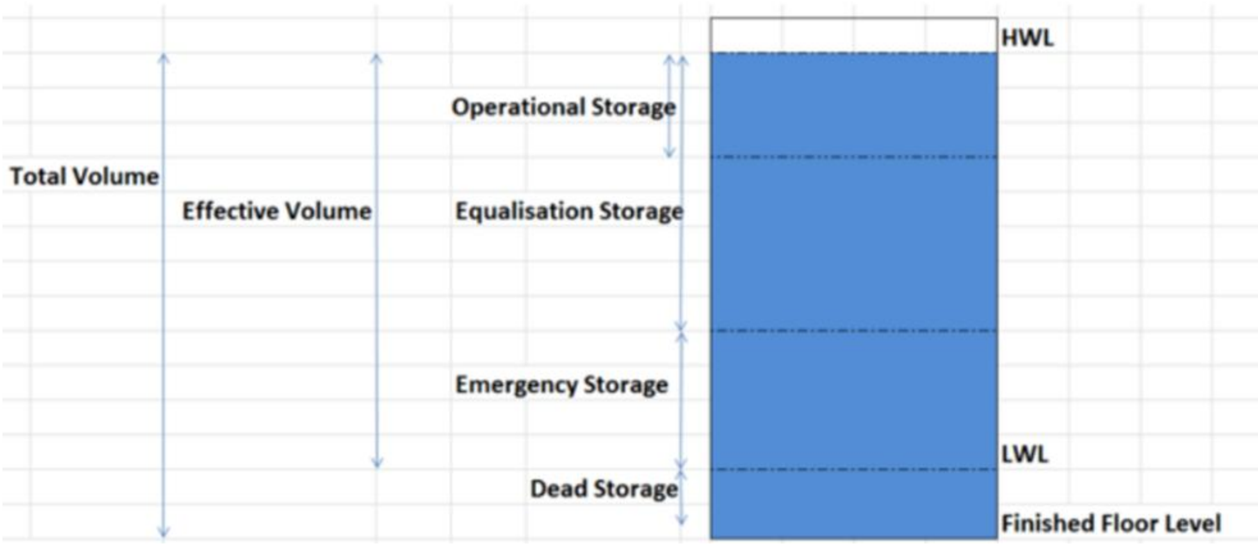

Figure 1: Tank levels

5.2 Hydraulic requirements

Tank capacity and water levels are usually determined by hydraulic modelling undertaken by SA Water System Planning Team and provided for design development purposes.

The required inflow rates, outflow rates, storage components, and capacities of tank/s to be incorporated into the SA Water supply system shall be determined in accordance with the SA Water System Planning Master Plan Report.

The sizes of tank fixtures, such as inlets, outlets, overflows, scours and vents, shall be determined during the concept or the detailed design phase. Refer to Section 8 and 17 for operational requirements and Tank Pipework and valves respectively.

The Design shall finalise the dead storage based on peak outflow, outlet pipe diameter and water quality.

Assessment shall be made on a site-by-site basis to determine if multiple tanks are to be installed in series or in parallel. The assessment should be inclusive of water quality risks and requirements and required hydraulic needs of the system.

On sites with multiple tanks the hydraulic system shall be balanced to avoid large differences in tank levels.

Where a multiple tank installation is proposed consider how further tanks can be easily added to the installation and allows provision for future connection with the existing tanks being in service.

5.3 Tank sizing

The dimensions and volume of a required tank are usually provided by SA Water to suit site requirements or to satisfy the hydraulic requirements of a scheme design.

Preferred tank storage volumes are:

- 50kL increment tanks up to 1ML
- 1ML
- 2.25ML
- 4.5ML
- 9.09ML
- for tanks larger than 10ML in 1ML increments.

The number and sizes of tanks to be constructed at a site shall be determined based on the adequacy of water supply to consumers through bypass and alternative supply arrangements during the maintenance period.

If adequate supply cannot be maintained during a prolonged refurbishment or maintenance period, at least two tanks will be required at the site.

Advice from SA Water System Planning and Asset Manager shall be sought to finalise the size and number of tanks.

5.3.1 Wall height and freeboard

The wall height of a tank is usually based on the High-Water Level requirement (HWL), set by hydraulics requirements.

Other considerations include aesthetic, planning and/or environmental requirements, and access to the roof with locally available hire equipment.

To enable inspections, maintenance, or repairs, the wall height should not exceed the lift capacity of commonly available elevating work platforms. Designers shall demonstrate that all elements requiring inspection and maintenance can be accessed by commonly available elevating work platforms.

Tank wall height shall be based on the maximum of:

a. A minimum 100mm airgap between the water head level above overflow level and the nearest surface of the steelwork of the roof structure measured at the lowest point of the roof (tank wall side).

b. A minimum of 300mm freeboard between the High-Water Level (HWL) and top of wall.

c. Wall height needed to accommodate the maximum wave oscillation generated by earthquake acceleration measured from the highest operating level.

In water tanks, the consequences of overtopping of the walls or damage to the roof under uplift pressure are unlikely to be significant damage to the walls and are unlikely to result in significant loss of liquid. Therefore, subject to SA Water approval via a TDRF, consideration may be given to using a lower seismic return period factor when checking overtopping or roof pressure than that used for the design of the tank walls.

Tank walls should not retain soil but if unavoidable soil backfill shall be to a consistent level all around the tank.

5.4 Tank materials

The selection of materials shall be based upon the requirements of this Technical Standard and the Technical Standards referenced herein. In particular, materials and their treatment shall be selected to enable compliance with the requirements of TS 0109 and TS 0110.

Refer Section 10 for the criteria to be considered in selecting tank materials.

Reference shall also be made to:

a. Section 12 for concrete tanks.

b. Section 13 for steel tanks.

c. Section 14 for plastic tanks.

5.5 Material of tank structural components

A consistent approach shall be taken during material selection for each structural component. For example, all components of a staircase including attached handrails, kick plates, stanchions, knee braces, and landings shall be of the same material; that is only steel or aluminium, unless noted otherwise on drawings/specifications. Where materials are mixed, these shall be assessed for dissimilar metals reactions.

Typically, material of tank structural components are as follows:

Table 4: Material of tank structural components

Component	Details	Material
Roof sheeting	Greater than 200m from marine and/or industrial influence	COLORBOND® Ultra steel
	Less than or equal to 200m from marine and/or industrial influence	Permalite®
Hook bolts	10mm with cyclone assembly and neoprene washers to suit the roof sheet profile	Steel (HDG 390)
Safe access	Sliding hatch, including attached guardrails, kick plates, stanchions, roof sheeting, wheel guides, and guide rails	Aluminium
	Grating, guard rails, kick plates, stanchions, self-closing gates, and stairway treads	Steel (HDG 500)
	Stair stringers, service platform beams, platform support beams, and knee braces	Steel (HDG 900)
	Flush mounted davit arm brackets	Stainless steel grade 304
Tank interior	Rafters, purlins, support beams, and cleats	Steel (HDG 900)
	Rafters, purlins, and support beams	Permalite® downturn lips
Bolts, nuts and washers	Tank interior	Stainless steel A4 to ISO 3506 with appropriate insulation
	Aluminium	
	Tank exterior – chemical anchors to concrete	
	Tank exterior – galvanised steel connections	HDG to AS 1214
Aluminium members	Tank exterior - aluminium members within 1 Km of coast	Anodized

5.6 Waterstops

Reference shall be made to SA Water Technical Standard TS 0464, which details the type, jointing, installation and location requirements for the use of PVC Waterstops in the construction of water retaining structures.

5.7 Equipment

Tank-related equipment includes, but is not limited to:

a. Switchboard containing metering, main distribution, PLC, telemetry.

b. Instruments for tank-level monitoring and alarms.

c. Area lighting and power.

d. Security system.

e. Lightning protection system.

f. Solar power supply system.

g. Pumps.

h. Mixers.

i. Chlorine dosing.

j. Transformer rectifiers.

k. Other ancillary electrical equipment.

Equipment installations shall comply with the relevant SA Water Technical Standards and Australian Standards, including but not limited to the following:

1. TS 0300 – Supply and installation of low-voltage electrical equipment.
2. TS 0302 – Stand-alone solar power supply systems.
3. TS 0350 – SCADA systems.
4. AS/NZS 3000 – Electrical installations.
5. AS/NZS 3008.1.1 – Electrical installations – Selection of cables – Cables for alternating voltages up to and including 0.6/1 kV – Typical Australian installation conditions.

As much as reasonably practicable, locate equipment, including electrical, instrumentation, controls and communications, so that it is accessible at ground level to eliminate the need for roof access.

Provide site GPOs at the main switchboard and instrumentation panel, with each GPO from a separate earth leakage circuit breaker.

5.8 Penetrations

The tank design shall be co-ordinated with the mechanical, hydraulic and electrical engineering design to enable all necessary embedments and penetrations to be fully designed and detailed and any thrust forces and corrosion considerations accounted for.

Safe access for maintenance and repairs shall be a major consideration with adequate space provided around pipes, flanges, valves, etc.

5.9 Design life

The SA Water Technical Standard TS 0109 defines minimum Design and Service Life requirements for infrastructure for consistency in design and detailing and to enable SA Water infrastructure to be constructed and commissioned to achieve a similar level of service and performance across South Australia.

The requirements established in TS 0109 are based on the criticality, redundancy and accessibility principles provided in Technical Standard TS 0110, as well as drawing on SA Water's extensive experience managing its infrastructure.

Design Life will vary according to the type and use of infrastructure or component being considered. The default minimum Design Life and Service Life values SA Water requires for infrastructure components have been summarised in tabular form in TS 0109.

Changes to the required infrastructure Design Life and/or Service Life before a project is initiated will be specified by SA Water's Infrastructure Planning and Strategy team based on project specific requirements that may differ from those presented in TS 0109, otherwise the default minimum values apply.

5.10 Durability assessment

The SA Water Technical Standard TS 0110 contains:

a. General durability principles to be applied to designs where formal durability planning is not required.

b. Durability Assessment Report (DAR) guidelines where durability planning is specifically specified to be required.

The purpose of TS 0110 is to enable consistency in durability concepts and planning for SA Water infrastructure projects.

5.11 Safety in design

The SA Water Technical Standard TS 0101 specifies the minimum mandatory requirements of the Safety in Design process that SA Water considers necessary.

TS 0101 enables key stakeholders to collectively identify and reduce health and safety risks associated with the design of assets for the whole of life, including construction, installation, commissioning, operation, maintenance, repair, demolition and recycling.

Safety in Design considerations for tanks and associated works shall be in accordance with TS 0101.

SiD documents shall be included as a subsection of the project's Design Management Plan.

Compliance with TS 0101 and other SA Water Safety in Design (SiD) documents will not, in itself, ensure compliance with WHS legislation or SA Water corporate WHS objectives. It is the designer's responsibility to ensure that designs comply with the WHS legislation.

5.12 Environmental assessment

An Environmental Assessment shall be undertaken throughout the design phase by the design team, in consultation with the assigned SA Water Environmental and Heritage team representative, to ensure that all environmental impacts and risks are identified and evaluated to avoid or minimise issues.

Engagement with the Environment and Heritage team will also provide opportunity to identify matters of environmental and heritage importance for example, avoiding impacts to listed heritage sites and native vegetation, through site selection and input into the project design.

The Environmental assessment will also consider whether project proposals require specialist assessments for required approvals and to enable compliance with environmental legislation and regulations.

Environmental and heritage risks to be considered include, but not limited to:

1. Aboriginal/European heritage – Sites to avoid or mitigate.
2. Native Vegetation – Avoiding or minimising impacts or clearance.
3. Stormwater discharge to the receiving environment/watercourses.
4. Opportunities to identify water-sensitive urban design principles to reduce and improve water quality runoff from sites.
5. Water Affecting Activities – Overflow and scour discharge to receiving environment to ensure appropriate erosion controls and ease of treatments such as de-chlorination.
6. Legal advice – Native Title status of land and/or Indigenous Land Use Agreement matters.
7. EPA requirements such as, but not limited to:
    a. Soil contamination management.
    b. Noise generation (construction and operational).
    c. Bunding and spill management of hazardous substances.
    d. Landscaping and revegetation – to minimise visual impacts of infrastructure upgrades, particularly near sensitive receptors.
8. Statutory approvals may include:
    a. Development approval – infrastructure upgrades and impacts or clearance to regulated or significant trees.
    b. Native vegetation clearance and environmental offsets.
    c. Water Affecting Permits.
    d. EPA Licenced activities.
9. Local Council requirements.

Environmental risks should be captured in project risk registers, and assessment inputs should be factored into each upgrade design proposal.

5.13 Noise assessment

The tank and associated works design shall consider the following and any other noise-generating items and minimise the impact on-site workers and neighbours:

a. Inlet water flow.

b. Hydraulic control valves.

c. External pumps.

d. Barometric loop.

e. Mechanical mixers.

f. Venting.

Operational noise levels are required to comply with the EPA Noise Policy and are of particular importance when upgrades are proposed in proximity to sensitive receptors, for example, residents.

Where noisy equipment is likely to be required as part of upgrades, noise modelling and acoustic treatments need to be factored in, as well as noise levels measured during commissioning.

5.14 Climate change

How to deal with climate change in Australia is a fundamental and far-reaching issue confronting our governments, people and infrastructure owners. Rising temperatures, changing rainfall patterns, higher sea levels and the increasing frequency, severity and intensity of extreme events such as heat waves, droughts and storms are issues needing consideration. A pre-emptive approach to adapting to our changing circumstances is preferable to dealing with the consequences of our inaction in the future.

The impacts of climate change may vary for different projects in different locations. The nature and extent of adaption in each situation will depend upon the costs and efforts involved compared with the benefits of adopting different adaption strategies.

In accordance with TS 0109 and AS 5334, a risk-based approach shall be undertaken to determine how the effects of climate change are incorporated into the design of tanks and associated works projects, noting the typically long service life of this infrastructure and its importance in the wider water supply network.

Use climate projections published by Department of Environment and Water (DEW), South Australia to inform climate change risk assessment. Most current projections are publicly available from https://www.environment.sa.gov.au/topics/climate-change/climate-science-knowledge-resources/latest-climate-projections-for-sa.

Reference shall be made to the Sustainability Considerations of TS 0109.

The climate change risk assessment shall form an Appendix to the Basis of Design Report with key adaption measures and design criteria listed in the body of the report.

5.15 Earthing, equipotential bonding and lightning protection

Due to the nature of and location of water storage tanks, all internal and external metallic structures, including platforms, handrails, stairs and posts shall be equipotentially bonded and connected to a suitable earthing system designed in accordance with AS/NZS 3000.

A risk-based lightning assessment study to AS 1768 shall be conducted to determine the necessary elements of a lightning protection system for each installation. Depending upon the type of tank construction and the outcome of the risk assessment, this may involve the design of an engineered lightning and earthing system.

All electrical distribution boards, switchboard, control panels, instrumentation data networks and telecommunications equipment shall be protected against power surges, equipotentially bonded and connected to the earthing system.

As a guide, based on the above, Table 5 provides a summary of the minimum requirements for various water tank design configurations and construction materials.

Table 5: Minimum requirements for equipotential bonding of tanks

<table>
<tr><th>Location of tank</th><th>Supported on</th><th>Tank material</th><th>Roof material</th><th>Minimum requirements</th></tr>
<tr><td rowspan="3">Ground level</td><td rowspan="3">N/A</td><td rowspan="2">Concrete</td><td>Steel</td><td>Two down conductors connecting metallic roof to the earthing system.</td></tr>
<tr><td>Concrete</td><td>No earthing requirements for the tank required. Any external metallic structure must be equipotentially bonded and earthed.</td></tr>
<tr><td>Steel</td><td>Steel</td><td>Earth base of tank at two connection points to a grading ring.</td></tr>
<tr><td rowspan="4">Elevated</td><td rowspan="2">Concrete columns or shaft</td><td rowspan="2">Concrete</td><td>Concrete</td><td>Equipotential bonding and earthing of internal metallic structure (reinforcement bars).</td></tr>
<tr><td>Steel</td><td>Two down conductors terminated into an earth system. Equipotential bonding and earthing of internal metallic structure (reinforcement bars).</td></tr>
<tr><td>Concrete columns</td><td>Steel</td><td>Steel</td><td>Two down conductors connecting metallic roof and tank to the earthing system.</td></tr>
<tr><td>Steel frame</td><td>Steel</td><td>Steel</td><td>Earth base of tank and steel frame at two connection points to a grading ring.</td></tr>
</table>

5.16 Asset labelling and signage

The SA Water Technical Standard TS 0133 specifies the requirements for consistent asset labelling of SA Water infrastructure assets.

TS 0133 shall be used by constructors to order labels and by suppliers to produce labels.

Provision shall be made for security signage to be wired to perimeter fencing all-round the site at the spacings specified in TS 0121.

AS 1657 covers the selection, design, risk assessment and testing of fixed platforms, walkways, stairways and ladders and mandates permanent labelling to verify compliance, namely to:

a. Identify the designer, fabricator, installer and certifier.

b. Provide effective product recalls of faulty equipment.

The Constructor shall supply and install labelling compliant with AS 1657.

In addition to TS 0133 and AS 1657, safety signs shall comply with AS 1319 Safety signs for the occupational environment.

Provision shall be made to show the tank name and number at a suitable location visible from the adjacent public road. In designing these signs, the materials and colours shall be chosen not only to be sympathetic with the landscape, but also to ensure that the sign will be durable, readily seen and easy to read. The height of lettering may need to be varied according to the distance which it is intended to read.

5.17 Security

Security against unauthorised access is vital to the protection of water quality and continuity of supply.

Security measures shall be assessed for each site and shall consider the previous history of unauthorised access and likelihood of future unauthorised acts.

All security requirements shall be discussed with SA Water's Security Team

A site-specific Security Risk Assessment may be required for the project.

The SA Water Technical Standard TS 0120 defines the minimum installation standards for electronic security at SA Water sites. All works shall be carried out in accordance with these installation requirements and to other appropriate Australian Standards.

The SA Water Technical Standard TS 0121 defines the minimum installation standards for physical security at SA Water sites. All works shall be carried out in accordance with these installation requirements and to other appropriate Australian Standards.

6 Site selection and layout

6.1 Site selection

The selection of the tank site location is largely influenced by the:

a. Water supply network hydraulic analysis and requirements.

b. Proximity to pipelines.

c. Tank elevation above sea level.

d. Environmental assessment.

e. Water quality requirements.

f. Land ownership and easements.

g. Aboriginal and European Heritage impacts.

h. Impact on native vegetation and fauna.

However, as a minimum, the following shall also be considered in the concept design phase:

1. Sufficient buffer from houses, built-up areas and future development.
2. Discuss the proposal with stakeholders, such as the local authority, native title claimants, adjacent and nearby property owners etc.
3. Minimizing costs and risks.
4. Site topography and geotechnical conditions/foundation suitability.
5. Accessibility for construction and maintenance considering the equipment involved.
6. Power availability.
7. Communications availability.
8. Adequacy of stormwater drainage.
9. Flood levels.
10. If possible, locate the tank so as to not change the skyline from significant viewpoints.
11. Use significant existing vegetation, if available, to provide screening for the tank subject to meeting the requirements for Bushfire Protection, or alternatively, provide for landscaping with indigenous species to provide screening for the tank.

6.2 Site layout

The layout of the tank site and associated works shall consider:

1. Dimensions of the tank site to accommodate anticipated future works, including:
    a. De-chlorination chamber.
    b. Overflow onsite detention.
    c. Scour sump.
    d. Sludge capture.
    e. Crane pad.
2. Locating ancillary structures on the tank site away from major viewpoints.
3. Locating the security fence as close as practical to the cleared tank site, allowing for bushfire protection.
4. Preferably routing pipes to the tank along the access track in order to minimise clearing of vegetation and increasing distance away from bushfire fuel load.
5. Designing tank site earthworks to blend with natural contours and to minimise scour and erosion.
6. Select the most favourable ground to optimise earthworks and foundation designs.
7. Avoiding retaining walls where possible due to expense, required fall protection and ongoing maintenance.
8. Maintenance and operational access for the tank and general site-related access for major inspections, i.e. trucks, scaffolds, and cranes, need to be considered when looking at the overall site footprint and location.
9. Crane pad size and location to enable crane set up such that the crane hook can be positioned directly over the centre of the roof hatch in the tank roof.
10. Control and safe discharge of scour overflow and stormwater.
11. Rehabilitation of the site upon completion of the work.

6.3 Site survey

The SA Water Technical Standard TS 0103 details SA Water accuracy requirements for surveys. The survey accuracy requirements given in TS 0103 shall apply to all survey types.

In scoping a Design or Site Survey, the Design Team should consider:

a. Uncertainty over the final location of the proposed new infrastructure.
b. The need to locate existing utilities by potholing or other non-destructive methods.
c. The need to lift/open access covers to obtain pit invert or pipework levels.
d. Adequate pickup of vegetation information, including heights and spread.
e. Easements.
f. The extent of work required to match into existing infrastructure beyond the site.
g. Likely construction access and laydown areas.

6.4 Bushfire prone areas

SA Water is responsible for construction, operation and maintenance of infrastructure within state-wide Bushfire Prone Areas.

While existing Australian Standard AS 3959 and South Australian legislation provides guidance to the design and construction of residential properties within Bushfire Prone Areas these documents do not consider the unique built form and criticality of SA Water assets.

The Technical Standard TS 0700 (formerly TS 0601) gives designers guidance such that new infrastructure will be more resilient to the damaging impacts of bushfires. The process of identifying, designing, operating and maintaining assets within Bushfire Prone Areas is described in TS 0700.

A bushfire expertise, meeting the minimum experience requirements and holding one of the certifications listed in TS 0700, shall be responsible for ensuring that the design and construction work is completed in accordance with TS 0700.

6.5 Hardstands and access roads

Design of the siteworks shall include hardstand, paving and access roads so that material, equipment and vehicles have access to the full perimeter of the tank, and its associated infrastructure, for operation and maintenance activities.

To prevent erosion from roof runoff, a concrete apron, suitable to support an elevated work platform, shall be provided around the tank perimeter with appropriate cross fall, jointing and sealing. The minimum width of the apron shall be in accordance with Table 6.

A minimum 4.5m wide single lane all weather access track shall be provided from the adjacent roadway that enables for a 12.5m heavy rigid vehicle, in accordance with AS 2890.2, to access the tank.

Adjacent, the tank perimeter concrete apron provides a minimum 4.0m wide all-weather access track around the tank perimeter that connects to the all-weather access track from the adjacent roadway. The design of the access track shall consider the location of the safe access system such that a full perimeter access is provided.

A rock apron may also be considered around the tank perimeter, with prior TDRF approval from SA Water.

A dedicated all weather crane pad shall be provided such that a 100-tonne crane can position its crane hook over the centre of the tank roof access hatch with a 5-tonne safe lifting load capacity.

The remainder of the hardstand may be an unsealed pavement. Bitumen or concrete pavement could be used for this section of the hardstand if better quality access around a tank is required.

Access roads shall be designed in accordance with Austroads, DIT pavement details and materials and SA Water standard drawing 94-0163-12.

Vehicle access from the adjacent Council or DIT roads shall be in accordance with the road authorities' standards with a design vehicle turning path provided.

The design vehicle operating speed shall be 10 kmph, and this shall be clearly signed near the entry gates.

Design of handstands and access roads must address drainage management and design, to enable controlled runoff from site which does not cause long term erosion management issues.

Refer to TS 0109 for the minimum design life required of paths, hardstands and pavements.

Table 6: Minimum tank apron width

External tank diameter	Minimum tank apron width
≤32m	1000mm
>32m	1500mm

6.6 Stormwater drainage

Roofs covering SA Water tanks shall not be fitted with gutters. All rainwater shall be allowed to run freely off the roof.

The site should be graded or drained so that water cannot pond against or near the proposed tanks. This drainage requirement should be maintained for the economic life of the tanks. The designer shall consider the constructability aspects so that the tank sites are kept well drained during the preparation for footing construction, to avoid wetting and softening of the foundation strata.

For site drainage, the combination of perimeter concrete paving, surface drains, pipe drains, subsurface drains, soakage pits/detention basins and formed overland flow paths shall be designed and constructed such that:

a. Damage to the tank and its foundations is prevented.

b. Damage to associated infrastructure is prevented.

c. A safe working environment is provided for operations and maintenance personnel.

d. The requirements of AS/NZS 3500.3 are complied with.

e. Water sensitive urban design principles are considered for example, use of detention basins and drainage swales with aquatic plantings to reduce and improve water quality runoff to watercourses.

f. The requirements of the local Council and its stormwater policies are complied with.

The stormwater drainage system shall be designed to contain stormwater within surface drains, pipe drains or formed flow paths for the following average recurrence interval.

Table 7: Stormwater average recurrence interval

Effect of surcharge – overland flow	Average recurrence interval
Minimum average recurrence interval	10 years
No ponding against adjoining buildings or impeding access	20 years
Where it presents a hazard to people and vehicles or cause any damage to the tank foundation, associated SA Water infrastructure or adjacent areas and properties.	100 years

Where PVC stormwater pipes are appropriate to be used, they shall be a minimum DWV SN8 grade pipe. The design and installation of flexible pipes shall be in accordance with AS/NZS 2566.1 and AS/NZS 2566.2.

Surface and subsurface flows, any stormwater discharge from adjacent land onto the SA Water site, flows from sub-soil drains, flows from tank overflow and scour discharges shall all be considered.

Erosion protection of all surfaces, including cut or fill slopes, shall be addressed as part of the design.

6.7 Other siteworks associated with tanks

When undertaking site works design, site-specific considerations shall be considered, including, but not limited to:

a. A level platform at the nominated height suitable to support the tank base slab considering the tank design requirements and geotechnical conditions. Tanks shall be founded uniformly.

b. A bench beneath a tank made by cut and fill of the site may be acceptable, provided that geotechnical advice has been provided and followed on a site-specific application.

c. Siteworks design is satisfactorily carried out to cater for site-specific characteristics and other design requirements.

d. Any soft areas shall be excavated and replaced with geotechnically approved materials, particularly over rock of varying depth or quality.

e. Grading of the site so that roof and site water drains away from the tank foundations so as not to adversely affect the tank base or subgrade.

f. Providing stable embankment slopes designed to suit the material type in accordance with geotechnical engineering recommendations.

g. Suitability of site-won materials for reuse on site.

h. Safe discharge of stormwater so as not to affect adjacent properties.

i. Safe discharge of tank overflows and tank scour so as not to affect adjacent properties.

j. Erosion protection to all surfaces, including cut and fill slopes, tank overflow, scour discharge and stormwater discharge.

k. Cut-off drains shall be provided at the base of slopes above the tank formation level. The cut-off drains shall be graded such that ponding of water does not occur between the tank and the embankment. Good drainage of the site is especially critical where tanks are not found on the rock.

l. Need for a Control Building.

m. Spatial requirements, locations and clearances to switchboards, SCADA panels, communications equipment, antennas and alike.

n. Access – both short-term to enable construction and long-term for maintenance.

o. Clearances to overhead and underground services.

p. Effect of cut/fill on adjacent structures or trees.

6.8 Landscaping

SA Water is one of the largest land holders in the state, which comes with a large responsibility and opportunity to lead by example in the management of land.

SA Water tank sites, particularly in the metropolitan area, have been identified as providing opportunity for progress against aspects of SA Water's environmental, customer and community corporate strategies.

Landscaping design shall maintain, as far as practicable, the aesthetics of the area.

The landscaping design shall cover all of the site affected by the works and be in compliance with associated Development approval conditions or stakeholder engagement expectations.

In developing the landscape design, the following shall be considered as a minimum:

a. Choices of flora shall be local natives suitable to the area and following consultation with the local Council and/or stakeholders.

b. Mature size of vegetation to avoid future overhanging of infrastructure.

c. Avoidance of planting large tree species in the vicinity of services and under powerlines.

d. Subject to Environmental team assessment, trees and vegetation shall be removed in the vicinity of tanks consistent with SA Water's Standard Operating Procedure for Native Vegetation, endorsed by the Native Vegetation Council, to mitigate potential tree limb damage, moisture changes and interference to footings due to tree roots.

e. Reference shall be made to TS 0700 in general and Section 9.1 Perimeter Protection in particular.

f. Surface treatments shall prevent scour from rainfall runoff.

g. SA Water Landscape Design Management Guidelines, Environment and Heritage Services shall be followed.

The development of garden beds should not interfere with the drainage requirements. Garden beds should not be established immediately adjacent to tanks and care should be taken to avoid over-watering of garden beds near to tank footings. All trees and gardens should be provided with adequate watering during dry periods to avoid the foundation strata drying out and affecting the performance of the footing system.

For guidance on tree clearance considerations, refer Section 10 of TS 0136 and the references therein and the SA Water Technical Guideline TG 0650.

7 Geotechnical works

The scope of works shall be undertaken in accordance with AS 1726 and TS 0632.

A site-specific risk assessment for evaluating health, safety and environmental impacts shall be developed for the project, including the geotechnical investigation aspects, to ensure adequate controls are in place to minimise the risks.

Nonetheless geotechnical investigations shall be informed by the ultimate user of the information (e.g., designer, constructor, etc.) so that the report can meet their requirements.

The geotechnical design shall include, but not limited to:

a. A review of available geotechnical investigation data. Any identified gaps in the geotechnical data shall be confirmed early in the project phase. A supplementary investigation shall be caried out to inform the design.

b. A review of existing conditions and proposed tank design.

c. Producing ground models, based on geotechnical data.

d. Develop characteristic geotechnical design parameters for the geotechnical design works.

e. Geotechnical design recommendations.

f. Slope stability assessment and ground improvement analysis.

g. Update Project Risk Register, Safety in Design Register to include all geotechnical risks.

7.1 Geotechnical investigation and interpretation

A geotechnical investigation shall be undertaken by a suitably qualified Geotechnical Engineer or Engineering Geologist:

a. To meet the minimum requirements of TS 0632.

b. In accordance with AS 1726.

A review of the ground conditions is required, addressing the following tank specific geotechnical issues:

1. Geotechnical risks associated with problematic materials as listed in AS 1726 including, but not limited to:
    a. Acid sulphate soils.
    b. Arid soils.
    c. Collapsible soils.
    d. Dispersive soils.
    e. Reactive soils.
    f. Soils that will liquefy under the design earthquake.
    g. Soft soils.
    h. Soils with organic contents.
    i. Non-engineered fill.
2. Groundwater (both perched and true groundwater tables, including fluctuation of groundwater) and associate subdrainage requirements.
3. Assess potential risk of foundation damage (for example dissolution, softening, piping etc.) due to tank leakage or other water flows.
4. Derivation of ground model and geotechnical design parameters, including:

a. Site classification in accordance with AS 1170.4, such as site sub-soil class and earthquake hazard factor.

b. Site classification in accordance with AS 2870, for soil reactivity.

c. Aggressiveness of the soil and groundwater to relevant standards.

d. Ground compositions.

e. Geotechnical strength and stiffness design parameters.

f. Design parameters for deformation/compressibility.

7.2 Geotechnical design

The geotechnical design for tanks shall be in accordance with the relevant Standards, Codes and Guidelines.

The design shall include the following as a minimum:

1. Selection of suitable footing types.
2. Geotechnical design of the selected footing type.
3. Assessment of ground movement, especially total and differential settlement of the selected footing.
4. Design assessment for construction staging, including:
   a. Earthworks requirements shall be as per TG 0631 including but not limited to:
      - Site preparation.
      - Bulk cut including excavatability, slope and associated retaining structures.
      - Bulk fill including filled batter, reuse of onsite materials, compaction and associated retaining structures.
      - Erosion protection and maintenance.
      - Earthworks quality control.

   b. Loading stages.
   c. Stability analyses for both short and long terms and design earthquake.
   d. Consolidation assessment from construction phase to the end of the design life.
   e. Design for earthquakes. Including liquefaction assessment.
   f. Design of associated access:
      - Trafficability during construction.
      - Pavement for permanent access.
5. Construction phase inspection, instrumentation and monitoring.
6. Incorporate durability design, allowing for aggressiveness of the soil and groundwater (pH, chloride, sulphate and electrical conductivity).
7. Design parameters for buried pipelines.
8. Pipework thrust restraint.
9. Permeability assessment of soil to help determine location and size of sumps.
10. Dewatering assessment (if required).

7.3 Foundation settlement monitoring

Settlement measurement pins (DN20) shall be cast or chemically anchored into the reinforced concrete tank shell or welded to the wall plate of steel tanks. The pins' location shall be accessible above ground for ongoing survey and monitoring. The pins material shall be selected to suit the shell construction materials.

The minimum number of pins shall be four (4 off.) for tanks of capacity less than 4.5ML, and eight (8 off.) for larger tanks.

Refer to Section 18.2 of this Technical Standard for monitoring surveying requirements before and after first filling of the tank, to measure foundation settlement.

7.4 Assessment of underdrainage requirements

All tanks leak to various degrees.

Concrete tanks typically leak through joints, unhealed large cracks, and voids in poorly sealed form tie holes or in the concrete mass due to poor compaction.

Welded steel tanks can leak through poor welds, and with time through the corroded, unprotected underside of the floor plates.

Lined tanks can leak through pinholes in the liner or poor weld at the seams.

Any leakage through tank walls or the wall/floor joint is easily observed from outside the tank and can be repaired. However, leakage through the floor is generally unquantified (unless it is massive), and therefore presents a "known unknown" type risk of foundation damage.

If the foundation is susceptible to leakage water, possible foundation saturation, weakening, damage or dissolution may result. The foundation damage may be dissolution of the foundation rock (generally limestone) or a softening, weakening or swelling of weathered rock/clay foundation.

7.4.1 Foundation susceptible to leakage water

For foundation materials susceptible to leakage water, a detailed site investigation by an experienced geotechnical engineer shall be undertaken in order to assess the susceptibility of foundation damage by tank leakage and groundwater seepage.

The investigation shall be of sufficient extent in plan and depth, covering the tank zone of influence to a depth where the additional load resulting from the tank is negligible relative to the existing in-situ stresses, and use appropriate investigation techniques in order to sufficiently characterise the site's geotechnical issues.

The geotechnical issues investigated shall cover, but not be limited to:

a. Understanding of the site hydrogeology and groundwater flow regime.

b. Groundwater pressures that pose a risk of damaging the liner.

c. Range of possible foundation saturation.

d. Long term erosion/foundation damage or alteration by leakage.

e. Underdrainage performance.

f. Soil erodibility and dispersivity.

g. Foundation piping risk due to leakage or groundwater flow.

h. Global and local stability of the tank foundation under the full matrix of operating and loading conditions.

i. Cavities and/or sink holes.

j. Weak shear planes in soil and rock.

k. Vertical settlements (primary and secondary consolidation, creep, collapse of calcareous particles, etc.).

l. Swelling pressures.

m. Horizontal movements.

n. Surface erosion.

o. Surface drainage requirements, including surface water courses, tank overflows and scouring, and rainfall storm runoff.

p. Sub-surface drainage requirements, including groundwater and tank leakage collection.

7.4.2 Design measures

For foundation materials susceptible to leakage water, the following design measures shall be implemented, unless approved otherwise by TDRF:

1. An early detection system in the form of sub-surface drainage and tank leakage collection.
2. Limit crack width of tank concrete floor to 0.1mm or uncracked section for post-tensioned.
3. Minimise penetrations in floor slab by:
   a. Combining outlet and scour and control by a valve. Refer Section 8.2.
   b. Inlet and overflow penetrations through tank wall.
4. Design access way around the tank to shed water away and prevent ponding against tank foundation, as part of the overall stormwater design.
5. Increase acceptance criteria of tank hydrostatic water testing to "No measurable loss" as per TS 0600.

8 Operational requirements

8.1 General

Each of the SA Water's regions may have specific operational requirements for a proposed tank.

Regional requirements shall be investigated during the definition or the Concept Design phase and be resolved before commencing the design.

8.2 Scour

Tanks shall have a suitable means of scouring unusable water and for cleaning purposes.

Scour discharge points shall include allowance for:

a. Scour protection/energy dissipation.

b. Trapping of sludge for collection/pump out.

c. Means for preventing vermin entering the pipes and storage.

The rate at which water is released from the scour depends upon the:

1. Flowrate the receiving environment can safely disperse.
2. The capacity of the means of de-chlorinating the scour water.

Scour point discharge locations must have sufficient erosion protection factored in the design and capability to control flow rate, as well as ability to de-chlorinate water where flow is expected to enter a natural waterway.

Planned discharges to the natural environment require assessment and approval under the SA Water Best Practice Operating procedure for Water Affecting Activities through a Discharge Request Form to comply with environmental regulations.

Discharge volume amounts should be avoided e.g. reuse, or minimised where possible with appropriate planning.

Determine the appropriate scour flow rate and, hence, time to empty the tank and review with SA Water's Representative.

Refer Section 17.7 for scour pipework.

8.3 Overflow sump

An overflow sump is required on tank sites where there is no suitable alternative for emergency overflow discharge.

Alternatives may include overland flow or a piped drainage system.

The Overflow Sump capacity shall be subject to a risk assessment that considers the following factors:

a. Time to detect an overflow, taking into consideration the alarms and telemetry and their reliability.

b. Likely time required to rectify the overflow condition.

c. Consequences of a sump overflow.

The sump embankments or walls shall be designed and constructed to be stable under all loading conditions.

A stable emergency overflow shall be provided in the sump embankment as a safety measure.

A controlled discharge into a street drain would be preferable to uncontrolled failure of the sump.

Sumps shall have access for cleaning by earthmoving plant such as a front-end loader or a skid-steer loader. Sumps should be enclosed by a safety fence which can be the site fence.

Where the construction of a sump is impractical, alternative measures shall be determined on a case-by-case basis.

In some cases, drainage of overflow water has been directed into the local drainage system with the agreement of the local authority after meeting environmental requirements.

Where a sump is not practical, design must address the:

a. Erosion protection for discharge outlets.

b. Ability for operators to capture potential sludge/sediments from the tank as these are not permitted to be discharged into the environment.

c. Treatment methods such as de-chlorination, especially in proximity to natural watercourses.

8.4 Scour sump

A scour sump shall be provided where an overflowing sump is not available, or there is no environmentally acceptable discharge location. The material to be discharged could be tank floor sludge and must be fully contained.

The capacity of a scour sump for a tank should be adequate to accommodate the following:

a. The unusable water.

b. A volume equivalent to the volume in the tank to a height of 300mm above the outlet pipe level.

c. As agreed with the SA Water asset manager and environmental representatives, based on the cleaning process to be adopted.

d. Controlled overflow with erosion protection and positioned as far as practical from natural waterways.

If the depth of the sump is greater than 300mm, the need for safety fence and access for cleaning shall be assessed and provided as necessary.

Generally, a temporary sump/lagoon or vac truck are used pending tank size and the presence of Asbestos Cement pipes. In some cases, a scour sump/lagoon is built for ongoing raw water/sludge cleaning purposes.

8.5 Underdrainage collection sump

Where sub-surface drainage and tank leakage collection system is envisaged as per Section 7.4, an underdrainage collection sump shall be constructed.

The sump shall be:

a. Fitted with inflow measurement system linked to the SA Water SCADA system.

b. Designed and constructed from reinforced concrete to a standard of a liquid retaining structure for waterproofing (infiltration and exfiltration of water).

c. Raised 250mm above surrounding ground to prevent surface water ingress.

d. Fitted with light weight cover for manual handling without the need for lifting equipment.

e. Accessible to the Operations and Maintenance team.

f. Located in non-trafficable area.

8.6 Inflow control

The design of inflow control to a tank should be determined through hydraulic modelling in the concept design phase and take into consideration network and site-specific conditions.

Inflows to tanks are usually controlled by:

a. Pressure measurement (hydrostatic pressure of liquid head) linked to an actuated valve and/or pump.

b. Limit Pressure switches linked to an actuated valve and/or pump. The valve may be hydraulically or electrically actuated.

c. In remote areas with no power or signal and subject to an approved TDRF a float valve and hydraulically operated valve can be used.

Electronic measurements of levels shall be linked to the actuated valve or pump through an approved device for control, typically this will be an RTU or PLC. The inflow control measurement system shall be linked to the SA Water SCADA system.

8.7 Level measurement

Telemetry must be available to remotely read and regulate storage levels. As a minimum, all tanks must have their level visible on SCADA with the ability to change tank set points.

Any flowmeters or analysers that are installed must also be visible on SCADA.

Instrumentation panels, antennas and other equipment associated with telemetry must not overhang the roof as this can create nesting or roosting locations.

Consideration should be given to the criticality and consequences of measurement failure. Duplication of the pressure transmitter or a backup measurement type (such as pressure switches) shall be used to provide security of the measurement if it is deemed required for the measurement/control point.

Instrumentation and any associated equipment valves shall be accessible at ground level. Where instrumentation or associated equipment is roof mounted, this will require dispensation by SA Water demonstrating safe access and frequency of maintenance required.

8.8 Safe access system

8.8.1 Definition of safe access system

Safe Access System is an Engineering solution that eliminates (or as far as reasonably practical minimises) the use of administrative controls and PPE.

It includes three distinct activities:

a. Access from ground to top of the tank.

b. Working on top of the tank.

c. Internal access.

The requirements for these three activities are stipulated in details in TS 0720 and associated typical safe access drawings.

8.8.2 Design standards

Design of a safe access system shall be undertaken in accordance with the following technical standards:

a. SA Water Technical Standard TS 0720, which details minimum requirements for access systems for tanks of different sizes and construction.

b. SA Water typical safe access drawings.

c. AS 1657 Fixed platforms, walkways, stairs and ladders.

The design of the safe access system shall be developed in consultation with Engineering and Operations and Maintenance team prior to the completion of the Concept Design.

8.9 Bypass/isolation

During design, the ability to bypass or isolate a tank shall be considered for reasons including but not limited to:

a. Water quality/cleaning.

b. Other maintenance.

c. Refilling pipelines after burst repairs are complete.

d. Low demand.

The design shall adopt the use of double isolation.

Reference shall be made to section 17.8.

9 Water quality requirements

9.1 Background

The structural and functional design of a tank has a significant impact on water quality.

To enable the protection of public health, adherence to the Australian Drinking Water Guideline (ADWG) and Regulatory compliance in SA Water's drinking water systems, water quality impacts must be considered in tank design, construction, operation and management.

While the following serves as a guideline for best practice in design and construction of storages for optimal water quality, for each new tank an SA Water, Water Quality Specialist shall be consulted for further clarification and/or assistance, as system source or site-specific idiosyncrasies may lead to a variation in requirements.

9.2 Material compliance

All materials within the interior of potable water tank storages shall comply with AS/NZS 4020 and TS 0800.

9.3 Storage design

9.3.1 General considerations

Long detention times, improper sealing of the tank, hydraulic short-circuiting or poor mixing may lead to the deterioration of water quality in tanks, including:

a. Bacterial regrowth in the tank as a result of loss of disinfectant residual.

b. Increased formation of disinfection by-products.

c. A reduction or loss of disinfectant residual in the distribution system.

d. Nitrification of the storage and downstream distribution system.

e. Fouling of water causing taste and odour issues.

f. Increased turbidity from biofilm growth.

"Mixing and water age are two related phenomena that affect the water quality within water storage tanks. Overall, minimising detention time and promoting effective mixing of water should be an implicit objective in the design and operation of distribution system storage facilities" (Grayman, Walter, Rossman, Lewis, Deininger, Rolf, Charlotte; et al *American Water Works Association*. Journal: Sept. 2004).

9.3.2 Detention time

Long detention times promote disinfectant residual decay. Increased water age also promotes an increase in the formation of disinfection by-products.

Tank storages must have the ability to vary storage levels (and hence volume of storage) depending on the demand. This allows for shorter detention time in the storage depending on the demand on the system.

The use of float valves is **not** permitted.

Overdesign must also be avoided as redundant storage leads to decreased volumetric change and older water. The minimum/maximum number of days for which a tank should be designed will be site dependant (consultation with Treatment and Network Planning is essential). The travel time before and after the water's entry into the tank and the potential for water to move from one tank to the next sequentially are among other factors to be considered when determining acceptable detention time within storage.

9.3.3 Mixing

Uneven mixing can result in the formation of dead zones or older water within the tank.

Thermal stratification may also occur due to temperature differences between the inflow and the ambient water temperature. Both negative buoyancy (when the temperature of the inflow is lower than the ambient water temperature) and positive buoyancy (when the temperature of the inflow is above the ambient water temperature) have the potential to lead to ineffective mixing and stratified conditions within the tank. The critical temperature difference should be calculated to establish the potential for stratification for a given tank geometry and ambient and inflow temperature conditions.

Studies indicate mixing is maximized where separate inlet and outlet pipes are located on the bottom of the storage, on opposite sides of the storage, and placed near the storage wall (Roberts et al 2006; Mahmood et al 2005).

Directional nozzles can also assist by reducing diameter and increasing velocity as water enters a tank.

9.3.3.1 Separation of inlet/outlet

Separate inlet and outlet pipes shall be provided when designing a tank. The position of the inlet and outlet must be discussed and agreed with SA Water and must be designed to promote mixing and avoid short circuiting. The use of flow directors may be a preferred option in some cases.

9.3.3.2 Orientation of inlet and outlets to enhance mixing

The orientation of an inlet to the outlet shall be between 60 degrees and 90 degrees.

An inlet nozzle is generally directed into the tank at the following angles to the planes passing through it as shown on Figure 2:

a. 60 degrees to the radial vertical plane.

b. 45 degrees to the horizontal plane.

The design shall ensure that the proposed arrangement will not introduce turbulence when the water level is low and introduce air into the water that may find its way into the distribution system.

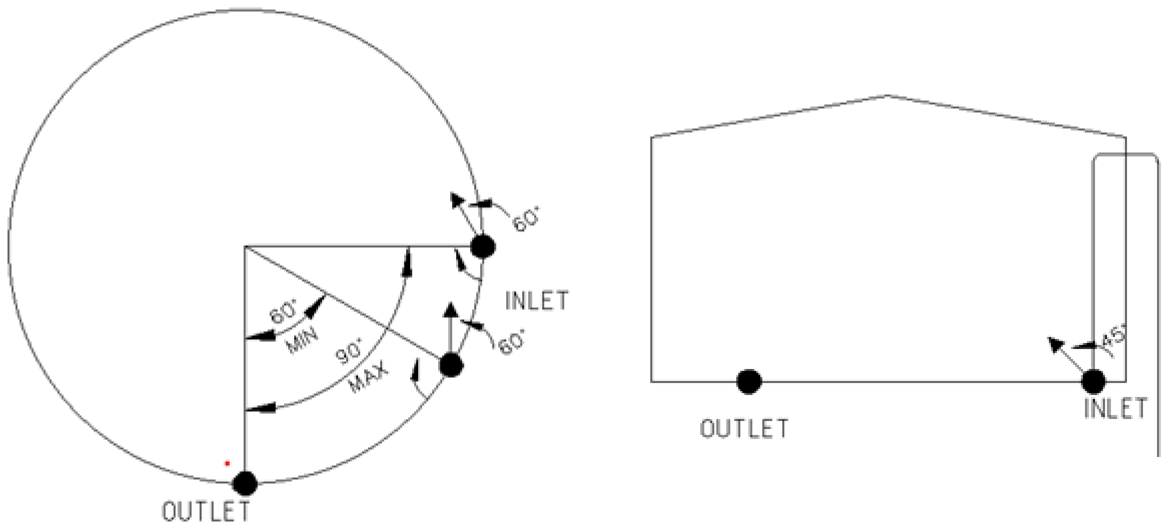

Figure 2: Tank inlet/outlet arrangement

9.3.3.3 Inlet Momentum

Inlet momentum is also a key factor for mixing of water in tanks. The higher the inlet momentum, the better the mixing characteristics. Increasing flow rates may be limited by system hydraulics. In such cases it may be feasible to increase inlet momentum with a reduced inlet diameter (Mahmood et al 2005).

9.3.4 Computational fluid dynamics modelling

If the Designer/Constructor cannot clearly demonstrate through hydraulic modelling that average mixing velocities above those listed below can be achieved with the tank inlet/outlet design proposed, then a more detailed analysis shall be undertaken.

Computational Fluid Dynamics (CFD) modelling is the preferred analysis and predictive tool to model flow of water within the tank and demonstrate the level of mixing/circulation achieved. The modelling should also consider temperature effects if the critical temperature thresholds for stratification (calculated based on available empirical formulae) are likely to be exceeded.

The CFD modelling should be used to understand the following aspects within the tank:

a. The effect of the mixing system to avoid short-circuiting and stagnant zones associated with stratification and low mixing velocities.

b. Inflow jet behaviour within the tank via the use of visualisation methods such as streamlines.

c. Average and maximum water age within the tank in all operating configurations.

d. A tracer model to understand disinfectant concentrations and deviation over the course of time.

While, at times, it can be difficult to predict what a suitable mixing velocity should be to achieve the above objectives, SA Water's experience indicates that average mixing velocities >1cm/s throughout the entire storage volume are deemed sufficient.

A successful CFD output would incorporate a timeline of outputs and demonstrate that >90 % of the velocity exceeds 1cm/s.

Where temperature stratification effects need to be considered, a temperature threshold of 0.1°C/m should not be exceeded in more than 30% of the tank volume.

If the CFD modelling indicates that adequate mixing cannot be achieved, then options should be discussed with the project stakeholders, including the relevant Technical Services Officer (TSO), to determine the best mixing method(s) and whether mechanical mixing needs to be considered.

9.3.5 Internal baffles

Internal baffles are sometimes placed in large distribution system storages to direct and control flow, usually large earth-lined storages.

In tanks where mixed flow is preferable to plug flow, the introduction of baffles inhibits mixing and can produce both stagnant and poor mixing zones thus, for most circumstances in distribution storages, baffles should be avoided (Grayman 2005).

9.3.6 Electric mixers

Electric mixers may be used in certain circumstances to improve mixing in tanks. However, the size, location and mixer materials/components need to be appropriate for a water supply before installation can occur.

To achieve storage mixing, it may also be possible to use a compressor to force air into the tank and better mix the water.

Based on the size of the storage (<10ML), mechanical mixing is not normally required if inlet/outlet configuration and characteristics are optimised.

Electronic mixers may be considered if other reconfiguration options mentioned above are not applicable.

9.3.7 Recirculation system

Recirculation systems designed from CFD modelling may be used to promote mixing and eliminate stratification in lined storages. These systems also enable reduced disinfection times due to the ability to mix the storage.

9.3.8 Outlet height

A stainless-steel mud ring and inlet cage shall be fitted over the outlet pipe to act as a silt stop and minimize sediment being drawn into the distribution system. A mud ring shall also be fitted to inlet pipes when located on the floor.

Such sediment may contain heavy metals and/or pathogenic amoeba and generate customer complaints about the aesthetics of the water.

The height off the bottom of the tank should be determined based upon the configuration of the tank with 150mm being a typical mud ring height.

Electrical isolation between dissimilar metals shall be provided and detailed on the design drawings.

9.3.9 Materials in contact with drinking water

In addition to the need to comply with AS/NZS 4020 and TS 0800 as per Section 9.2, the following are known water quality issues with tanks:

a. Concrete storage may lead to increased pH, which may lead to ineffective disinfection (particularly in chlorinated systems). With ineffective disinfection, there is the increased risk of bacteriological contamination or build-up of biofilms. Flushing and/or pH correction should be considered to mitigate pH increases associated with new concrete tanks. Discharges to the environment must be between 6.5 – 9 pH to comply with environmental regulations.

b. Tank liners may lead to increased BTEX (benzene, toluene, ethylbenzene, and xylenes) levels or the possibility of higher taste and/or odour components being present in the water and hence the possibility of complaints. Tank material selection containing these potential toxins should be avoided where possible. Glues used for joining liner sheets can also be a source of taste and odour issues.

c. Rubber fittings/connections have been linked to leaching of N-nitrosodimethylamine (NDMA) and should be avoided with material selection (Morran et al, 2011).

d. Until materials are cured in accordance with the manufacturer's specification, they may not be compliant.

Awareness or advice on recent or arising issues regarding materials may be sought from SA Water Materials Science Principal Engineer, Improvement and Compliance (Compliance Officer), Asset Management and/or Laboratory Services (Supervisor, Product Testing).

9.3.10 Pipe penetrations

For water quality purposes, and unless approved otherwise via TDRF, pipe penetrations shall be designed, and constructed as follows:

Table 8: Location of pipe penetrations for water quality purposes

Pipework	New tank penetrations preference	Rehabilitated tank penetrations preference
Inlet	1. Through the wall near the top. 2. Through the roof via TDRF.	1. Through the wall near the top. 2. through the roof via TDRF.
Overflow	Through the wall	Through the wall
Notes: a. Roof penetration is not preferred due to poor design, poor construction, deterioration and corrosion of materials. b. Floor penetrations are also not preferred for waterproofing purposes. c. Typical penetration design details shall be developed to address waterproofing and water quality and submitted for SA Water review.		

9.3.11 Disinfection considerations

Tank design shall incorporate provision for disinfection.

In selecting the type of disinfectant and disinfectant system, the Designer shall take the following into consideration:

a. Initial disinfection and testing prior to the tank being brought into service; refer to SAWS-WQ-0004.

b. Maintaining or boosting disinfection levels during normal operation.

c. Potential need for breakpoint chlorination (chloraminated systems only), which would normally be done with the reservoir offline.

The disinfection method shall take into account:

1. Capacity of the tank.
2. Tank characteristics and mixing design.
3. Likely dose frequency and duration.
4. Undertaking disinfection work, sampling, etc, from ground level to reduce the need to access the tank roof.

9.3.12 Roofing and vermin

All tanks must be constructed with a roof.

The roof, access hatches and associated flashings and vents shall be designed and constructed to give an adequate seal preventing dust, vermin, chemicals (e.g. from aerial spraying) and other sources of contamination from entering the tank.

Metal flashing with durability that matches the roof sheeting shall be detailed, scribed to the roof profile, and installed to provide effective seal between tank wall and roof sheeting with a maximum gap of 2mm at any point.

Foam inserts are not accepted as they are prone to dislodging, bird picking and deterioration resulting in potential water quality issues.

Ideally, the tank roof surface should be constructed so that vermin stoppers are not needed. If needed vermin stoppers must be present and form a tight seal between the tank roof and the wall of the tank. Vermin stoppers must be corrosion-resistant, and the material must be AS/NZS 4020 compliant.

Refer also to the requirements in SA Water Technical Standard TS 0720 for SA Water Assets and associated typical safe access drawings.

9.3.13 Rainwater management

New tanks must not be designed with gutters.

All rainwater shall freely run off the roof (full length sheeting where practical) and as such, prevention of erosion shall be ensured at the bottom of storages.

A concrete skirting/apron extending the full circumference around tank and site drainage pits and pipes shall be used to direct runoff away from the tank to ensure drainage management from the site is controlled and does not cause long term erosion. Refer Sections 6.5 and 6.6.

Floating covers must have a pumping system installed to remove water which may pool on the cover (on inspection there should be no water pooling on the cover) and connect into the stormwater drainage system. Water on the cover may promote vegetation growth, encourage animal activity, collection of contaminants or growth of algae. This may lead to contamination of the water supply if there is ingress into the storage.

9.3.14 Aeration/ventilation

Storages located in areas with high trihalomethane (THM) levels close to or greater than the ADWG health limit of 250µg/L may need aeration capability as this has been shown to reduce trihalomethane (THM) levels (while still maintaining sufficient chlorine residuals) (Lowe et al., 2011).

The risk/potential for disinfection by-product formation should be assessed in a system where a new tank is to be installed.

Storage aeration using Packed Tower Aeration (PTA) columns or a manifold with submersible pump has been shown to reduce THM's in excess of 50 percent in trials conducted in SA Water storages.

Aeration is not effective in removal of non-volatile disinfection by-products. Aeration may not always be the most appropriate method of removing THMs (treatment or other methods may be more effective). Advice must be sought initially from SA Water Operations, Water Quality and Water Design and Standards before progressing with installation of aeration.

Adequate ventilation should be used in conjunction with aerators within storages to mitigate corrosion due to humidity of the storage roof, which is crucial in promoting further volatilisation of dissolved THMs leading to enhanced removals.

Ventilation points must be secure and not prone to vandalism. Storages with air vents must have secure covers, and any holes, as a result of venting, must be covered with corrosion-resistant mesh (2mm maximum aperture) to prevent access by vermin and debris.

9.3.15 Storage disinfection

Where dosing equipment is required at storage to boost disinfectant residual in the downstream network, it should ideally be placed at the storage inlet, or the tank is configured with trim dosing on a recirculation line. This ensures that there is an adequate chlorine contact time for efficient disinfection before the first downstream customer and the storage itself serves as a buffer should any disinfection failure occur.

In the case of new storage, the determination of whether disinfection is required must be considered early to allow for adequate land space for the operation and maintenance of the facility.

A dosing point and compressor point shall be installed to facilitate ad-hoc or temporary chlorine dosing on both the inlet and outlet pipes. Consideration must be given to adequate mixing of any chlorine solution injected.

The provision of a dosing point at ground level also eliminates the need for accessing the roof for dosing thereby reducing the potential of falls from heights.

A tank must not be constructed at the end of a water supply system where there is low demand and potentially a low residual entering the storage.

Storage of liquid-based chemical/hazardous substances must ensure they are appropriately bunded meeting EPA Bund and Spill Guidelines.

9.3.16 Sample point locations and type

Installation of a sampling point for sampling water which is representative of the water in the storage is essential. The sample should be representative for both online and offline conditions.

Sampling points shall be installed on the inlet and outlet of the tank.

Sampling points shall be accessible from ground level at ergonomic height (approximately shoulder height of 1.5m).

Sampling provisions will include facility to enable grab samples by a manual device, grab samples by portable pump, grab samples from hatch, as well as sampling at on-line analysers.

Permanent sampling points shall enable aseptic techniques to be used for bacteria sampling and incorporate an isolation ball valve and tail pipe suitable for sterilisation by flaming prior to sample collection.

Sampling for sediments in storages will normally be ad hoc and at the time of tank cleaning/inspection. Sampling procedures are determined at the time; hence no special sampling facilities are required.

9.4 Construction practices

During construction of the tank good practices must be adopted which reduce the potential of contamination once commissioning activities commence.

Practices to adopt include:

a. Regular cleaning of the storage floor of soil, dust and construction debris.

b. Restricting the use of petrol/diesel plants and equipment inside the storage structure.

c. Security of the site to prevent vandalism and/or activities that could result in contamination.

New tanks shall be commissioned as per SAWS-WQ-0004 New Assets – Water Quality and Monitoring Requirements for Commissioning.

10 Tank material selection

10.1 General

Tank material-specific requirements are stipulated in subsequent sections of this Standard.

The following criteria shall also be considered and documented in the Detailed Design Report in the selection of materials for tanks and associated works.

10.1.1 Design life and associated durability

Tank material selection shall be documented on a case-by-case basis in accordance with the following technical standards:

a. TS 0109 – Infrastructure Design.

b. TS 0110 – Durability Design.

The Design shall select tank materials that achieve the longest design life without (or with minimum) maintenance and/or for lifespan extension through maintenance and rehabilitation.

Where specifically requested by SA Water, a Durability Assessment Report (DAR) shall be undertaken to TS 0110, to demonstrate that the required Minimum Design Life and Minimum Service Life will be achieved.

Refer also to Sections 0 and 5.10 for general design life and durability requirements associated with tanks.

10.1.2 Sustainability

Sustainability shall be considered during the life cycle of the proposed water storage tanks, in accordance with the following principles:

a. **Circular Economy:** Design for re-use and recycling with an emphasis on energy recovery and minimising waste providing a creation cycle.

b. **Durability:** Design for longer design life (e.g. a minimum 100 yrs design life without maintenance) and/or for lifespan extension through sustainable management, maintenance and rehabilitation.

c. **Substitution:** Replacement of materials with a higher environmental impact with materials with a lower impact and the same or better performance (e.g. supplementary cementitious materials in place of Portland cement). Reference shall be made to the Environmental Product Declaration (EPD).

d. **Dematerialisation:** Material reduction through smart design, e.g. optimisation of design and use of high strength materials.

e. **Sustainable Production and Construction Processes:** Efficient energy and water use and the use of sustainable transport and renewable energy.

f. **CO_2 Capture:** Direct CO_2 capture, storage, and reuse.

g. **CO_2 Uptake:** CO_2 uptake in the environment (terrestrial sequestration), geological formation (geological sequestration) or in materials used in construction (industrial sequestration).

Sustainability considerations shall generally comply with Section 3.1.4 of TS 0109 and be documented in the Design Report.

10.1.3 Resilience and reliability

Reliability of service to customers shall include consideration of criticality and design and service life requirements of TS 0109 and as referenced in Section 0.

SA Water's water storage tank infrastructures shall be designed to optimise operation and maintenance works for the total life cycle of infrastructure and equipment, including the following principles:

a. Developed in consultation with SA Water operation and maintenance team.
b. Incorporate adequate redundancy to allow maintenance works while maintaining supply of service.
c. Maintainable using SA Water standard maintenance practices.
d. Incorporate valves for flexibility of operation.
e. Include double isolation for all liquid carrying pipeline connections.
f. Incorporate bypass arrangements for taking asset offline without adversely affecting service supply.

10.1.4 Bushfire

For water storage tank infrastructures proposed in bushfire prone areas, reference shall be made to TS 0700 and Section 6.4 of this standard.

The following hierarchy of controls shall be considered:

1. Building Protection:
    a. Selection of tank material that is more resistance to bushfire (e.g. concrete).
    b. Reduces the sources flammable vegetation in immediate proximity of the asset as per TS 0700. For bushfire attack level BAL- FZ, where the proposed infrastructure is exposed to flame contact, a minimum of 10m clearance shall be established between the tank and the edge of the classified vegetation.
2. Site Protection
    a. Asset Protection Zones.
    b. Vegetation Clearance.
    c. Establishment of Fire Barriers.
3. System Protection
    a. Bushfire Sprinkler System.

Large vegetation clearances required to reduce the site-specific bushfire attach level to suit tank materials, shall not be entertained for environmental reasons.

System protection against bushfire using sprinkler system is not preferred due to ongoing maintenance and its questionable reliability during a bushfire fire event.

10.1.5 Vandalism

In selecting tank material, the following types of vandalism shall be considered:

a. Contamination of water supply.

b. Damaging hardware.

c. Operating and/or stealing equipment.

d. Graffiti.

e. Shooting practice where people shoot at the tank structure.

Based on tank locations and local history of vandalism incidents, a robust tank material coupled with proper security measures shall be considered.

Refer Section 5.17 for site security considerations in the selection of materials for tanks.

10.1.6 Cost effectiveness

The cost effectiveness of materials shall be considered in the assessment of selection of materials of construction and include costs associated with the operational and maintenance/replacement activities during the whole life cycle of the tank.

The construction cost of tanks can vary significantly with the location of the tank and the availability of specialist 'concrete' or 'steel' construction constructors at the time of tender.

10.2 Tank construction – SA Water requirements

The following table for concrete tanks and steel/plastic tanks hierarchy stipulate SA Water requirements for material selection and tank construction.

Reference shall also be made to the relevant sections of this standard.

Should the Design and Construct wish to propose an alternative than those listed below, a proposal shall be made to SA Water via TDRF for SA Water to assess and approve, on a project-by-project basis, their technical viability and associated risks and cost.

10.2.1 Concrete tanks

For concrete tanks, the following requirements shall be considered.

Table 9: Concrete tanks - SA Water requirements

Tank size	Tank material/construction
≤2.25 ML	Conventionally reinforced insitu concrete floor slab and tank walls.
	Precast post tensioned tank wall with insitu post-tensioned floor slab.
>2.25 ML	Precast post tensioned tank wall with insitu post-tensioned floor slab.
Post tensioned precast/tilt up walls tank structure with internal liner (no concrete floor slab) and floating cover	On a project by a project basis.

10.2.2 Steel tanks

For Steel tanks, the following hierarchy shall be considered:

1. Welded steel tanks.
2. Bolted steel tanks with liner.
3. Glass fused steel tanks.

The Supplier of steel tanks shall submit for SA Water review the following aspects of their system but not limited to:

a. Compliance with the requirements of this standard.

b. Compliance with TS 0720 for safe access system.

c. Compliance with AS/NZS 4020 (refer Section 9.2 and 9.3.9 of this standard).

d. Design standards.

e. Design life of various components.

f. Materials of each component (shell, sealant, bolts, floor plate, roofing, internal roof structure, ventilators, internal columns, safe access, pipework's, etc).

g. Protective coating for both internal and external surfaces including floor plate, shell and roof structure.

h. Vermin and waterproofing details.

i. Repair and maintenance methodology.

j. Schedule and type of maintenance required over the life span of the tank structure.

k. Insitu repairs (coating, liner etc).

l. Quality control measures during fabrication, transport and installation.

m. Installation methodology and its impact on the design.

n. Commissioning requirements (spark test, water tightness test, etc).

o. End of life removal.

p. Successful application in the water industry (case studies, referees, etc).

10.2.3 Plastic tanks

For Plastic tanks, the following hierarchy shall be considered:

a. Fibre reinforced plastic (FRP) tanks.

b. Polyethylene (PE) tanks.

11 Surface tanks

For this Technical Standard, a Surface Tank is defined as a water storage structure constructed with the floor at ground level.

11.1 General

As essential parts of the water supply system, it is important that SA Water tanks have a long watertight and maintenance free life.

All aspects including the structural design, material selection, joint design and construction techniques are required to be to a high standard.

11.2 Durability

The minimum durability requirements for tanks shall comply with the requirements in SA Water Technical Standards:

a. TS 0109 – Infrastructure design.

b. TS 0110 – Durability.

c. Relevant construction material standards/requirements as stipulated below.

11.3 Construction materials

Reference shall be made to Section 10.

Construction materials of Surface Tanks include but are not limited to:

a. Concrete (refer section 12).

b. Steel (refer section 13).

c. Fibre-Reinforced Plastic (FRP) and Polyethylene (refer to section 14).

11.4 Underdrains

Surface tanks shall be provided with underdrains where soils on site could be affected by water leakage and in accordance with the recommendations of the site-specific geotechnical engineering report.

The objectives of an under drainage system include:

a. Keeping the foundation dry from leakage and thereby protecting the foundation from possible saturation, alteration and damage by leakage by cutting off, collecting and safely discharging leakage water.

b. Providing a direct asset management measure of tank leakage performance by enabling the direct measurement of the leakage rate through the underdrainage system.

c. Helping in finding and repairing leaks by narrowing down the source of leakage to the tank floor area contributing to a single drainage pipe.

d. Is simple, easy to construct, access and maintain. The straight pipes can be inspected by cameras and cleaned by rodding, flushing or chemical sparging.

The drain layout shall be partitioned to enable the location of the tank leakage to be identified with collection drainage pits that are operator accessible for regular inspection.

Reference shall be made to section 7.4 and 8.5.

11.5 Requirements for liners and floating covers

For liners and floating covers, the following requirements shall be considered:

1. Liners/floating covers material selection shall be developed in consultation with SA Water Material Science team.
2. The liner shall be compatible with chloraminated water and the maximum disinfectant levels and pH possible at that location.
3. Floating cover material to be UV resistant to maintain its integrity during its design life.
4. Lead time, shelve life and period for installation.
5. Quality control measures during fabrication.
6. Insitu welding, qualification of welders and welding procedures.
7. Fixing details to tank wall, around columns etc.
8. Quality control for insitu works.
9. Commissioning plan and testings.
10. The lining system shall consist of the following, in line with TS 0711.5:
    a. A flexible liner.
    b. Geotextile between the liner and tank as required by the supplier.
    c. Fixings to secure the liner to the tank as required by the supplier.
    d. Gaskets or other materials to seal at penetrations, valves and protrusions.
    e. Tape or other materials to form a watertight seal at the top edge of the liner.
11. Internal liner shall comply with TS 0711.5 Concrete remedial works: surface protection and lining of concrete.
12. Reference shall be made to TS 0421 – Welding of thermoplastics.

11.6 Safe access system

Refer Section 8.8.

12 Reinforced concrete and post-tensioned tanks

This section of the Standard covers the following construction types:

a. Insitu reinforced concrete tank structure (floor slab and tank wall).

b. Post-tensioned precast/tilt-up walls tank structure (floor slab and tank wall panels).

c. Post-tensioned precast/tilt-up walls tank structure with internal liner (no concrete floor slab) and floating cover.

12.1 Advantages and disadvantages of concrete tanks

Table 10: Advantages and disadvantages of concrete tanks

Advantages	Disadvantages
• No corrosion issues if well-constructed and maintenance costs typically low. • Walls provide good heat insulation. • Long asset life if well-constructed • Autogenous (self-fused) healing of fine cracks. • Resistant to malicious damage. • Resistance to fire. • Post-tensioned concrete construction can provide material savings and increased quality control through the use of precast panels of thinner wall sections.	• Leak-free joints are not guaranteed. • Can be prone to cracking and calcification at leaks. • Joint sealant will require periodic replacement. • Specialist repairs are required if reinforcement corrodes and concrete spalls. • Low pH water can attack concrete. • Cannot be maintained in perpetuity. • Post-tensioned concrete construction requires increased technical and construction skills.

12.2 Standards

The design of reinforced concrete tanks shall include reference to the following standards:

a. AS 3600 – Concrete structures.

b. AS 3735 – Concrete structures for retaining liquids.

c. NZS 3106 – Code of practice for concrete structures for the storage of liquids.

Note that this standard is to be adopted for seismic design for all reinforced concrete tanks in addition to AS 1170.4.

d. SA Water Technical Standard TS 0710 – Concrete.

12.3 Durability

In addition to the requirements of section 11.2, the minimum durability requirements for reinforced concrete tanks shall comply with the Standards:

a. AS 3735 Concrete Structures for Retaining Liquids.

b. SA Water Technical Standard TS 0110 Durability Design.

c. SA Water Technical Standard TS 0710 – Concrete.

AS 3735 requires an assessment of how aggressive the stored water will be on the interior of the concrete tank. The water characteristics are defined by the Langelier Saturation Index and pH.

Some of the water in the SA Water supply has a negative Langelier Saturation Index. This means the water has an affinity for $CaCO_3$ (seeking to extract it from the concrete) resulting in a more aggressive exposure classification being required than is indicated in AS 3735.

In the absence of specific water quality data for the water to be stored in the tank, exposure classification of B2 as per section 4 of AS 3735 shall be used for design.

The concrete mix design is to be Special Grade, with mix design to comply with the requirements set out in SA Water Technical Standard TS 0710 for B2 exposure.

12.4 Crack control

Reference shall be made to TS 0710 for the maximum crack width requirements for liquid retaining structures.

For post-tensioned floor slabs, base the design on uncracked sections.

To ensure cracks are minimized in a concrete tank, special attention shall be given to thermal and shrinkage cracks and plastic shrinkage cracking.

Early age thermal behaviour and imposed restraint of all concrete elements shall be evaluated to determine the risk of cracking and potential loss of compression strength. Those elements of particular risk include:

a. Thick concrete sections.

b. Walls cast onto mass foundations.

c. Slabs butted against prior cast slabs.

Early age and long-term shrinkage of all concrete elements shall be evaluated to determine the risk of cracking and durable surface finish, and appropriate curing for the environmental conditions. The designer shall prepare a report for early age thermal and shrinkage effects.

Reference shall be made to Section 32 - Contractor Works Method Statement for Concrete including Early Age Thermal Crack Assessment of TS 0710.

Plastic shrinkage cracking shall be controlled in accordance with Cement Concrete and Aggregate Australia.

Appropriate measures to restrict the evaporation of water from the concrete surface must be taken.

12.5 Reinforcement spacers, bar chairs and form ties

All reinforcement bar chairs and spacers shall comply with Section 28 of TS 0710.

Form ties shall comply with Section 26.3 of TS 0710.

12.6 Concrete joints

Joints in concrete tanks are critical to the long-term performance of a liquid retaining structure. Typically, problems with joints are the main cause of tank leakage.

Attention shall be given to the deterioration of elements that cannot be easily accessed for maintenance or repair. The design of such elements shall ensure that the durability of the elements and the minimum design life applicable to the whole structure is attained without maintenance.

For tank floor, the design shall develop joint free floor slab, integral with the ring beam, whether conventionally reinforced or post tensioned.

The design approach of concrete joints shall include:

a. Waterproofing of all construction and expansion joints (if present).

b. At least 2 two lines of continuous barrier against water penetration, in order to provide levels of redundancy and backup where necessary.

c. Detailing of PVC waterstop to TS 0464 at:

d. Ring beam/floor – Wall interface.

e. Horizontal construction joint of tank wall.

f. Access to all vulnerable areas.

g. Ability to return and treat leaks by injecting through re-injectable tubing, where provided.

h. Ability to return and drill and grout leaks with polyurethane or other approved methods.

Noting that:

1. The use of epoxy fixed surface bandages for waterproofing purposes are not accepted by SA Water.
2. Vertical joints shall not be permitted in cast-in-situ walls.
3. Care must be taken with the fixing in place of waterstops to ensure that they remain in position square to the joint, without folding, when concrete is placed and vibrated around them. Site jointing of waterstops must be limited to simple butt joints which must be made in accordance with the manufacturer's instructions. Reference shall be made to TS 0421.
4. All joint sealing systems shall be installed strictly in accordance with the manufacturer's recommendations including:
    a. Joint preparation.
    b. Bond breaker installation where recommended.
    c. Joint priming.
    d. Joint masking.
    e. Mixing, finishing and curing of the sealant.
5. Cover requirements for hydrophilic water stops to prevent spalling damage to concrete if the swelling component is activated (minimum 100mm cover required based on material manufacturer often stating 50mm minimum and extra construction allowance).

12.7 Concrete finishes

The minimum design requirements for concrete finishes are as follows:

a. Unless architectural finishes are specified, the finishes of formed concrete surfaces shall be in accordance with the applicable requirements of AS 3610 and TS 0710.

b. The formwork finish class for concrete wall surfaces shall be class 2X. All surface finish qualities per AS 3610 shall be to class 2, whereas a relaxation to class 3 for 'face step' is allowed.

c. Finish for the exposed floor slab shall be an unformed U3 surface finish. To achieve a U3 finish, the procedure shall consist of steel trowelling work, which shall commence only after the moisture film and shine has disappeared from the concrete surface and after the concrete has hardened sufficiently to prevent an excess of fine materials and water from being drawn to the surface. Steel trowelling shall produce a dense, uniform surface free from visible blemishes and trowel marks with a tolerance of 5mm in 3m.

d. Surfaces that will be permanently concealed (buried), shall be Class 5, as defined in AS 3610.1 1.

e. Surfaces of other structures (for example, valve chambers) shall be of Formed Finish Class 3, AS 3610.

f. Concrete colour control in accordance with AS 3610.1 shall be Class B.

12.8 Tank floor slab

Concrete tank floor slab design shall comply with the following:

1. A floor thickness not less than 150mm.
2. For concrete floor slab, the floor shall have a minimum 1:200 fall from the centre of the tank towards the perimeter of the tank.
3. For tank structure with internal liner, the floor shall have a minimum 1:100 slope for the leak detection system usually installed under the liner.
4. There shall be no abrupt changes of level in the tank floor, including at columns and perimeter ring beams.
5. The finished surface level of the ring beam shall match that of the floor slab for safe access purpose, where the ring beam thickness does not protrude above the finished surface level of the floor slab.
6. Designed as joint free floor slab, integral with the ring beam, whether conventionally reinforced or post tensioned.
7. Two layers of 0.2mm thick polyethylene membrane shall be provided on all ground surfaces in contact with new concrete in accordance with AS 2870 with joints lapped a minimum of 200mm and sealed with an approved 75mm wide pressure sensitive tape.
8. Where floor slab is on rock, provide a lean mix concrete base below the tank floor slab. Install a 0.2mm thick polyethylene membrane between the lean mix concrete and the floor slab.
9. Pipework under the tank floor shall be encased in reinforced concrete.
10. Minimise pipe penetrations in floor slab as follows:
    a. Inlet and overflow pipe penetration through the top of tank wall. Refer Section 0.
    b. Combine outlet and scour openings into one and control by a valve. Refer Section 8.2 and 17.7.

Post-tensioned floor slabs are acceptable provided careful consideration is given to:

a. The treatment of underfloor pipe penetrations.
b. The treatment of floor thickening.
c. Provision of slip layers beneath the slab and ground.
d. Effective corrosion protection of the tendons.

12.9 Additional requirements for post tensioned tanks

In addition to the above requirements, the minimum design requirements for post-tensioned concrete tanks are as follows:

1. Post-tensioned concrete tanks shall be designed and constructed to the relevant Australian Standards with no residual tension in the tank wall under all loading conditions.
2. Steel tendon materials shall comply with the requirements of AS/NZS 4672 Parts 1 and 2.
3. Steel tendons shall be 7-wire stress-relieved steel strands.
4. Sheathing that forms the ducts shall be of corrugated galvanised steel. The sheathing shall have a maximum curvature coefficient of 0.25.
5. Anchorages shall comply with the requirements of AS/NZS 1314.
6. Tendons shall be protected against corrosion through the pressure injection of cementitious grout into the cable ducts.
7. A pre-tension system for circular tank walls is not acceptable.

8. Where a post-tensioned tank is constructed of precast concrete wall panels, special attention shall be given to the treatment of the joints to achieve water tightness at the joints. Refer section 12.6.
9. Vertical joints shall be wet joints only. This is especially important for tank structure with internal liner. Design is to consider on-site tolerances, including manufacturer and construction tolerances, taking into account eccentricities that may be induced.
10. Precast member manufacture and acceptance shall be in accordance with the Concrete Institute of Australia publication, "Precast Concrete Handbook (2002)."
11. The maximum temperature of concrete during accelerated curing of precast manufacture shall not exceed 70°C for cement type GP and 80°C for cement type LH. Reference shall be made to TS 0710.
12. Tank floor slab for a post-tensioned tank may be of either post-tensioned or reinforced concrete.
13. Special attention shall be given to the treatment of the wall-to-floor joints to allow for the effect of relative displacement and/or deflection in order to achieve water tightness.
14. The design shall include a strength analysis for the transfer load case, the primary post-tensioning load that creates compressive stress in the concrete structure.
15. The load factor on the transfer jacking force shall be taken as 1.15 in accordance with CL 2.5.2.2 of AS 3600.
16. The basis for using a load for 1.15 factor includes:
    a. AS 3735 does not specifically list a load case for transfer.
    b. Clause 2.1 of AS 3735 references the use of AS 3600 for strength load combinations.
    c. The transfer forces can cause failure from overstressing at the transfer case, which is a strength combination. Refer also AS 3600.
    d. The intent of AS 3600 is to provide a load factor on the transfer prestress load generally. Usually, gravity is relevant for the transfer case (i.e. beams and other horizontal members). For the wall panels, the gravity load becomes either zero or very small if considering the horizontal and vertical tendons acting together.
    e. AS 3600 and AS 3735 use the same maximum compression limiting stress at the transfer of 0.5f'cp for stress distributions like the panels. AS 3600 combines this with the 1.15 factor. In other words, if the stress limit is the same it would be logical to use the same load factors.

12.10 Coating

Concrete tanks shall not be painted due to ongoing maintenance required and to minimise the contrast between the chosen colour against white coloured calcification and leaching at cracks and construction joints that is likely to occur.

13 Steel tanks

This section of the Standard covers the following construction types:

a. Welded steel tanks (refer Section 13.4).

b. Glass Fused steel tanks (refer Section 13.5).

c. Bolted steel tanks with liner (refer Section 13.6).

These tanks can be constructed as surface tanks and on elevated platforms.

For design life requirements, refer to SA Water Technical Standard TS 0109.

13.1 Reinforced concrete ring beams supporting steel tanks

The design of reinforced concrete ring beams shall include reference to:

a. AWWA D100-21 – American Water Works Association Standard for welded carbon steel tanks for water storage.

The minimum design requirements for reinforced concrete ring beams supporting steel tanks are as follows:

1. The design and selection of a suitable footing system shall be completed in conjunction with geotechnical investigations and design, as set out in section 7.
2. Refer to section 12 for additional design requirements for the use of reinforced concrete, including durability.
3. The size of the ring beam footing shall be sufficient to meet the allowable soil bearing requirements as specified through geotechnical investigations; loads to be considered include:
   a. Weight of concrete.
   b. Self-weight of superstructure.
   c. Weight of stored water.
4. The size of the foundation shall be sufficient to maintain bearing pressures below the bearing capacity of the soil when subject to an overturning moment of 1.5 times the design seismic or wind-induced loads.
5. Where anchors are required to maintain stability of the tank, the size of the ring beam footing shall be sufficient to accommodate the anchors. Considerations include:
   a. Geometrical tolerances such as edge distance or embedment depth.
   b. Concrete failure mechanisms under the anchor axial and shear design loads.
6. Founding material for ground-supported steel tanks shall typically be graded to uniformly slope away from the centre of the tank floor unless otherwise specified.

13.2 Reinforced concrete floor slab

Refer to section 0 - Tank Floor Slab for minimum requirements.

13.3 Coating steel water tanks

Reference shall be made to:

a. AWWA D102-21 Coating Steel Water-Storage Tanks.

b. AWWA D103-19 Factory-Coated Bolted Steel Tanks for Water Storage.

c. ISO 28765 'Vitreous and porcelain enamels – Design of bolted steel tanks for the storage or treatment of water or municipal or industrial effluent and sludges.

The following data shall be provided:

1. Coatings manufacturer. The company that manufactures the coatings to be applied.
2. Application method. The application method for inside and outside coatings—that is, brushing, rolling, or spraying, and whether the use of dehumidification equipment is required during blast-cleaning and coating operations for interior coating systems.
3. Materials. The identification of each coating material intended for use on the project.
4. Compliance with AS/NZS 4020 and TS 0800 for tank interior applications, refer Section 9.2.
5. Material safety data sheets. Current material safety data sheets (SDSs) for each product to be used.
6. Life to first major maintenance and warranty.
7. Quality control measures during fabrication, transport and installation.
8. Coating repairs.
9. Inspection and testing.

13.4 Welded steel tanks

Welded steel tanks can provide long, leak free, cost effective, custom designed solutions for water storage with or without cathodic protection.

13.4.1 Advantages and disadvantages of welded steel tanks

Table 11: Advantages and disadvantages of steel plate tanks

Advantages	Disadvantages
• No cracks or weeps • Suitable for large volumes • Welded tanks have no joint sealant leakage problems • Pipework easily modified or enlarged • Surface is hard and smooth, not subject to scouring, does not attract or harbour organisms such as algae • No leach or weep stains and can be painted for aesthetic reasons • Cathodic protection option can ensure long life if designed and maintained properly. • Metal loss as a result of corrosion can be repaired by welding in new steel sections/components/patch plates.	• Requires periodic coating inspection and repair • Stored water may be subject to slight temperature rise adversely affecting water quality • Welded plate tanks require a high level of welding skill • Underside of the floor is difficult to protect from corrosion • Maintenance of cathodic protection systems where installed.

13.4.2 Design standards

The design of welded steel plate tanks shall include reference to:

a. AWWA D100-21 – American Water Works Association Standard for welded carbon steel tanks for water storage.

b. TS 0420 – Welding requirements (metal).

For requirements or design details not specifically given or shown in the above document, the following standards may be used:

1. British Standard BS EN 14015 Specification for the design and manufacture of site built, vertical, cylindrical, flat-bottomed, above ground, welded, steel tanks for the storage of liquids at ambient temperature and above.

2. American Standard API Standard 650 – Welded Steel Tanks for Oil Storage.

Design based on the combined use of the two standards is not acceptable.

13.4.3 Seismic design

Seismic design for welded steel plate tanks shall be in accordance with AWWA D100-21 – American Water Works Association Standard for welded carbon steel tanks for water storage.

13.4.4 Design requirements/criteria

The minimum design requirements for welded steel plate tanks are as follows:

a. Wall thickness shall be structurally adequate to meet strength and durability requirements.

b. No corrosion allowance for the shell thickness is necessary. However, the theoretical shell thickness shall be rounded up to match the next higher standard plate thickness.

c. The floor plate is to be a minimum of 8mm thick. If a corrosion allowance is required, the floor shall be designed based on the corrosiveness of the foundation soil and the occurrence of groundwater.

d. Area of the tank foundation pad in contact with the tank steel floor shall be covered with a 50mm (+15, -0) thickness of compacted bitumen, sand mix where cathodic protection system for underside of floor plate is not provided.

e. All welding personnel and welding equipment shall be qualified and acceptable to SA Water Technical Standard TS 0420.

f. Welding sequence and methodology shall be specified by the fabricator to eliminate local buckling of the wall and floor plates.

g. All welds shall be structural sealed welds to prevent the ingress of moisture into the welded joints and comply to SA Water Technical Standard TS 0420.

h. Support brackets for roof beams shall be above the tank top water level.

i. Use of gusset plates for the purpose of providing rigidity at base of columns supporting roof beams is not acceptable.

j. Material for the floor level/wall hatch of welded steel tanks shall be mild steel grade coated internally and externally as specified for the main tank.

13.4.5 Durability requirements

For durability requirements, refer to SA Water Technical Standard TS 0110.

In addition to the requirements of section 0 and 13.4.4, the minimum durability requirements for welded steel plate tanks shall comply with the following:

1. External Coating:
   a. In accordance with TS 0400 and AS 2312.1 SA Water requires the coating system to provide a minimum of 25-years to first maintenance when 1% to 2% of the surface in any unit area is showing signs of deterioration or corrosion.
   b. With ongoing touch-ups and coating maintenance, SA Water expects that the coating system will provide >50-years service before the coating system needs to be partially removed or replaced.
2. Internal Coating:
   a. In accordance with TS 0400 and ISO 12944-5, SA Water requires the coating system to provide a minimum of 25-years to first maintenance when 1% to 2% of the surface in any unit area is showing signs of deterioration or corrosion.
   b. In conjunction with a maintained cathodic protection system the years to first maintenance is expected to extend beyond 25-years.
3. Cathodic Protection:
   a. The submerged portion of the tank is to be protected with a cathodic protection system noting that submerged portion will vary depending on operational settings throughout the year.
   b. Cathodic protection system design shall be undertaken by a specialist to ensure protection for a minimum of 20-years.
   c. Australian Standard AS 2832.4 – Cathodic Protection of Metals – Internal Surfaces shall be used for the design of the cathodic protection system, with details provided to SA Water for approval.
   d. In areas of aggressive soils or areas subject to water inundation, the underside of the floor plate shall be protected with an impressed current cathodic protection system. The floor plate shall rest on plain sand where a cathodic protection system for the underside of the floor plate is in place.
4. QA Requirements:
   a. The coating inspector shall hold an AMPP Senior Certified Coatings Inspector credential (formerly NACE CIP Level 3 and SSPC PCI Level 3 certification) or equivalent certification.

13.5 Glass fused steel tanks

Glass Fused Steel (GFS) tanks combine the strength and design flexibility of steel with the high corrosion resistance and hygiene benefits of glass.

13.5.1 Advantages and disadvantages of glass fused steel tanks

Table 12: Advantages and disadvantages of glass fused steel tanks

Advantages	Disadvantages
• High corrosion resistance. • Shop fabricated. • Relatively light compared to concrete options. • Relatively easily assembled. • No on-site welding.	• Can be damaged by impact. • Difficult to make spot repairs. • Fire resistance limited by sealants. • Limited number of manufacturers. • Difficult to repair coating defects.

13.5.2 Design standards

The design of glass fused steel plate tanks shall be to:

a. AWWA D100-21 – American Water Works Association Standard for welded carbon steel tanks for water storage.

b. AWWA D103-19 – American Water Works Association Standard for Factory-Coated Bolted Steel Tanks for Water Storage.

c. AWWA D100-5 for the minimum inspection and quality requirements for steel tanks.

d. ISO 28765 'Vitreous and porcelain enamels – Design of bolted steel tanks for the storage or treatment of water or municipal or industrial effluent and sludges.

13.5.3 Design requirements/criteria

The minimum design requirements for glass fused steel tanks are as follows:

a. Tank design limitations are to be in line with ISO 28765 'Vitreous and porcelain enamels – Design of bolted steel tanks for the storage or treatment of water or municipal or industrial effluent and sludges.

b. All bolts for the tank shell shall be installed such that the head portion is located inside the tank and the washer and nut are on the exterior.

c. The torque values (as set down in the Manufacturers Construction Guide) shall not be exceeded during tank construction.

d. All lap joint bolts shall be designed to prevent rotation during tightening.

e. All tank shell bolts shall have UV-resistant polypropylene encapsulation of the bolt head.

f. Surface preparations and coatings, external and internal, shall be provided to meet the requirements of SA Water TS 0109 and TS 0110.

g. Field erection of the Glass-Fused-to-Steel, bolted-steel tank shall be in accordance with the procedures outlined in the Manufacturer's Construction Guide.

h. Refer to Section 0 Tank Floor Slab for minimum floor slab requirements.

13.5.4 Durability requirements

For durability requirements, refer to SA Water Technical Standard TS 0110.

In addition to the requirements of the section 0 and 13.5.3, the minimum durability requirements for glass fused steel tanks shall comply with the following criteria:

1. External Coating:
   a. In accordance with TS 0400 and AS 2312.1 SA Water requires the coating system to provide 25-years to first maintenance when 1% to 2% of the surface in any unit area is showing signs of deterioration or corrosion.
   b. With ongoing touch-ups and coating maintenance SA Water expects that the coating system will provide >50-years service before the coating system needs to be partially removed or replaced.
2. Internal Coating:
   a. All panels' internal glass fused coating shall have zero defects when tested in accordance with AS 3894.1 using high voltage continuity testing prior to shipment from the factory and at the completion of erection prior to the tank being placed into service.
   b. All internal tank bolting shall be plastic coated cup finned/nibbed bolts (silo bolts) to prevent turning on tightening. The head of the bolt shall be encapsulated with polyvinylidene fluoride (PVDF), ABS, polypropylene co-polymer, or polyester. A sealing ring shall be moulded under the head of the bolt.

c. In accordance with ISO 12944-5, SA Water requires the coating system to provide 25-years to first maintenance when 1% to 2% of the surface in any unit area is showing signs of deterioration or corrosion.

d. In conjunction with a maintained cathodic protection system the years to first maintenance is expected to extend beyond 25-years.

e. All panels should be electrically continuous with each other and tested and certified on-site for continuity during construction.

3. Joint Sealant:

a. A polyurethane, 1-part, moisture curing, elastic sealant approved to AS 4020, which provides a waterproof seal and mechanical properties to resistant immersion and remains elastic over a wide range of temperatures as recommended by the tank manufacturer.

4. QA Requirements:

a. The coating inspector shall hold an AMPP Senior Certified Coatings Inspector credential (formerly NACE CIP Level 3 and SSPC PCI Level 3 certification) or equivalent certification.

b. Continuity testing in accordance with AS 3894.1 on all panels prior to shipping from the Manufacturer.

13.6 Bolted steel tanks with liner

Sheet steel tanks with a liner are typically easy and fast to erect but may be subject to a shorter design life depending on the use and environmental conditions. The replacement of the liner should be considered, as the liner may have a shorter design life than that of the sheet steel tank.

13.6.1 Advantages and disadvantages of bolted steel tank with liner

Table 13: Advantages and disadvantages of bolted steel tank with liner

Advantages	Disadvantages
• Leak free. • Lightweight. • Shop fabricated. • Easily assembled. • Can be relocated.	• Limited to small sizes. • Tank can be damaged by impact. Susceptible to vandalism, particularly bullets. Liners susceptible to damage by foot traffic. • Limited life. • The liner can be degraded by UV if unprotected. Not a problem with an internal liner apart from storage prior to use.

13.6.2 Design standards

The design of bolted steel plate tanks with liner shall be to:

a. AWWA D103-19 American Water Works Association Standard for factory-coated bolted carbon steel tanks for water storage.

b. AWWA D100-21 – American Water Works Association Standard for welded carbon steel tanks for water storage.

c. AWWA D130-02 – American Water Works Association Standard for Flexible-Membrane Materials for Potable Water.

d. SA Water Technical Standard TS 0460 – Liners and floating covers for earth bank storages for portable or recycled Water, clauses 4.1 to 4.8 and Appendix A and B.

e. SA Water Technical Standard TS 0711.5 – Concrete remediation works: surface preparation and lining of concrete, clauses 9.1 to 9.5, 9.9 and 11.24-11.26.

13.6.3 Durability requirements

In addition to the requirements of section 0, the minimum durability requirements for bolted steel tanks shall comply with the following requirements:

1. Roof cladding and ventilation:
   a. Minimum 0.48 BMT COLORBOND® Ultra roof sheeting with no end lapping and provided the location is more than 200m from the coast.
   b. Permalite® Aluminium Alspan® roof Aluminium solutions, material gauge 0.90mm or 1.2mm.
   c. Roof ventilation requirement in accordance with Section 16.5 and as described in BlueScope Warranty Advice. Adequate ventilation reduces the impact of condensation on material performance.
   d. Ventilation to be evenly distributed across the roof surface.
   e. Screw fixings in Crest (sheeting ribs) not in valley (sheeting pans).
   f. Screws: BUILDEX® CLIMASEAL® 5 for Colorbond® Ultra and stainless steel for Permalite® roof sheeting.
   g. Consideration is required for dissimilar metals, including direct contact with Zincalume® Steel, Galvanised Steel, lead, copper, brass and copper alloys and concrete. Refer to AS 1562.1 - Design and installation of metal roof and wall cladding Metal and BlueScope Corrosion Technical Bulletin CTB-12 – Dissimilar Metals.
2. Substructure supporting the roof cladding:
   a. Stramit ZAM products with a coating of ZM350g/m^2 to AS 1397 with downturned lip.
   b. Permalite® Aluminium Structural Purlins in Z and C profile. Purlin range from size 100 to 400 with BMT (Base metal thickness) range from 2.5mm to 3.0mm. Product available in mill finish and Down Turned Lipped (DTL).
   c. Aluminium alloy 5251 or 5052 grade in accordance with AS/NZS 1734.
   d. As produced, Permalite® Aluminium demonstrates compliance with AS/NZS 4020as tested by AWQC.
   e. Downturn lips purlins (preferable); otherwise, holes in the bottom flange to drain water.
3. Steel shell:
   a. 0.48 BMT COLORBOND® Ultra sheeting provided location is more than 200m from the coast.
   b. Steel plate with approved coating system for both internal and external surfaces. Refer Section 0.
4. Bolts:
   a. Stainless steel A4 to ISO 3506.
5. Internal lining:
   a. Refer Section 0.

14 Fibre-reinforced plastic (FRP) tanks and polyethylene tanks

This section of the Standard covers the following construction types:

a. Fibre-reinforced plastics.

b. Polyethylene.

These tanks can be constructed as surface tanks and on elevated platforms.

14.1 Advantages and disadvantages of fibre reinforced and polyethylene tanks

Table 14: Advantages and disadvantages of FRP tanks

Advantages	Disadvantages
• High corrosion resistance • Relatively lightweight compared to steel and concrete options • Shop fabricated – transported to the site in rolled panels or complete tanks • Simple, fast to erect	• Limited to smaller sizes • Subject to UV degradation • Can be damaged by impact • Susceptible to vandalism, particularly bullets • Low fire resistance

Table 15: Advantages and disadvantages of polyethylene tanks

Advantages	Disadvantages
• High corrosion resistance • Shop fabricated – transported to site as complete tanks • Low coefficient of friction • Low cost • Ease of recycling	• Limited to smaller sizes • Subject to UV degradation if not manufactured correctly • Low stiffness and susceptible to creep • Can be damaged by impact • Susceptible to vandalism, particularly bullets • Limited temperature resistance above 80°C • Low resistance to fire

14.2 Design standards

The design of FRP tanks shall be to:

a. D120-02: AWWA Standard for Thermosetting Fiberglass-Reinforced Plastic Tanks.

b. BS EN 13121 – GRP tanks and vessels for use above ground.

c. ASME RTP-1 Reinforced Thermoset Plastic Corrosion-Resistant Equipment.

The design of polyethylene tanks shall be to:

- AS/NZS 4766 - Rotationally moulded buried, partially buried and non-buried storage tanks for water and chemicals.

The time-dependent effects caused by creep and relaxation shall be accounted for in design where such effects reduce the structural capacity of the tank.

The effects of exposure to the service environment, both internal and external, on the strength and stiffness properties of the tank material shall be accounted for in the design, based on testing.

14.3 Durability

The minimum durability requirements for FRP and polyethylene tanks shall comply with the following requirements:

a. Tank materials to be UV resistant to achieve the minimum design life specified in TS 0109.

b. Materials to maintain chemical resistance for the intended application during the required design life.

c. Materials to maintain minimum properties at all temperatures encountered due to the outdoor location of the tank and the fluid contents during the required design life.

The effects of exposure to the service environment, both internal and external, on the strength and stiffness properties of the tank material shall be accounted for in the design based on testing.

14.4 Design requirements/criteria

14.4.1 General

FRP and polyethylene tanks shall be designed to resist the combined effects of fluid contents, fluid temperature, internal hydrostatic pressure, abrasion, erosion, weight of roofs, baffles, piping, agitators, pumps, etc., as applicable. Refer to AS/NZS 4766 for load case combinations for polyethylene tanks.

14.4.2 FRP tanks

The minimum requirements for FRP tanks are as follows:

a. The minimum required wall thickness of the tank shall be determined by design however this shall not be less than 5mm. Check of thickness shall form part of the quality inspection.

b. Chemicals: The resin shall be selected to withstand chlorine/chloramine disinfection prior to use and chlorine dosing throughout its life.

c. All reinforcing fibres in the finished product shall be protected from exposure to the liquid contained in the tank, internal and external surfaces must be smooth with no projecting fibres.

d. The FRP material (resin, fibres, curing system) shall be compatible with the liquid contained and at the maximum temperature to which it will be exposed.

e. If post cure is required to meet AS 4020 then this shall be done by the manufacturer to the same extent as the AS 4020 test pieces.

f. All resin and catalyst used in construction must be in date. The resin used shall not contain fillers, pigments, dyes or colourants except as required for viscosity control and ultraviolet stabilisers (exterior layers only). Up to 5% by weight of a thixotropic agent, which will not interfere with visual inspection, may be added for viscosity control. Calcium carbonate may not be used. Fire retardant agents shall be used only with prior approval of SA Water.

g. All catalysts used for curing of the internal corrosion barrier or internal joint laminates shall be phthalate-free peroxides (for example, Cadox M-50a and Curox M20-K). The use of catalysts with phthalates is acceptable for use in the structural laminates.

h. The reinforcing material shall be commercial grade of glass fibre having a coupling agent which will provide a suitable bond between the glass reinforcement and the resin.

i. The laminate shall consist of an internal corrosion barrier, a structural layer and an external layer. The inner corrosion barrier must have a minimum thickness of 2.75mm, meeting the requirements of the design standard. The corrosion barrier must include an inner resin-rich (minimum 90% resin) layer of C glass or synthetic surface tissue/veil of minimum dry thickness of 0.25mm, backed up by a minimum of two layers of 450g/m2 chopped strand matt with a glass-fibre content not less than 20% and not greater than 30% by mass. Resins used in the corrosion barrier shall not contain pigments, dyes or other additives. Before any structural filament winding is applied, the corrosion barrier layer shall be allowed to gel completely so that it will not be squeezed down to a thinner layer of glass content over 30%.

j. The entire final external layer shall contain a pigmented exterior flowcoat. The external laminate shall consist of a resin-rich (minimum 90% resin) layer of C glass or synthetic surface tissue/veil with a minimum dry thickness of 0.25mm. The final resin surface shall be paraffinated in accordance with the resin manufacturer's recommendations to obtain a complete cure. The pigmented layer shall only be laminated after the preceding layers have gelled and then visually inspected and accepted in accordance with the quality plan.

k. Where the structural layer is fabricated from filament wound laminate, then the calculated minimum wall thickness shall exclude the specification requirement for a corrosion barrier and external layer, which both must be added to determine the total wall thickness. The minimum required wall thickness of the total tank shall be determined by design; however, this shall not be less than 5mm.

l. All changes in laminate cross-section or wall thickness shall be gradual to avoid stress concentrations. Gradual tapers in the cross section shall not exceed 1:6 or 15 degrees in any situation.

m. All edges of reinforcement material shall be lapped, 25mm minimum for surface tissue and chopped strand mat, and 50 mm minimum for woven roving. Lapped edges of reinforcement adjacent layers shall be staggered.

n. All cut edges shall be coated with thermosetting resin so that no glass fibres are exposed, and all voids are filled.

o. Process equipment equipped with agitators, shall have the shell reinforced with external circumferential reinforcing ribs to provide rigidity or alternatively, agitators shall be independently supported.

p. Lifting lugs and suitable stiffening for handling, lifting, and locating shall be provided. Each shall be designed and attached to ensure no local over-stressing of the tank.

q. Where intermediate supports are required to support tank roofs, tank floors shall be reinforced to distribute the load from any struts provided. For fully supported flat based tanks such local supports shall allow for a design bearing pressure of 100kPa.

r. Only contact moulded butt and strap or other fabricated joints employing secondary bonding and attachment procedures shall be accepted, except where flanged joints are used. All jointing structural laminate shall be applied to the external surface of the components to be joined. Where accessible, the internal surface of such joints shall be sealed with a corrosion barrier. The width of joints shall comply with the standard.

s. Roof access is not permitted. All equipment shall be located at ground level, and no roof hatches will be provided.

14.4.3 Polyethylene tanks

The minimum requirements for polyethylene tanks are:

a. The minimum material thickness shall be 4.5mm. This minimum thickness shall not be used as the basis of structural design. The required material thickness shall be determined by engineering design methods that include FEA and make allowance for the nominated service temperature. Check of thickness shall form part of the quality inspection.

b. The tank shall be designed so that it does not buckle for all applicable ultimate limit state load case combinations; the minimum buckling factor shall be greater than unity

c. The calculated ultimate stress and allowable stress shall be as per AS/NZS 4766.

d. The tank must withstand chlorine/chloramine disinfection prior to use and chlorine dosing through its life. All chlorine and chloramine shall be diluted before addition to the tank.

e. The time-dependent effects caused by creep and relaxation shall be accounted for in design where such effects reduce the structural capacity of the tank. The minimum duration of long-term creep tests shall be 5000 hours.

f. Compounds shall be manufactured from virgin polymer base resins containing additives and pigments as required.

g. Polymer base resin shall contain sufficient antioxidants to maintain material properties through the compounding, rotational moulding and life of the tank.

h. UV resistance for the life of the tank shall be provided. The requirements of AS/NZS 4766 “Carbon black for UV stability” and “UV Resistance” shall be met. When tested in accordance with ASTM D 2565, the polymer compound shall contain UV stabilisers such that the natural (non-pigmented) compound will retain 50% tensile elongation after 12000 hours of exposure in a Xenon-Arc weatherometer.

i. All additives and pigments, including anti-oxidants, UV light stabilizers, pigments, carbon black, etc, shall be evenly dispersed in the compound. Pigment content, other than carbon black shall not exceed 2% of the total mass. Pigment levels in drinking water storage tanks shall be adequate to prevent light penetration, which will promote algal growth.

j. The polyethylene base resin shall have a stress-cracking resistance of 500h minimum F50 in accordance with ASTM D 1693, Condition A, 100% Igepal CO-630. The test specimens shall be compression moulded and shall meet the requirements of ASTM D 4703 with a minimum platen temperature of 177°C.

k. Roof access is not permitted. All equipment shall be located at ground level, and no roof hatches will be provided.

14.5 Testing

The tank supplier shall compile for submission to SA Water information comprising of, but not limited to:

a. All design calculations, procedure documents, inspection and test plans, inspection and test reports, purchaser written approvals, test certificates and design verification.

b. Batch analysis certificates for resins, catalyst, glass and additives. Storage conditions and shelf life for all materials. All documentation shall provide complete traceability from purchased raw materials to individual tanks.

c. For FRP, manufacturing records shall be maintained for all lay-up and curing, including batch numbers, laminator identification, pot test gel times, hardness tests, acetone sensitivity tests, use of glass fibre, resins, catalyst, solvents etc, mix ratios, start and finish times, temperature, relative humidity and any other parameter which may affect the quality of the finished product. Butt and strap joint lamination tables and procedures shall be provided.

14.5.1 FRP tank testing

During and at the completion of production, the following shall be conducted and recorded:

1. Laminator qualification testing and approval shall be conducted prior to manufacture.
2. Prior to manufacture, a representative laminate sample may be used for the determination of acceptable surface finish and visual imperfections.
3. Resin gel time pot tests.
4. The surface hardness on interior and exterior surfaces when taken with a Barcol Hardness Tester shall meet 90% of the resin manufacturer's published cured hardness.
5. The cure shall be checked for tackiness of the surface after being wiped with a cloth dampened with acetone. If the surface softens or becomes tacky, the laminate will be considered under-cured and not acceptable.
6. Glass content tests shall be conducted to meet design requirements.
7. Dimensional surveys and wall thickness measurements shall be conducted to meet design requirements.
8. Physical and mechanical properties of tank shell as required by the design. Glass content, tensile strength, comprehensive strength, flexural strength, stress and modulus.
9. Water Fill/Hydro tests on tanks including fill rate.
10. The tank shall have a visual acceptance level of ASTM D 2563 level II.
11. It shall be the responsibility of the supplier to retain all cut-outs from nozzles and man-ways during fabrication and to have these cut-outs available during inspection. The supplier shall retain cut-outs for 12 months after the date of equipment commissioning.
12. Tolerances:
    a. The minimum wall thickness shall not be less than 90% as specified.
    b. The minimum corrosion barrier thickness shall not be less than 0.5mm below the specified thickness.
    c. Diameter ±1.0% of the declared diameter.
    d. Tank bottoms are to be flat within ±0.1% of the tank diameter down to a maximum of ±3 mm.
    e. Out of roundness/ovality ±1.0% of the declared diameter up to 2000mm diameter and ±0.75% of the declared diameter above 2000mm diameter.
    f. Angular deviation of flange face to the centre line of tank or vessel ±1.0°.

14.5.2 Polyethylene tank testing

During and at the completion of production, the following shall be conducted and recorded:

a. When tested in accordance with ISO 1133-1, ISO 1133-2 or ASTM D 1238, the melt flow index of the polymer compound shall not deviate by more than 20% from the value nominated by the compound manufacturer.
b. A sample for visual inspection under a light source shall be provided for inspection of even colour distribution without any evidence of agglomeration, blotching or other visual evidence of uneven dispersion.
c. A light penetration test shall be carried out in accordance with AS/NZS 4766, and the transmitted light shall be not greater than 500 lux.
d. Raw material names and standards shall be supplied. The short- and long-term physical properties relevant to the life of the tank shall be supplied. For the base resin, this shall include the following short-term properties as determined by the standards referenced in AS/NZS 4766: density, Poisson's ratio, short-term yield strength, and short-term tensile

modulus. Testing of long-term tensile properties shall be undertaken on the base resin, including ISO 899 (all parts), ASTM D 2990 or the hydrostatic design basis in accordance with ASTM D 2837 for a duration consistent with the minimum life of the tank.

e. The tolerance for outside dimensions, including out of roundness, shall be ±3%.

f. The material thickness shall be verified as per AS/NZS 4766.

g. Ongoing rotational moulding process evaluation shall be carried out as per AS/NZS 4766.

h. The finished tank surface shall be free, as practicable, from visual defects such as foreign inclusions, air bubbles, pinholes, crazing and cracking that will impair the serviceability and durability of the tank.

i. The internal surfaces shall be smooth, have a homogeneous appearance and be free of any loose powder particles.

14.6 Fibre reinforced plastic (FRP) roofs

14.6.1 General

Fibre-reinforced plastic roofs shall only be used on FRP tanks. The roof shall be designed and constructed as part of the tank package by the FRP tank manufacturer.

14.6.2 Design criteria

The minimum requirements of a FRP roof are:

a. The roof slope may exceed 3° but should be kept to the minimum practical.

b. Special attention shall be given to the anchorage system to hold down the tank, roof and hatches under wind conditions. Calculation of the wind uplift on the roof shall form part of the design. Reinforced anchor lugs or continuous anchor skirts complete with bolt holes shall be provided where determined necessary to resist overturning or shear forces arising from wind or seismic forces in both full and empty conditions.

c. The weight of the roof and any insulation or stiffening components shall be taken into account in the design loads for FRP tanks.

d. Roofs may be designed and fabricated integrally or separately with the tank wall. Roofs may be integrally attached or removable.

e. Roofs shall satisfy the mechanical property requirement of design. As FRP is relatively flexible, consideration shall be given to the stiffness required to meet the roof span required. The minimum thickness shall be 6.0mm including the corrosion barrier, support of auxiliary equipment may require additional reinforcement or stiffening ribs, or both.

f. The inner surface of the roof shall have the same corrosion barrier construction as the tank wall.

g. Where cut-outs are made in the roof for the addition of nozzles etc, the reinforcement shall be such as to withstand all design, operational and handing loads.

15 Elevated tanks

15.1 General

Elevated tanks may be incorporated into a water supply system to provide the required pressure to serve an area if the required minimum pressure cannot be achieved through other means.

The types of elevated tanks can include the following:

1. Tanks on Stands:
    a. Fabricated steel tank supported on steel framework.
    b. Fabricated steel tank supported on concrete columns.
    c. Concrete tank supported on concrete columns.
    d. FRP or Polyethylene tank supported on steel framework.
    e. FRP or Polyethylene tank supported on concrete columns.
2. Water Towers:
    a. Concrete tank supported on concrete shaft.
    b. Steel tank supported on steel shaft.

15.1.1 Design standards

The design of tank stands for elevated tanks shall be to:

a. AS/NZS 1170.0 – Structural Design Actions Part 0: General Principles.

b. AS 3600/AS 5100 – Concrete Structures.

c. AS 3735 – Concrete structures for retaining liquids.

d. AS 4100 – Steel Structures.

Seismic considerations for elevated tanks and structures are considered to be very important, with careful consideration required when detailing the connection interface between tank structure and tank stand

The seismic performance of the elevated tank will need to consider the performance criteria of the selected tank material type, with reference to both Australian and International Standards where appropriate. Refer to the Design Requirements for tank material types in sections 12 to 14.

15.2 Tank on stands

15.2.1 Tank stands

Tank stands referred to in this section are of the braced steel frame structure type supporting a steel or fibre reinforced plastic tank.

The minimum design requirements for tank stands are as follows:

a. Tank stands shall be designed for a service life exceeding that of the tank and not less than 100-years with a period of 25-years to first maintenance of coatings with safe access assumed.

b. The structure shall be designed so that member geometry installation will promote self-drainage to minimise the risks of corrosion (open steel sections in lieu of hollow sections).

c. Protective coating against corrosion shall be based on site-specific exposure classification assessment but not less than HDG900.

d. The design of elevated platforms/towers shall allow for EWP entry to the confine of the tower. This is usually achieved by a dedicated bay without bracing. Provide a ramp to suit.

e. Bolted connections are preferred to site welding, wherever practicable.

f. Each fastener projection and nut shall be fitted with 'Radolid' cap filled with 'Denso 305 Primer' or Lanotec Type A Grease.

15.2.2 Decking

The minimum design requirements for decking are as follows:

a. The decking shall provide a uniform bearing surface for the tank floor, with interface between decking and the tank structure to be coordinated.

b. The decking shall be non-slip.

c. The decking material shall be suitable for the design life of the tank and structure.

d. The decking shall be structurally connected to its supporting structure.

e. The decking shall provide a structural connection to the tank it supports.

f. To prevent crevice corrosion, the deck shall be free draining and the interface between a galvanised tank and galvanised deck shall be coated with an approved product.

15.3 Water towers

The access towers referred to in this section are the integral supporting structure of an elevated tank.

Minimum design requirements for access towers are as follows:

a. The access tower shall be of the same material of construction as the tank.

b. The access tower shall be subject to the same minimum design requirements as the tank it supports.

c. Appropriate lighting shall be provided within the access tower.

The access tower shall be appropriately sized to accommodate:

1. All required pipework.
2. Access stairs and landings.
3. Required cables and supporting cable trays.
4. Lifting of maintenance cleaning tools and equipment.
5. SA Water emergency rescue procedures from within the tower.
6. Access from ground level to the tank roof through the tank interior via a 'dry shaft.' The dry shaft shall remain watertight during the service life of the tank.
7. Secure access to the tower that complies with the security requirements of SA Water Technical Standard TS 121.
8. Working platforms at suitable levels relative to the positions of the internal pipework and all valves to enable access for operation and maintenance.

15.4 Safe access system

Refer Section 8.8.

16 Tank roofs

16.1 General

A roof structure shall be provided to completely cover the tank.

The minimum design requirements for tank roofs are as follows:

a. The roof and roof to tank joint shall not allow dust or vermin to enter the tank.

b. Roof and all fittings shall be watertight and not leak.

c. Water shall not pond on the tank roof.

d. Minimise penetration into roof sheeting. Refer Section 0.

e. The tank roof framing shall support the access hatches and platforms. Design requirements for these platforms shall comply with SA Water Technical Standard TS 0720 and associated typical safe access drawings.

f. The structural design shall coordinate the location of the pipework (inlet and overflow) relative to the roof structural elements to ensure adequate safe access space, for future maintenance and repairs, are provided. The drawings (plan and sections) shall superimpose the pipework on the roof structure.

g. Fixing of the roof shall allow for contraction and expansion thermal movements relative to its supporting members. These details are to be in line with SA Water typical drawings.

h. Slope of roof structure shall not exceed 5 degrees slope.

i. Roof slope shall not be less than 1° or the manufacturer's recommended minimum slope, whichever is greater in order to prevent ponding.

j. Unless the tank is designed for internal pressures, one or more vents shall be provided to limit the internal pressures, in line with NZS 3106.

k. Where locking nuts are specified, 'Nylock' or similar approved nuts shall be used. The use of two plain nuts locked against each other is not allowed.

16.1.1 Durability

The durability requirements for tank roofs shall comply with the requirements in SA Water Technical Standards TS 0109 and TS 0110.

Reference shall be made to section 5.

In addition, tank-specific minimum durability requirements are as follows:

a. Incompatible materials shall be separated by a concealed layer of suitable inert material (non-hydroscopic, non-conductive) of appropriate thickness and bolts isolated via top hat washers or washer and sleeve.

b. Full height metallic columns are not accepted to support the roof.

c. Roof beams (irrespective of materials) shall be designed as simply supported with bearing/cleat connections on the tank wall and/or columns. Internal splices for roof beams are not permitted.

d. Refer section 0 for the minimum airgap to roof members.

e. Hollow sections (irrespective of materials) shall not be used in the tank interior.

f. Cold-formed steel framing sections to AS 4600 shall not be used in the tank interior.

g. Structural steelwork for tank roof structure (purlins and beams) shall be hot rolled protected HDG900 galvanised to AS/NZS 4680.

h. Aluminium roof structure (purlins and beams) shall be downturned lip sections manufactured from 5000 series alloy of durability rating "A" to EN 1999-1-1.

16.1.2 Standards

The design of tank roofs shall be to:

a. AS/NZS 1170.0 – Structural Design Actions Part 0: General Principles.

b. AS/NZS 1170.1 – Structural Design Actions Part 1: Permanent, imposed and other actions.

c. AS/NZS 1170.2 – Structural Design Actions Part 2: Wind actions.

d. AS/NZS 1170.4 – Structural Design Actions Part 4: Earthquake actions in Australia.

e. AS 4100 – Steel Structures.

f. AS/NZS 5131 - Structural steelwork - Fabrication and erection

g. AS/NZS 1664.1 Aluminium structures – Limit state design.

16.2 Tank roof live loads

Design loads on buried tanks shall be specially calculated and approved on a project specific basis taking account of parameters including soil material types, drainage, maintenance loads, vehicle access, vehicle loads and geotechnical engineering recommendations. Table 16 provides live loads for lightweight tanks roofs.

Table 16: Tank roof live loads

Description	Live load
Roof structural elements	1.8/A + 0.12 ≥0.25kPa or 1.4kN
Roof cladding	1.8/A + 0.12 ≥0.25kPa or 1.1kN
Service Platforms, walkways and staircases	2.5kPa or 3.5kN point load
Air bridge	4.0kPa
Sliding Hatch	1.0kPa or 1.4kN
Ladders	In accordance with requirements of AS 1657
Guard rails and kick boards	In accordance with requirements of AS 1657
Supporting structure of Davit arm (Metro)	12.0kN vertical and 13.5kNm
Supporting structure of Davit arm (Regional)	22.2kN vertical and 10.2kNm
Davit arm	2.1kN working load limit, apply 4:1 factor of safety

16.3 Tank roof cladding

16.3.1 General

Steel sheeted roofs are typically the most widely used roof type for large tanks. Alternatively, aluminium sheeted roofs have been used on various SA Water sites in high corrosion environments.

The minimum design criteria for roof cladding are:

1. Notwithstanding the manufacturer requirements, the spacing of the purlins shall not exceed 2.0m to prevent denting and ponding of water, with first purlin at 1.2m maximum from tank centreline.
2. The roof sheeting design/installation shall not include longitudinal overlaps.
3. Long length roof sheeting shall be designed from tank wall to central roof ridge with appropriate design for thermal loads.
4. Concealed fix roof sheeting systems are not permitted due to:
    a. Crevice corrosion of the fastener.

   b. Inability to inspect fasteners.
   c. Difficulty in removing and reinstalling existing sheets.

5. Roof geometry and colour finish shall be designed to satisfy visual and environmental requirements including aspects of light reflection and glare.
6. Design of the sheeting, flashings and closures shall consider the possibility of the flow of water up-slope in strong winds.
7. metal flashing scribed to match the sheeting profile and with a maximum gap of 2mm shall be used to seal the roof sheeting ends.
8. Foam insert to seal the roof sheeting ends are generally not suitable or acceptable because of their deterioration when exposed to the sun or heat, their dislodgment from the intended positions, attack by birds and rodents, and generally short service life.
9. Tanks are not to include gutters. Site drainage is to be designed for stormwater run-off from the roof structure.
10. Flashing and accessories shall be of similar design life to the main roof sheet material.
11. Flashings and mouldings are to overlap sheeting by a minimum of 200mm.
12. Warranty document shall be issued in the name of the Asset Manager, not the Roofer or the Constructor.

16.3.2 Steel cladded roofs

Steel roof sheeting shall consider the followings:

a. Roof sheeting shall be Lysaght KLIPLOK CLASSIC®, 0.48mm BMT (base metal thickness-material gauge) in COLORBOND® Ultra steel generally unless the tank environment dictates the specification of Permalite® aluminium.
b. Roof sheeting fasteners shall be hot dipped galvanised J bolts (hook bolts) unless approved otherwise.
c. Installation location shall be greater than 200m from marine and/or industrial influence.
d. The installation of COLORBOND® Ultra steel, KLIPLOK CLASSIC® shall not incorporate end lapping of sheets.
e. The Longest length that Lysaght recommend for fixing KLIPLOK CLASSIC® is 24 metre sheet length keeping in mind thermal expansion & contraction in the sheeting, refer to BlueScope Lysaght's roofing and walling Installation manual.
f. For sheet lengths up to 24m, installation can be done without providing any additional provisions for thermal expansion and contraction (treated as pierced fixed install as per BlueScope Lysaght's Roofing and walling Installation manual).
g. Any roof sheeting over 24m may be installed using a step joint as per as per SA HB39:2015: Installation code for metal roof and wall Cladding and Lysaght Roofing and Walling Installation manual.
h. The Longest sheet length Lysaght SA can transport is 30m.
i. Transport to remote areas based on time & resource.
j. Lead time on COLORBOND® Ultra steel coil is approximately 4-6 weeks.
k. Minimum roof pitch shall be 1 degree.
l. The ventilation requirement as per Section 16.5 and as described in Appendix 2 "BlueScope Warranty Advice – COLORBOND® Ultra steel Roofing for Potable Water Reservoirs". Adequate ventilation reduces the impact of condensation on material performance.
m. Sealant type shall be neutral-cure and compatible with the roof material.

n. Confirm roof sheeting warranty information prior to tender to ensure the design and selection allows for required warranty at the specific site and application.

o. The roof shall be separated from the purlins with a PVC capping such as supplied by Australian Plastic Profiles Pty Ltd.

p. At side laps and similar situations self-tapping screws may be used that meet the requirements of Corrosivity Category C4 to AS 3566.1.

16.3.3 Aluminium cladded roofs

Aluminium roof sheeting shall be designed and detailed in addition to comply with the following:

a. The sheeting and fascia cladding material Permalite Alspan 0.9 BMT of Aluminium alloy 5251 or 5052 grade in accordance with AS/NZS 1734.

b. Maximum sheet length is 23 metres.

c. Roof sheeting fasteners shall be M6 Stainless Steel or M10 galvanised, both with approved isolation to dissimilar metals.

d. Subject to SA Water prior approval, fixing could be hex head stainless steel roof zips with bonded washer of length to suit sheet profile with consideration for thermal movements.

e. Consideration required for dissimilar metals include direct contact with Zincalume® Steel, Galvanised Steel, lead, copper, brass and copper alloys and concrete.

f. Permalite® Alspan® roof profile is rolled interstate. Prior project delivery information and coordination are required for smooth delivery and effective logistic management.

g. Minimum roof pitch shall be 1 degree.

16.4 Safe access system

Refer Section 8.8.

16.5 Roof vents, security mesh and fly screen

Roof Vents, Security Mesh and Fly screening shall be designed and detailed to comply with the following:

a. Ventilation of the roof sheeting comprising a vent area at least 0.2% of the total roof area shall be provided. The locations of the ventilators shall be agreed with the roof sheeting manufacturer to secure the required warranty duration.

b. Ventilation points must be secure and not prone to vandalism. Storages with air vents must have secure covers and any holes because of venting must be covered with mesh to prevent access by vermin and debris.

c. Vents shall prevent the entry of contaminants, including liquids.

d. Roof vents shall prevent the entry of insects (mosquitoes, flies and larger), birds and animals

e. Maximum gaps shall be 2mm or less at any point on the vent.

f. Vents shall be adequately supported, using trimmers where necessary and fixed down to structural components.

g. Whirly birds, where specified, to be located at least 4.0m clear from the roof edge and to be cyclone rated for added durability.

h. Roof ventilation shall be appropriately sized to ensure rapid rates of rise/fall in water levels within the tank can occur without causing negative or positive pressures on the structure and cladding not considered in the design.

i. Roof vents shall be manufactured from 'Colorbond Ultra steel' sheets of minimum 0.55mm base metal thickness, or from a compatible material such as aluminium, with material colour matching the roof sheeting. For material compatibility, refer to AS 1562.1 or Corrosion Technical Bulletin 12 – Dissimilar Metals from BlueScope website.

j. An acceptable fly screen is Locker Group 316 stainless steel plain weave Mesh 10 Gauge 26 or approved equivalent (0.457mm strand, 2.08mm opening, and open area of 67%).

k. Roof vents shall be designed for the appropriate wind loadings.

l. Roof vents shall be designed in accordance with roof sheet manufacturer's requirements where necessary to comply with and obtain the manufacturer's material warranty.

16.6 Roof substructure

Steel framed roofs are typically the most widely used roof type for large tanks. The prevention of corrosion to structural members in a chloraminated environment and the prevention of the entry of contaminants are major concerns to be considered throughout design.

Aluminium framed roofs have been used on various SA Water Sites in high corrosion environments. Appropriate aluminium alloys suitable for required durability and workability shall be selected and used. Permalite G5000 alloy is an example of a suitable product.

16.6.1 Steel roof framing

Steel roof framing shall be designed and detailed to comply with the following:

1. All workmanship and materials shall be in accordance with AS 4100 and the project specification.
2. Structural steelwork shall be of the following grades unless noted otherwise
   a. Grade 300 hot rolled members
   b. Grade 250 for plates to AS 3678.

For galvanising purposes, the following shall be considered:

a. Eliminate double dipping, where possible.

b. Detail continuously welded joints.

c. Increase the size of cut-out/mitre cut (snips), grind mitred cut and continuous seal weld.

d. Eliminate overlapping and contacting surfaces.

e. Include lifting lugs.

f. Remove all weld slag/spatter/residue, surface contaminants and grind sharp edges and thermally cut edges as per AS/NZS 2312.2 and AS 8501.3 grade P2 as a minimum.

g. De-bur bolt holes with a de-burring tool.

h. Defects that prompt repairs after galvanising include, but not limited to, bare spots, blistered or flaking areas, lifting and transporting chains and wires marks, clogged holes, delamination and peeling, large dross inclusions, flux residues and inadequate coating thickness.

i. Provide random thickness testing for galvanising requirements.

j. Galvanising repairs shall be undertaken by an PCCP class 4 accreditor applicator.

16.6.2 Aluminium roof framing

The minimum design criteria for aluminium framed roofs are:

1. All workmanship and materials shall be in accordance with AS/NZS 1664 and project specifications.
2. All structural aluminium alloys shall be of the following grades:
    a. Tank interior: 5052 H36.
    b. Tank Exterior: 6082/T6.
3. Aluminium shall comply with the following standards:
    a. Sheet and plates to AS/NZS 1734.
    b. Extruded rods, bar, solid and hollow shapes to AS/NZS 1866.
    c. Drawn tube to AS/NZS 1867.
4. The constructor shall supply test certificates indicating compliance of all materials with the relevant standards.
5. Unless noted otherwise, all bolted connections are to have 2-M16 A4-70 bolts to ISO 3506 with appropriate isolation.
6. All aluminium welds are to be compliant to AS 1655 Category B.
7. Welding consumables must conform to ISO 18273 or AS/NZS 1865 for continuous wire. Testing of consumables must comply with AS/NZS 1665.
8. Incompatible materials shall be separated by a concealed layer of suitable inert material (non-hydroscopic, non-conductive) of appropriate thickness and bolts isolated via top hat washers or washer and sleeve.
9. Permalite Aluminium Structural Purlins are available in Z and C profiles from size 100 to 400 with BMT from 2.5mm to 3.0mm. Available in mill finish with downturn lip. Aluminium alloy 5052 H36.

16.7 Columns supporting tank roof

The minimum requirements for internal columns in a new tank structure are:

1. The design life of columns to match the tank structure.
2. Internal columns shall be designed for earthquake loads in accordance with AS 1170.4 and the relevant material standard.
3. The columns shall be precast or insitu concrete columns with stainless steel or FRP reinforcement.
4. Column cross section shall be square cross section for ease of roof beam connections.
5. Columns height to vary to achieve roof slope. Alternatively, roof slope can be achieved by varying the stub column heights, if used.
6. If steel stub columns are detailed, their base connection shall be a minimum of 100mm higher than the water head level above overflow level.
7. Connection of stub columns or roof beams to the top of columns shall be detailed with cast-in bolts. Chemically anchored bolts are not supported for the following reasons:
    a. Drilling in high strength concrete may result in cracking and edge spalling.
    b. The potential of encountering reinforcement during drilling.
    c. The challenge of achieving vertical alignment during drilling.
8. The columns shall tiedown the roof against uplift under the tank empty condition.

9. The use of concrete/grout-filled FRP columns (as currently used in tank rehabilitation works) is not acceptable.

16.8 Floating cover

16.8.1 General

Floating covers on tanks shall generally comply with the requirements of TS 0460 – Floating covers and liners for earth bank storages.

Reference shall be made to Section 0.

16.8.2 Design criteria

A floating cover shall:

a. Operate at all levels between minimum and maximum water levels.
b. Prevent contamination of the water from vermin, debris, leaves and other external contaminants.
c. Allow removal of rainwater from the floating cover.
d. Allow safe access to hatches and sampling points.
e. Allow safe access for cleaning and inspection (for example, by using divers or remote operated vehicles).
f. Be non-combustible under normal operating conditions, refer to TS 0700.
g. Prevent sunlight penetration to the stored water.
h. Have sufficient strength to perform under imposed wind loads over the design life.
i. Be designed to minimise air pockets at the water/cover interface.
j. Be capable of being repaired/patched without the need to withdraw water from the storage tank.

16.8.3 Quality management system

The Quality management requirements of TS 0460 and TS 0421 shall apply to floating covers on tanks.

16.9 Safety grates

Portable and removable safety grates shall be designed to meet the following minimum requirements:

a. Design requirements for safety grates is to be in accordance with SA Water Technical Standard TS 0720 and SA Water typical safe access drawings.
b. Deflection not to exceed 5mm.
c. Load combination to be in accordance with AS1170.0 Structural design actions – general principles.
d. Removable safety grates shall be signposted with “No Step” or the international symbol of a person walking with diagonal line over with the words, “No Step” below.
e. Where practicable, a lifting tool should be used to remove safety grates in line with SA Water Technical Standard TS 0720.

17 Tank pipework and valves

17.1 General

The minimum general design requirements for tank pipework are as follows:

1. Tank pipework and associated couplings, valves, hydrants, flange accessories, access covers, corrosion protection, signs, markers and warning tape shall be developed in consultation with SA Water and generally in accordance with:
   a. TS 0503 – Authorised Products Water Systems, where relevant.
   b. Material standards and manufacturer's data sheet when outside the scope of TS 0503.
   c. TS 0230 - Gate and Butterfly Valve Requirements.
   d. TS 0260 - Requirements for Flow Meters.
   e. TS 0730 – Stainless Steel Durability, Fabrication and Erection.
   f. TS 0800 – Materials in Contact with Drinking Water.
2. Tanks shall be fitted with the following pipework and valves:
   a. Inlet pipework.
   b. Outlet pipework.
   c. Overflow pipework.
   d. Scour pipework.
   e. Sampling pipework.
   f. Isolation valves.
   g. Inlet control valves.
3. Tanks may also need to be fitted with the following pipework and valves:
   a. Non-return valve.
   b. Pressure reducing valves.
   c. Tank bypass pipework.
   d. Bypass valves.
   e. Flowmeter.
   f. Ground level dosing pipework.
   g. Air/vacuum breaker valves for vacuum protection.
   h. Other auxiliary pipework.
4. Air/vacuum valves on drinking water supply are employed on a case-by-case basis. Typical approach to mitigate vacuum pressure includes multiple valves or a vent stack.
5. The design life for tank pipework to comply with SA Water Technical Standard TS 0109.
6. All underfloor pipework shall be concrete encased with a Class N20 concrete to provide a 200mm minimum thick encasement. The encasement shall extend a minimum of 500mm beyond the external perimeter of the tank footing.
7. Cast-in or built-in tank pipework shall be designed to allow for the ultimate flow rates.
8. Where steel pipes penetrate through the tank wall or floor slab, a minimum clearance of 50mm shall be maintained between the pipe wall and the tank reinforcing steel to prevent galvanic corrosion. The electrical isolation of the pipe from the reinforcing bar shall be checked once all the steel has been fixed and after the concrete is placed.

9. Valves for tank pipework shall be located as near as practicable to the tank.
10. A risk assessment with SA Water should be undertaken to determine on a case-by-case basis if design allowance for seismic requirements to NZS 3106 is required to be included for pipework design.
11. Where seismic restraints for pipework are deemed necessary by SA Water, these restraints shall be in accordance with NZS 4219.
12. Use pipework that is coated or painted to a consistent standard that will ensure all substances contained in the pipework are clearly identified to achieve safe management of substances, chemicals and processes. Identification coding shall comply with SA Water Technical Standard TS 0204 and AS 1345.
13. The tank must be able to be isolated from supply network.
14. Pipework to be designed for thermal and hydraulic loads.
15. Piping must be flexible enough to accommodate shell rotation and deflections due to elastic growth caused by hydrostatic pressure, seismic movements, and settlement in the tank or piping system; where potential settlements are identified to be significant provide articulated joints.
16. The requirement for water quality sampling, feed water offtakes, dosing injection and residual sampling points along the inlet and/or outlet pipework is to be agreed with SA Water.

Table 17: Pipework and valves design criteria

Pipe and valves design criteria	Requirement
Design flow	To consider future growth, where possible
Design pressures	To consider future growth, where possible
Design velocity	Optimised to minimise hydraulic head losses under maximum demand conditions.
Minimum pipe class	PN16
Minimum negative pressures (unless pipe strength calculations are undertaken and approved by a TDRF).	-10m
Pipe materials	MSCL or where relevant to TS 0503 Authorised products – water systems. GRP or Stainless steel pipework and fittings only inside tanks.
Minimum fill cover	To TS 0136 – Pipework access and protection
Minimum clearances to other services	To TS 0136 – Pipework access and protection
Embedment material	TS 0631 – SA Water, Water Supply Construction Manual.
All new pipe and valve flanges	To AS/NZS 4087 – Metallic flanges for waterworks purposes

17.2 Pipework materials

Pipework shall be generally constructed of cement lined mild steel, protected in accordance with:

a. TS 15 – Protection of steelwork in submersible environments.

b. TS 16 – Protection of steelwork in atmospheric environments.

c. TS 17 – Protection of steelwork in buried environments.

d. AS 1281 – Cement mortar lining of steel pipes and fittings.

e. AS 4321 - Fusion bonded medium density polyethylene coating.

f. TS 0465 – Mortar Repair Systems.

Specials shall be fabricated from Grade 250 mild steel in accordance with AS 1579 and lined internally with cement mortar in accordance with AS 1281.

The clean skin external wrapping or coating of steel pipes shall extend at least 100mm into concrete surround.

For buried applications, pipes of stainless-steel material shall not be used.

17.3 Inlet pipework

The minimum general design requirements for tank inlet pipework are as follows:

a. Refer section 9 for water quality requirements including mixing.

b. The inlet must have adequate structural support where required.

c. Design requirements for inlet pipework shall be defined as part of the preliminary/concept phase of design.

d. Refer section 0 for inlet pipe penetration.

e. Inlet pipe penetration through top of wall (or as approved by a TDRF through the roof) shall be fitted with hydraulic break at the high point to provide consistent upstream hydraulic conditions and provides backpressure for the tank inlet control valves. The hydraulic break should be adequately vermin protected and shall be accessible to Operations & Maintenance team to undertake inspections as required.

f. While penetrating at a high level, the inlet main will then come down to tank floor level and discharge at an upward angle as per section 9.3.3.2.

g. A facility for chlorine dosing and/or water sampling points should be in accordance with the project requirements. However, if dosing and sampling is not specifically stated, a risk assessment should be undertaken, during concept design, of the need for dosing and sampling points.

17.4 Outlet pipework

The minimum general design requirements for tank outlet pipework are as follows:

a. Refer section 9 for water quality requirements including mixing.

b. Tank outlets are typically through-the-floor outlets and be designed such as to minimise hydraulic head losses.

c. A 150mm high mud ring shall be provided around the outlet to prevent sediments from being drawn into the outlet. For operational safety, the outlet opening shall be fitted with an FRP or stainless steel grate. The gratings shall be trafficable and removeable and not dislodge under normal operation.

d. Representative sampling points shall be provided on the storage outlet.

e. Determine anti-vortex requirements during the design.

17.5 Combined inlet/outlet

A separate inlet and outlet arrangement is preferred, exceptions will be considered against water quality requirements and risks coupled with hydraulic requirements.

17.6 Overflow pipework

Overflow pipework is required in the situation where the failure of tank controls prevents the usual stopping of inflow into the tank.

The tank wall height provision (refer section 0) is designed in conjunction with the overflow pipework and provides sufficient head over the overflow and a margin of safety to pass the design inflow. The design shall be such that over-topping of the tank wall shall never be allowed to occur.

The tank shall be equipped with an overflow to protect the tank from overpressure and overload. The type and size of the overflow shall be specified during design.

Overflow pipework shall be external to the tank as per section 0.

The overflow pipe shall be fitted with a bell mouth structure to improve the rate of overflow.

If the design flow is supplied by more than two valves, the overflow pipework shall be designed for the maximum design flow of one valve.

If only one valve feeds the tank with no controls available to close the inflow, the overflow pipework shall be capable of discharging not less than 120% of the design inflow rate.

SA Water Engineering are to be consulted if the overflow size is >DN300.

Where possible, overflow pipework shall be directed to an existing stormwater system with allowance for de-chlorination prior to discharge to receiving systems. Where this is not possible, overflow shall be controlled as to minimise environmental damage through scouring and not impact on adjoining or downstream private property. Design of the overflow system shall be incorporated on the design drawings issued for approval.

Overflow pipework shall be designed to be vermin proof.

17.7 Scour and pipework

A scour is required in the floor of tanks for drainage of the unusable storage and for cleaning purposes.

The scour shall be at the bottom of the tank.

To minimise penetration in the tank floor slab, the scour and outlet floor slab openings shall be combined into one with discharge to either the outlet pipework or the scour pipework controlled via an isolation valve accessible to Operations and Maintenance team.

The rate of drainage from the scour shall take into account the receiving environment and overflow or scour sump capacity.

The size of scour pipe shall be determined based on the allowable flow velocity, which is dependent on the TWL referenced against elevation of the scour. However, the minimum scour pipework size shall conform to the following table.

Table 18: Minimum scour size

Tank volume	Minimum scour size
500kL to 1000kL	DN150
1000kL to 9000kL	DN200
Larger than 9000kL	DN300

Scour pipework shall be laid at a grade no flatter than 1 in 500 to the discharge point. The scour pipework shall have a valve installed close to the tank wall. The valve shall be of the same diameter as the pipe (i.e., no reducers) to prevent sediments from becoming trapped at the valve.

Scours on elevated tanks shall have an additional valve installed at ground level so that the valve does not need to be operated or maintained from the tank platform or a landing.

Scours are required to discharge into the scour/overflow sump. The scour pipework is usually connected to the overflow pipework outside the plan outline of the tank.

Reference shall be made to section 8.2.

17.8 Provision to bypass

The pipework and tank shall be designed to allow the tank to be taken out of service for maintenance.

Any bypass provisions need to be risk assessed and a design determined on how a bypass will be achieved.

Bypass may be achieved by:

a. Provision of flange / branch connections.

b. Provision of a bypass between the tank inlet and outlet pipework or elsewhere on the site or adjacent road in which the supply and outlet mains run including required valves, vacuum and pressure considerations.

c. Determination of alternative supply options for the event of the tank being out of service.

d. Provision of two or more tanks on site.

17.9 Additional requirements for elevated tanks

a. Pipework is to not be supported from the tank, but can be supported by the tank supporting structure, with consideration to operational use.

b. All valves must be able to be operated and replaced from a safe working position, preferably at ground level.

c. A flexible joint shall be incorporated into the pipework near the tank to ensure the pipe is self-supported and not supported by the tank. The flexible joint must be designed to accommodate the movement of the tank and movement of the pipes due to changing operating levels and temperature.

17.10 Valve chambers, thrust and anchor block design

Buried pipework shall be restrained as necessary by valve chambers, anchors or thrust blocks designed and detailed in accordance with TS 0760 Pipeline Design.

The need of a chamber should consider the risks associated with directly burying an isolation valve in proximity of the tank and the risks of excavating to replace and or maintain the isolation valve adversely affecting the tank structure.

The designer shall take account of the following in the design:

a. The use of unrestrained or restrained pipeline jointing.

b. Unrestrained or restrained fixing of the pipeline at valve chamber walls.

c. Hydraulic forces.

d. Temperature forces.

e. Vertical as well as horizontal changes in pipe direction.

f. Restraint of pipes laid on steep grades.

g. Flotation effects of high-water tables/leaking tanks.
h. Differential settlement between pipes and valve chambers.
i. Surge and water hammer effects.
j. The worst combination of closed and open valves.
k. Reversal of forces on anchors and chambers.
l. Siphoning and formation of vacuum.
m. For safe access and clearances, reference shall be made to TS 0720.

17.11 Pipe end dissipator design

Design of the pipe end dissipator at the end of the overflow and scour pipes shall take account of the recommendations of TS 0760 Pipeline design and provide for safe discharge of tank overflows.

The design shall consider the need to reduce energy of the flow due to the driving head of the tank water level.

Also consider the impacts to downstream receiving areas including flooding and contamination.

The pipe end dissipater shall be appropriately sealed to prevent the ingress of vermin.

18 Construction

18.1 General

Documentation for the construction of the tank and its associated works shall be produced by the tank designers in accordance with section 4 of this Standard. Documentation shall convey to the construction constructor all the necessary information to enable the works to be constructed in accordance with the designer's requirements, this Standard and associated Technical Standards.

Construction work on site shall not proceed without the SA Water's Representative's written approval.

18.2 Geotechnical

It is the responsibility of the constructor to verify the geotechnical report on site and advise the Design Engineer of any variations in the ground conditions to those identified in the report supplied or subsequent commissioned reports. The Design Engineer shall recommend any modifications to the design or construction procedures to ensure the foundations for all parts of the work are acceptable. Should any unforeseen geotechnical conditions be revealed during the construction that will affect the tendered price or the design in any way, the Constructor shall immediately advise SA Water's Representative.

Where required by the geotechnical report, the designers, or SA Water, the load/settlement behaviour of foundations shall be carefully monitored during water testing by accurate survey and ongoing comparison to the baseline survey. All survey work shall be carried out be an independent registered surveyor, with a report summary of results presented to SA Water on completion.

18.3 Constructors' submissions

The constructor shall submit the following information, and where material and services are to be procured, samples and information on service providers shall be submitted two weeks ***prior to order*** of the relevant product or service;

a. Constructor submissions for all concrete works are to be in line with SA Water Technical Standard TS 0710.

b. Supply the name of the proposed NATA registered laboratory undertaking compaction testing.

c. Submit plans showing the proposed topsoil stockpiling area.

d. Submit plans addressing environmental and heritage resourcing and controls in line with environmental legislation and regulations for example, heritage protection, works in waterbodies, native vegetation and regulated and significant trees etc.

e. Submit a sample of the waterstop to be used in the works.

f. Submit a sample of the form tie to be used in the wall formwork construction.

g. Submit a sample of all types of bar spacers to be used on the project and identify where they are to be used.

h. Supply a valid certificate of approval issued by the Australian Certification Authority for Reinforcing Steel (ACRS) showing compliance of the reinforcement to be used on the project with AS/NZS 4671.

i. Supply a Manufacturer's Test Certificate and a Compliance Certificate for high strength structural steel bolts used on the project to AS 1252.

j. Submit a sample of the proposed roof sheeting, full width by 150mm long. Supply a test certificate in accordance with clause A4 of AS 1397 for each batch of roofing material delivered to site.

18.4 Shop drawings review

All shop drawings shall be reviewed by the Constructor and Designer. A copy of the reviewed drawings with the Constructor and Designer's signature and comments shall be sent to SA Water for information.

18.5 Surveying

18.5.1 Tank set-out

The constructor is responsible for all survey and set-out work. The constructor shall engage a licensed surveyor to carry out duties including the following:

1. Prior to construction commencing, establish site boundaries, easement boundaries and the location of the tank in accordance with the drawings and benchmarks.
2. During construction activities to check on:
   a. The levels of inlet and outlet pipes levels of overflow pipe.
   b. Grading of the tank floor slab.
   c. Verticality of the tank walls.
   d. Height and consistency in the level of the rim of the tank.
   e. Diameter of the tank and roundness of the tank (if circular).
   f. Straightness of walls and internal angles of tank (if not circular).
3. During construction activities where existing survey marks are in danger of being lost or damaged by construction activities, a new survey mark must be established and coordinated.

18.5.2 Certification of set out

The Constructor shall supply SA Water written statements from the surveyor that the required works have been constructed in accordance with the "For Construction" design documents.

18.6 Concrete and reinforcement

The manufacture, supply, testing and placement of concrete shall be in accordance with SA Water Technical Standard TS 0710.

The placing and fixing of reinforcement shall be in accordance with SA Water Technical Standard TS 0710.

No items, including tie wire, that could be corroded by the environment shall be embedded in the cover zone.

Where hot dip-galvanised reinforcement is used it is subject to the requirements of AS 3735 section 5.3.1.2.

18.7 Welding

All welding works shall comply with the minimum requirements in SA Water Technical Standard TS 0420.

18.8 Waterstops

Waterstops shall be installed in accordance with SA Water Technical Standard TS 0464 – PVC waterstop. Special care is required to ensure that PVC waterstops are accurately held in position during concreting and the air is no trapped between the concrete and waterstop.

18.9 Roofing

All roof sheets shall be laid in single lengths. Sheets which are cut or trimmed to shape shall be left with a clean-cut edge with no distortion of the profile or cross section. Cut edges shall be recoated immediately after cutting in accordance with Appendix G of AS 1650. Side laps on the sheets shall be self-locking along the entire length of the sheets. The ingress of dust into the tank shall be prevented by sealing the flutes.

18.10 Completion

All earthworks cut faces and disturbed areas shall be reinstated with a layer of topsoil not less than 150mm thick to the satisfaction of SA Water Representative. Remove all temporary works and cleanup the site.

18.11 Inspections

Inspections shall be undertaken by the Design Engineer at the following stages of construction as a minimum:

a. Base or subgrade prior to covering.

b. Elements to be concealed in the final work prior to covering (for example, inlet, outlet and overflow pipework).

c. Reinforcement fixed in place (including on or off-site precast panel construction).

d. Completed formwork prior to placing concrete.

e. First and second fix of services.

f. Completion of works.

Inspection reports shall include:

1. Date and time of inspection.
2. Person undertaking the inspection.
3. Identification of the inspected work or portion of the work.
4. Requirements for additional work or changes to the inspected work for the construction to comply with the requirements of the drawings and specification or the Engineer's endorsement that the inspected work complies with the intent of the documentation and that construction may proceed.

Copies of all inspection reports shall be supplied to SA Water.

Notwithstanding the Design Engineers inspections, concrete shall only be placed in the presence of the Superintendent's Representative and the Constructor shall give not less than 5 days' notice of their intention to commence placing.

The sequence and procedure of placing and the method of compaction shall be approved by the Superintendent's Representative before placing commences.

18.12 Quality control

18.12.1 Tank concrete testing

All testing shall be undertaken in accordance with SA Water Technical Standard TS 0710.

18.12.2 Civil works

Materials for civil works are to comply with SA Water Technical Standard TS 0630 – Coarse aggregates for civil work.

Materials for access roads shall be comply with DIT pavement details and materials and SA Water standard drawing 94-0163-12.

Pipe embedment materials are to comply with SA Water Technical Standard TS 0631 – Fine materials for pipe embedment.

Compaction certificates and inspection of sub grade to be submitted.

18.12.3 Pipe pressure testing

Pipe pressure testing shall be undertaken in accordance with TS 0900 – Pressure testing of pipelines and the requirements including test pressure for each section of pipework shown on the design drawings.

Testing of above ground pressure piping shall be undertaken as per the technical specification or as outlined on the design drawings and in accordance with AS 4041, TS 0900 and AS/NZS 4087.

Testing of below ground piping shall be undertaken as per the technical specification or as outlined on the design drawings.

18.12.4 Cathodic protection testing

Testing requirements and quality control for cathodic protection are to comply with SA Water Technical Standard TS 0440.

18.12.5 PVC waterstop weld testing

Testing requirements and quality control for PVC waterstops are to comply with SA Water Technical Standard TS 0420.

18.12.6 Roof and access hatch testing

The Constructor shall allow to undertake testing of the roof in accordance with TS 0600 Water tightness testing of liquid retaining structures.

Give notice so that the Superintendent's Representative may attend the testing. Submit a report following the test signed off by the Constructor and Designer. If the test fails undertake repairs and re-test. Any leaks shall be made good immediately by the Constructor to the satisfaction of the Superintendent's Representative.

18.12.7 Noise testing

Noise level tests shall be conducted on site for compliance with environmental (EPA Noise Policy) and occupational noise levels and approvals upon completion of works.

19 Commissioning and handover

19.1 Disinfection and commissioning

Disinfection and commissioning of tanks shall be carried out in accordance with the following SA Water guidelines:

a. SAW-WQ-0003 – New Asset Water Quality Requirements Checklist.

b. SAW-WQ-0004 – New Asset Water Quality Monitoring Requirements for Commissioning.

c. SAW-WQ-0009 – Storages – Water Quality Guideline for Operation and Maintenance.

19.2 Water tightness testing of the tank on completion

Testing of the tank and roof structure shall be undertaken in accordance with SA Water Technical Standard TS 0600 with the following additional requirements:

a. Testing shall not be carried out until 28 days after the final wall pour has been placed. Before testing commences the Constructor shall ensure the inside of the tank and tank pipework are thoroughly cleaned to remove all loose and foreign material. The tank must also be sterilised by SA Water following cleaning but prior to testing.

b. Any defects in the tank (concrete structure, liner and roofing) shall be remedied by the Constructor as soon as they are disclosed.

c. The Date of Practical Completion of the tank will be taken as the date on which the tank is accepted by SA Water Representative as having satisfactorily passed the water test.

19.3 As constructed survey

'As constructed' survey and documentation shall be in accordance with the requirements of SA Water Technical Standard TS 0100. The survey datum shall be to the Geocentric Datum of Australia co-ordinate system (GDA94).

19.4 As constructed documentation

As Constructed documentation of the tank shall be undertaken in accordance SA Water Technical Standards TS 0132 and TS 0133.

As-constructed drawing submission to meet the requirements of SA Water Technical Standard TS 0100.

19.5 Operations and maintenance manuals

Operation and Maintenance Manuals are a required deliverable for water storage tank capital works projects.

Operation and Maintenance manuals shall be provided and presented in accordance with SA Water Technical Standard TS 0132.

The O&M Manuals shall give a clear, comprehensive description of all plant and systems provided under the Project including interfaces with other infrastructure. It shall cover the principles and mode of operation, both initially (when lower demand is experienced) and into the future when the system reaches capacity and maintenance requirements, with supporting documentation.

Statutory testing of any Davit Bases and fall arret points should be provided for Operational Hand over.

A draft O&M Manual, compiled as per TS 0132 shall be provided prior to the commencement of the run or performance test period for review by SA Water. The draft manual shall be complete in terms of original content and documentation provided by others. Outstanding information to be included in the final Manual shall be clearly indicated in the draft version.

Adequate time shall be allowed for review and for the outcomes of the review to be addressed, noting that delivery of the final O&M Manuals to SA Water is a condition for the granting of Practical Completion.

The quantity of final manuals to be provided depends on the nature of the Project and the associated site(s).

The requirements for SA Water security systems are covered separately by TS 0120 Installation Standards for Electronic security systems on SA Water sites.

19.6 Completion, acceptance and commissioning

The tank shall not be accepted until the microbiological, chemical and leak tests have been successfully passed, verified 'As Constructed' documentation received and the tank is considered to be satisfactory by SA Water.

A Schedules of hold points, witness points and identified records

A1 Schedule of hold points and witness points

Issue	Requirement
Concrete – Work Method Statement	The Constructor shall issue a Constructor Works Method Statement for Concrete to SA Water's Representative at least 20 working days prior to commencing any concrete works covering all concrete supply, testing, placement compaction and curing matters in accordance with TS 0710.
Concrete – supply	The Constructor shall plan, establish and maintain a quality system for the project which conforms to TS 0710 and complies, as a minimum, with all the relevant system elements of AS/NZS ISO 9001 and includes materials certification, method statements, quality records including inspection and test plans (ITPs), hold points, witness points and work instructions.
Concrete – inspection	The Constructor shall give SA Water's Representative a minimum of five (5) working days' notice of the Constructor intention to place concrete. Unless inspection is waived by SA Water's Representative in each specific case, placing of concrete shall be performed only in the presence of the SA Water's Representative. Concrete shall not be placed outside normal working hours without the prior approval of the SA Water's Representative.
Concrete – sprayed concrete test panels	Refer to TS 0710 – Sprayed concrete shall not be placed until the SA Water Representative has reviewed all prequalification procedures, the results of testing, and visual inspection of both the cores sampled and the test panels.
Concrete – crack inspection and assessment, 7 days, construction completion, 12 months or end of DLP.	A site crack inspection shall be completed on all concrete surfaces in accordance with the procedures contained in CIA Z7/07 and TS 0710 by the Constructor in the presence of SA Water's Representative.
Concrete – site concrete cover measurements	Refer to TS 0710
Formwork and Falsework	Unless it is waived by the SA Water Representative in each specific case, the relevant Certificate of Compliance for formwork and falsework shall be submitted. The application of any load shall not proceed until the Certificate of Compliance of the constructed formwork has been reviewed by SA Water's Representative.
PVC Waterstop	Refer to TS 0464 – PVC waterstop, Appendix A
Welding (Metals)	Refer to TS 0420 Welding requirements (metals)

A2 Schedule of identified records

Identified Records are those records required to be submitted to SA Water's Representative throughout the construction phase to demonstrate compliance with this and other referenced SA Water Technical Standards to enable acceptance of the works and granting of completion. Identified Records include but are not limited to:

a. Constructor/sub-contractor evidence of required/relevant qualifications.

b. Inspection and Test plans.

c. Inspection records.

d. Test results.

e. Certificates.

f. Product data sheets.

g. Instrument and Equipment lists.

h. Drawings.

i. Warranties.

j. Training documents.

k. Statutory Compliance Certificates.

l. Operation and Maintenance Manuals.

Issue	Requirement
Asset labelling	The completed label schedule shall be included in the O&M Manual and returned to SA Water after the asset is commissioned, refer to TS 0132.
Bolts	For bolts manufactured outside of Australia provide local independent NATA accredited laboratory compliance certification based on appropriate testing and verification. Provide supplier declaration of conformity letter in accordance with AS/NZS 1252.1, AS 4291.1 and AS/NZS 4291.2 for each lot of bolts.
Concrete – fine aggregate test results	Refer to TS 0710
Concrete – coarse aggregate test results	Refer to TS 0710
Concrete – admixtures – name, details, purpose, method of use, test results.	Refer to TS 0710
Concrete – sulphate and chloride ion content tests	Refer to TS 0710
Concrete – curing compound	Refer to TS 0710
Concrete – temperature and strain monitoring	Refer to TS 0710
Concrete – sprayed concrete testing	Refer to TS 0710
Materials in contact with Drinking Water	Certification to AS/NZS 4020 and product data sheets upon request.
NATA registered laboratory	Submit name and details.
Operation, maintenance and training manuals	Refer to TS 0132 – Operations and maintenance manuals
PVC Waterstop	Refer to TS 0464 – PVC waterstop, Appendix A

Issue	Requirement
Reinforcement	The reinforcement material supplier including but not limited to manufacturers and processors, shall be certified by the Australasian Certification Authority for Reinforcing and Structural Steels for the supply of the steel reinforcement. If requested, the Constructor shall supply to SA Water's Representative copies of the manufacturer's test certificates identifiable with the reinforcement supplied or provide documentary evidence that all products meet the requirements of AS/NZS 4671, and that the supplier has a system in place to prevent non-conforming material from being supplied.
Roofing	Manufacturer's warranty aligning to durability requirement.
Survey – 'As -constructed'.	'As constructed' survey and documentation shall be in accordance with the requirements of TS 100.
Survey – 'As -constructed'.	The Constructor shall supply SA Water written statements from the surveyor that the required works have been constructed in accordance with the "For Construction" design documents.
Welding (Metals)	Refer to TS 0420 Welding requirements (metals)

A3 Samples

Provide samples applicable to the type of tank construction, relevant Technical Standards and the following table.

Table 19: Schedule of samples

Issue	Requirement
Waterstop	300mm length of each type
Form tie	All types, 2 of each
Bar spacer	All types, 2 of each
Liner and floating cover	500mm x 500mm
Underfloor drainage materials	300mm x 300mm
Roof sheeting	Full width x 150mm long