Public Transport Authority

SPECIFICATION

Design of Drainage for PTA Infrastructure

Current		8880-450-090	Rev 1.00	**UNCONTROLLED IF PRINTED**
Date Approved: 22/05/2020		© PUBLIC TRANSPORT AUTHORITY OF WESTERN AUSTRALIA 2019		

Document History and Governance

Document Governance

	Role
Document Owner	Civil Engineering Manager - N&I

Document Compliance

If this document contains requirements that provide a standard of compliance in accordance with legislation, they shall be complied with irrespective of a project's stage in relation to the Project Management Framework. In all other circumstances, projects that have formally completed Stage Gate 3 may continue to comply with the relevant PTA standards that were current at the completion of project Stage Gate 3.

Document Authorisation and History

Rev	Date Approved	Compliance Date	Prepared by	Reviewed by	Authorised by	Comments
1.00	22/05/2020	22/05/2020	Project Engineer - Civil Major Projects, Venny Woo	Principal Civil Engineer N&I, Sam Burnett	Civil Engineering Manager N&I, Vijaya Moorthy	First Version

© PUBLIC TRANSPORT AUTHORITY OF WESTERN AUSTRALIA 2019

Table of Contents

© PUBLIC TRANSPORT AUTHORITY OF WESTERN AUSTRALIA 2019

© PUBLIC TRANSPORT AUTHORITY OF WESTERN AUSTRALIA 2019

© PUBLIC TRANSPORT AUTHORITY OF WESTERN AUSTRALIA 2019

List of Tables

© PUBLIC TRANSPORT AUTHORITY OF WESTERN AUSTRALIA 2019

Related Documents

Table 1: Legislation

Document Reference
Rail Safety National Law (WA) Act 2015
Rail Safety National Law (WA) Regulations 2015
Occupational Safety and Health Act 1984
Occupational Safety and Health Regulations 1996
Environmental Protection Act, 1986
Landfill Waste Classification and Waste Definitions 1996 (as amended 2019)
Environmental Protection (Noise) Regulations 1997
Rights in Water and Irrigation Act 1914
Water Agencies (Powers) Act 1984

Table 2: PTA Specifications, Procedures and Codes of Practice

Document Number	Name
8103-400-004	Procedure: Working in and around the PTA Rail Reserve
8110-100-013	Procedure: Engineering Management for Projects
8110-400-013	Procedure: Entry into Service and Final Asset Acceptance
8110-400-030	Procedure: Trenchless Excavations Beneath the PTA Operating Railway
8130-400-560	Form: Trenchless Excavation and Survey
8190-400-002	Code of Practice: Narrow Gauge Main Line Track and Civil Infrastructure
8190-800-001	Code of Practice: Design, Supply, Construction and Commissioning of 25 kV OLE
8203-000-003	Guideline: Drafting Stage 4 Design Report
8803-000-005	Specification: Stations and Buildings Civil Works
8880-450-010	Specification: Actions, Asset Design and Maintenance
8880-450-020	Specification: Design of Reinforced Concrete
8880-450-021	Specification: Concrete Durability
8880-450-051	Specification: Railway Tunnels and Dive Structures
8880-450-069	Specification: Fences and Noise Walls
8880-450-074	Specification: Earthworks, Slope Stability, Geotextiles and Erosion Protection
8880-450-300	Specification: Access to Rail Corridor Infrastructure

Table 3: Australian Standards, Specifications, Guidelines and Codes of Practice

Number / Organisation	Name
ARR (latest version)	Australian Rainfall and Runoff: A Guide to Flood Estimation, Commonwealth of Australia
AS 1141	Methods for Sampling and Testing Aggregates
AS/NZS 1254	PVC-U Pipes and Fittings for Stormwater and Surface Water Applications
AS 1289	Methods of Testing Soils for Engineering Purposes
AS 1379	Specification and Supply of Concrete
AS 1428	Design for Access and Mobility
AS/NZS 1477	PVC Pipes and Fittings for Pressure Applications
AS 1478	Chemical Admixtures for Concrete, Mortar and Grout
AS 1597	Precast Reinforced Concrete Box Culverts – Part 1 and Part 2
AS 1646	Elastomeric Seals for Waterworks Purposes
AS 1726	Geotechnical Site Investigations
AS/NZS 2416	Water Safety Signs and Beach Safety Flags
AS 2439.1	Perforated Plastics Drainage and Effluent Pipe and Fittings – Perforated Drainage Pipe and Associated Fittings
AS/NZS 2566	Buried Flexible Pipelines – Part 1 and 2
AS 2758	Aggregates and Rock for Engineering Purposes – Parts 1 and 7
AS/NZS 3500.3	Plumbing and Drainage – Stormwater Drainage
AS 3600	Concrete Structures
AS 3610	Formwork for Concrete
AS 3700	Masonry Structures
AS/NZS 3725	Design for Installation of Buried Concrete Pipes
AS 3743	Potting Mixes
AS 3972	General Purpose and Blended Cements
AS 3996	Access Covers and Grates
AS/NZS 4058	Precast Concrete Pipes (Pressure and Non-pressure)
AS 4100	Steel Structures
AS 4139	Fibre Reinforced Concrete Pipes and Fittings
AS 4198	Precast Concrete Access Chambers for Sewerage Applications
AS 4292.1	Railway Safety Management Part 1: General Requirements
AS 4419	Soils for Landscaping and Garden Use
AS 4454	Composts, Soil Conditioners and Mulches
AS 4586	Slip Resistance Classification of New Pedestrian Surface Materials
AS/NZS 4671	Steel Reinforcing Materials
AS 4799	Installation of Underground Utility Services and Pipelines within Railway Boundaries

Number / Organisation	Name
AS/NZS 5065	Polyethylene and Polypropylene Pipes and Fittings for Drainage and Sewerage Applications
AS 5100.5	Bridge Design Part 5: Concrete
AS 5488	Classification of Subsurface Utility Information
Austroads Publications	AUSTROADS Guide to Road Design, Parts 5, 5A and 5B – Drainage
	Technical Specification ATS2210: Supply of Steel Reinforced Precast Concrete Pipes
CRC for Water Sensitive Cities	Adoption Guidelines for Stormwater Biofiltration Systems
DS 66	Water Corporation – Urban Main Drainage Standard
DWER Publications	Stormwater Management Manual for Western Australia
	Water Resource Considerations when Controlling Groundwater Levels in Urban Development
IPWEA	Specification Separation Distances for Groundwater Controlled Urban Development
Monash University	Vegetation Guidelines for Stormwater Biofilters in the South-west of Western Australia
MRWA Publications	MRWA Drainage / Waterways Design Guidelines
	MRWA Specification 201: Quality Systems
	MRWA Specification 400 Series: Drainage
	Various Drainage-related MRWA Standard Drawings located on the MRWA website at https://www.mainroads.wa.gov.au/BuildingRoads/StandardsTechnical/MainRoadsDrawings/Pages/home.aspx
SPP 2.6	State Planning Policy 2.6 Coastal Planning Policy
SPP 2.9	State Planning Policy 2.9 Water Resources
WAPC	Better Urban Water Management Guideline

Table 4: International Standards, Specifications and Codes of Practice

Document Number	Name
ISO 9001	Quality Management Systems
ISO 14001	Environmental Management Systems – Requirements with Guidance for Use

© PUBLIC TRANSPORT AUTHORITY OF WESTERN AUSTRALIA 2019

1. Introduction

Drainage supporting the Public Transport Authority's (PTA) railway track and other infrastructure shall be designed, constructed and maintained to meet PTA's functional requirements. These include: railway operational requirements, engineering requirements, maintenance and access requirements, environmental and sustainability requirements, and minimisation of the whole life cost of assets.

1.1 Document Purpose

This specification identifies the minimum PTA requirements for permanent and temporary design and construction of drainage for PTA infrastructure.

1.2 Audience and Applicability

The requirements described within this document shall be implemented by any manager, consultant, contractor, manufacturer, supplier or other party involved in the delivery, acceptance, alteration or maintenance of civil engineering works either directly or indirectly for the PTA.

1.2.1 Document Applicability

The requirements of this specification apply to:

a. Design and implementation of new railway infrastructure;

b. Upgrading existing railway infrastructure;

c. Design and implementation of, or upgrading of, other PTA infrastructure (e.g. carparks, bus interchanges); and

d. Design and implementation, or upgrading works over or adjacent to railway property.

1.2.2 Document Exclusions

Exemptions from this specification can only be authorised by the PTA N&I Manager for Civil Engineering.

The requirements of this specification exclude the following:

a. Design of drainage for under and over track road crossings, tunnels, underground stations, dive structures and any drainage that is part of tunnel or hydraulic services design;

b. Design of drainage associated with rivers, estuary or creeks requiring the construction of a bridge type structure; and

c. Design of drainage infrastructure within buildings, station, platform within the rail reserve subject to building construction requirements.

The requirements described within this specification are supplementary to the requirements prescribed in any applicable Commonwealth, State and Local Government Acts, Regulations and By-laws and relevant Standards and Codes of Practice.

Refer to PTA document 8110-100-013 Engineering Management for Projects Procedure and 8110-400-013 Procedure Entry into Service and Final Asset Acceptance for further information and requirements.

1.3 Roles and Responsibilities

Refer to 8110-100-013 Engineering Management for Projects Procedure for a list of Roles and Responsibilities. Additional roles are listed in Table 5.

Table 5: Description of Roles

Role	Responsibility
Commissioning Team	Means the members of a team who, through their coordinated actions, are responsible for the commissioning of the works, including all inspection, testing and commissioning processes. The commissioning team usually consists of the contractor and its sub-contractors and is managed by a commissioning manager, which is fulfilled by the Supplier's Engineering Manager (SEM).
Construction Team	Means the members of a team who, through their coordinated actions, are responsible for the construction of the works. The construction team usually consists of the contractor, sub-contractors, manufacturers and suppliers, and is managed by a Construction Manager.
Contractor	Means a party(s) responsible for executing the works on behalf of the PTA. The contractor's officer or their nominated representative (typically the contractor's appointed Project Manager) shall be the person duly authorised by the contractor and charged with exercising the defined powers, duties and functions vested in the contractor under the contract and Engineering Management for Projects (EM4P) process as the SEM for the project delivery. Generally, the term 'contractor' shall be preceded by the role of the contractor in the design, construction and acceptance of the works (i.e. Design Contractor, Construction Contractor, D&C Contractor, etc.). In the case of this specification, the term 'contractor' shall include any other party(s) engaged by the contractor to execute various elements of the civil works, including all sub-contractors, manufacturers, suppliers and the like. The contractor shall enter into a sub-contract agreement with their sub-contractors, manufacturers and suppliers, which contains an obligation on the part of those parties to comply with the contract.
PTA Officer or Principal	Means the Public Transport Authority of WA. The PTA Officer or their nominated representative (typically the PTA appointed Project Manager) shall be the person duly authorised by the PTA and charged with exercising the defined powers, duties and functions vested in the PTA under the contract. During the construction and acceptance stages of the Works, the PTA may appoint a superintendent to assist with administering, reviewing and approving the Works to be executed under the contract on behalf of the PTA.
Superintendent or SEM	Means a party(s) appointed by the PTA to administer, review and approve the works to be executed under the contract on behalf of the PTA. The Superintendent's officer or their nominated representative shall be the person duly authorised by the Superintendent and charged with exercising the defined powers, duties and functions vested in the Superintendent under the contract.

Role	Responsibility
Supplier	An organisation or party, appointed by the PTA, to provide their services which are needed to fulfil the works' requirements. The supplier's team may consist of the SEM, SRE, supplier's project manager, designer, etc.

2. Requirements of this Specification

Unless otherwise stated, all design and construction shall be undertaken to the most recently issued version—at the date of contract award—of the Standards, Specifications and Codes of Practice included in Section 2.

The following order of precedence applies in the event of any inconsistency between the documents:

1. Legislative acts and regulations;
2. Project deeds;
3. Project specifications (SWTC, PRS or BDC);
4. This PTA specification;
5. Other PTA specifications, codes, standards, procedures, and guidelines;
6. The most recent version of DWER's Stormwater Management Manual for Western Australia;
7. The most recent version of Australian Rainfall and Runoff: A Guide to Flood Estimation;
8. MRWA Specification 400 Series: Drainage;
9. Other specifications, guidelines and codes of practice listed in Table 3;
10. Other Australian standards, specifications, codes of practice and guidelines; and
11. International standards, specifications, codes, procedures and guidelines.

2.1 Legislative, Standards and Code of Practice

2.1.1 Legisation

2.1.1.1 All design and construction shall comply with all Australian legislation. Key Acts and Regulations are shown in Table 1.

2.1.2 PTA Specifications, Procedures and Codes of Practice

2.1.2.1 All design and construction shall be undertaken in accordance with this specification and PTA Standards, Specifications and Codes of Practice listed in Table 2.

2.1.3 Australian Standards, Specifications, Guidelines and Codes of Practice

2.1.3.1 All design and construction shall be undertaken in accordance with the Australian Standards, Specifications and Codes of Practice listed in Table 3.

2.1.4 International Standards, Specifications and Codes of Practice

2.1.4.1 All design and construction shall be undertaken in accordance with the International Standards, Specifications and Codes of Practice listed in Table 4.

2.2 Functional Requirements

2.2.1 General Requirements

2.2.1.1 Drainage for PTA infrastructure shall be designed and constructed to satisfy PTA functional requirements, including the minimum requirements identified in this PTA specification, and other PTA specifications, procedures, codes of practice, and guidelines.

2.2.1.2 Drainage shall be designed and constructed to ensure integration with all PTA infrastructure, including provision of interfacing details in the design documentation.

2.2.1.3 Drainage shall be designed and constructed accounting for third party assets and services: approvals shall be gained from third party asset owners.

2.2.1.4 Drainage shall be designed to minimise whole life cost by limiting routine maintenance requirements over the design life.

2.2.1.5 The following requirements shall be applied to all stormwater and drainage management systems, except for those in tunnels, underground stations, dive structures and any drainage that is part of tunnel or hydraulic services design. In these instances PTA Specification: 8880-450-051 Railway Tunnels and Dive Structures shall apply.

a. Minimise interruption to existing stormwater and drainage management systems or modification of surface-flow patterns;
b. Manage all runoff and avoid ponding within, or near, the railway reserve, on any sub-ballast capping layer, access road surface, path or adjacent land;
c. Protect the rail formation and the project works from water ingress;
d. Capable of taking normal construction and maintenance vehicular traffic without collapse;
e. Prevent scour, erosion and sediment transportation;
f. Ensure people and public safety;
g. Avoid adverse impacts on the environment;
h. Minimise flow across track, paths and roads from adjacent landscaped areas;
i. Minimise the need for maintenance, such as scour repair and the removal of sediment deposits;
j. Allow for the impact of existing drainage features on, or adjacent to, the project works site;
k. Maintain the existing flow regimes, water balance and stormwater quality of the project works site, as much as possible;
l. Drainage shall make allowance for a sea level rise based upon current State Planning Policy No 2.6 requirements; and
m. All sag areas and trapped low points shall be completely drained.

2.2.1.6 Drainage system components shall be located, where possible, to avoid clashes with rail infrastructure items and the assets of utility service providers.

© PUBLIC TRANSPORT AUTHORITY OF WESTERN AUSTRALIA 2019

2.2.1.7 Drainage systems shall facilitate safe entry and access for maintenance and operation.

2.2.1.8 Modifications to existing drainage systems shall not adversely affect the performance of drainage within or outside of the project works site.

2.2.2 Specific Requirements – Water Sensitive Urban Design (WSUD)

2.2.2.1 Design, construction and operation of stormwater and drainage management systems including management of high groundwater table (where required) shall comply with the water and environmental management requirements specified and be in accordance with the principles of WSUD as described in Department of Water and Environmental Regulation's (DWER) Stormwater Management Manual for Western Australia and the relevant guidelines, codes and documents listed in Table 2 and Table 3.

2.2.2.2 Stormwater and drainage management systems shall be designed to intercept and treat (if required) pollutants and maintain the quality and quantity of runoff entering the receiving environments such as groundwater, waterways/rivers, tributaries, wetlands and other existing drainage facilities.

2.2.2.3 The principles of WSUD require that stormwater and drainage design achieves the pre-development (or specified) local storage and use and recharge to the groundwater by:

a. Using treatment (if required), retention and/or detention systems;

b. Using overland/surface flow in preference to piped flow where practicable;

c. Directing flow along vegetated surfaces, in preference to constructed drains; and/or

d. Minimising export of water from PTA land.

2.2.2.4 The design process should also have regard to the existing environment and ensure a requirement to retain good-quality bushland or screening vegetation.

2.2.2.5 In areas with high groundwater table where management of superficial groundwater is required, it shall be managed consistent with the DWER's publication: Water Resource Considerations when Controlling Groundwater Levels in Urban Development and current version of IPWEA's Specification Separation Distances for Groundwater Controlled Urban Development.

2.2.2.6 Where a railway alignment crosses any drainage or waterway, the crossing works may impact on the hydrologic and hydraulic regimes of the drainage or waterway. As part of the crossing work, appropriate hydrologic and hydraulic investigation of the drainage or waterway should be conducted to ensure that pre-development hydrologic and hydraulic regime will be maintained (up to 1% AEP event), and the proposed works do not increase any flood risks to people and property. The works also should ensure that it does not impact on the water dependent ecosystems (e.g. increasing frequency of inundation or draining of adjacent wetlands and connected floodplains).

2.2.2.7 Impacts to waterway or drainage including channel form and vegetation should be minimised; and affected upstream and downstream sections of the drain or waterway to be rehabilitated to its natural form that can provide water, environment, ecological and amenity benefits. Works may include rehabilitation

of degraded or disturbed drainage/waterway sections, erosion protection works with natural design (use of rocks and/or vegetations) and maintenance of passage of aquatic fauna (no obstruction to free movement of aquatic fauna such as fish).

2.3 Design Requirements

2.3.1 General Requirements

2.3.1.1 This section prescribes general procedures and deemed-to-comply requirements that shall apply for drainage designs. It applies to the design of new works, as well as the identification of existing flood locations and identification of the related events which may lead to unsafe conditions at those locations. It also sets out proven parameters for determining safe water-flow patterns within the Perth urban environment.

2.3.1.2 The factors to be considered shall include, but not be limited to, the following:

a. Catchment area and development (including future urban development);

b. Use of annual exceedance probability (AEP) and exceedances per year (EY) as defined in the Australian rainfall and runoff (ARR latest revision) guideline document and historical data relating to flooding at the location. For clarity, reference shall also be made to the previous annual recurrence interval (ARI) design return periods, however the new ARR terminology and design principles shall be used for design;

c. Stormwater management system's capacity (e.g. retention, detention and conveyance) required for the design AEP;

d. Identification of rainfall events that may result in flooding at specific locations;

e. Possible effects over asset life of global climate change (e.g. changing weather patterns, rainfall intensities, cyclonic influences, rising sea level);

f. Environmental, hydrological and hydraulic conditions that may influence the performance or deterioration of the waterways and drainage system (e.g. erosion or silting);

g. Need for protection from floodwater erosion and washaway (e.g. flood-mitigation structures); and

h. Required stormwater quality objectives within the catchment (i.e. within the Swan River catchment).

2.3.1.3 In designing the stormwater and drainage management system, the designer shall ensure that approvals from all drainage asset owners affected, including Main Roads WA, the local authority and/or Water Corporation (as appropriate) for all drainage that will be owned and managed by the authority in the future are obtained prior to commencement of construction.

2.3.1.4 Where a railway alignment crosses the proclaimed waterway under the Rights in Water and Irrigation Act 1914 (RIWI Act), and a permit from the DWER may be required to interfere bed and banks of the brook as part of the crossing work.

2.3.1.5 The drainage system shall be designed to accommodate runoff from all new and affected existing infrastructure, including railways, busways, roads, paths and above-ground station areas, including adjacent verges and earthworks, and runoff affected by the project works, also to consider – runoff from upstream catchment (where applicable)

2.3.1.6 All drainage designs and installations in building areas shall be completed to a minimum standard in accordance with AS/NZS 3500.3 unless otherwise detailed on the drawings or in this specification.

2.3.1.7 The drainage design shall be developed in accordance with the above General Requirements, and the deemed-to-comply design requirements prescribed in sections 2.3.2 to 2.3.17. The annual exceedance probabilities used shall be from Table 6 or Table 7 as dictated by location with respect to the rail reserve.

2.3.2 Runoff Calculations

2.3.2.1 Runoff calculations shall consider depression storages, variable soil loss rates and antecedent moisture conditions. A hydrologic and hydraulic loss and routing model with suitable parameterisation detailing expected initial and continuing losses and the resulting runoff from impervious and pervious surfaces shall be developed and used.

2.3.2.2 When assessing the runoff from railway ballast consideration as to storage, losses and potential for modified runoff when compared to other impervious surfaces shall be considered.

2.3.2.3 All assumptions and parameters used in drainage modelling shall be listed in a design report table with explanations for adopting certain values. Output from the model shall be presented in summary tables to the approval of the PTA.

2.3.3 Infiltration Rates

2.3.3.1 A variable infiltration rate cognisant of local soil and groundwater conditions shall be used. Values shall be confirmed by in-situ testing and a safety factor of 2 shall be applied to account for clogging over time and post-construction conditions. No infiltration rates higher than 8 m/day shall be used without approval by the PTA.

2.3.3.2 The designer shall demonstrate the sensitivity of the system for reduced infiltration (potentially due to clogging over time) within design report and consideration shall be given for having low height vegetation to achieve and/or maintain the required infiltration rates.

2.3.4 Ground Water Levels

2.3.4.1 The maximum groundwater level (MGL) shall be determined as the design MGL shall be the 2% AEP phreatic surface by evaluation of actual groundwater monitoring and historic data and presented to PTA for acceptance. In the absence of suitable historic or actual monitoring data, determination of estimated MGLs through a suitable modelling approach shall be undertaken and documented for acceptance. Where mobilisation of groundwater is likely as part of the project work, and the groundwater is polluted, appropriate treatment is required before discharging to receiving environment. Groundwater control work

also to ensure not to result in unacceptable impact to adjacent groundwater dependent ecosystem (e.g. wetland).

2.3.5 Annual Exceedance Probabilities

2.3.5.1 Annual exceedance probability (AEP %) shall be applied to flood protection components of the project drainage design.

2.3.5.2 The equivalent current Australian rainfall and runoff (ARR) latest revision probability terminology (available at http://arr.ga.gov.au/) shall be used in all design documentation and calculations.

2.3.5.3 The project works shall be able to withstand a design flood level for the 0.2% AEP event (an extreme flood event) without being significantly damaged.

2.3.5.4 The project works shall be designed so that, in the event of a flood level up to 300 millimetres higher than the 1% AEP event, floodwater does not enter the stations, tunnels and any other underground structures, ensuring there is no property or structural damage and no inundation of property and station floor levels.

2.3.5.5 Stormwater runoff from constructed impervious surfaces generated by the first 15 mm of rainfall from a frequently occurring event shall be retained and/or detained, and treated (if required) at the source as much as practical to meet WSUD requirements.

2.3.5.6 The stations and railway shall be proven to remain fully functional during a 1% AEP storm.

2.3.5.7 The capacity of any drainage treatment incorporated in the project works shall not be less than the capacity of any nearby existing drainage treatment of the same waterway or drainage line.

2.3.5.8 Stormwater runoff in excess of the 1% AEP rainfall event into the tunnels from dive structures and catchments shall not impact on critical infrastructure for a 0.2% AEP event to allow recovery and operation of train services. Critical infrastructure is considered to be any infrastructure that would take longer than 48 hours recovery time after inundation to enable resumption of train operations. As a minimum, electrical and communications infrastructure shall be considered critical infrastructure.

2.3.5.9 The maximum gutter flow across intersections for a 20% AEP shall be 30 litres (0.03 m^3) per second.

2.3.5.10 The maximum concentration of sheet flow across carriageways, from noses, islands or superelevation changes, shall not exceed five litres (0.005 m3) per second for the 1 exceedance per year (EY) event or 50 millimetres per hour intensity, whichever is the lesser.

2.3.5.11 No lanes of a road or busway shall become un-trafficable during the 1% AEP storm event. A lane shall be considered un-trafficable when more than 300 millimetres of total head, or 200 millimetres of static head, occurs at any point in the lane.

2.3.5.12 The flood immunity requirements of sections 4.5 and 4.6 of Austroads Guide to Road Design Part 5: Drainage, shall be applicable.

2.3.5.13 No part of the carparks shall be flooded, or inundated, during any storm event smaller than the 10% AEP storm event. The depth of stormwater during the 1% AEP event shall not be more than 200 millimetres in any part of the carpark, at any time, and there shall not be any ponding of stormwater for longer than six hours in any part of the carpark during a 1% AEP storm event.

2.3.5.14 The following tables outline the AEP % and EY that shall be applied to deemed-to-comply design. Deviation from the below shall require justification to the PTA and approval prior to acceptance of design.

Table 6: Drainage Annual Exceedance Probabilities for Inside the Rail Reserve

Item	Situation	AEP % (Approx. ARI)
1	Culverts under railway (min. 450 mm diameter). In railway embankment areas, the maximum headwater levels for the design AEP % shall be at the top of the subgrade level (below the base of the limestone capping).	2% (50 years)
2	Linear infiltration swales / open drains / ballast drains, with development or future development downstream.	10% (10 years)
3	Linear infiltration swales / open drains / ballast drains, with open space or future development upstream in Cuttings > 1.5 m.	1% (100 years)
4	Linear infiltration swales / open drains / ballast drains, with open space or future development upstream.	10% (10 years)
5	Locations with residential development upstream.	As above, where required
6	TWL to base of limestone capping (950 mm below rail level).	63.2% or 1 EY (1 year)
7	TWL to top of limestone capping (700 mm below rail level).	10% (10 years)
8	Major system check: TWL to underside of sleeper (500 mm below rail level).	1% (100 years)
9	Major system check: TWL to property and railway infrastructure with 300 mm freeboard.	1% (100 years)
10	Stormwater drainage contained in principal shared path (PSP) corridor: PSP crossfall shall be away from the rail reserve. For larger storms and major storm overland flow paths, and where discharge into PTA rail reserve is unavoidable, this shall be communicated with and accepted by the PTA prior to construction.	20% (4.48 years)
11	Water Corporation main / branch drains.[1]	In accordance with DS66
12	Local Authority drains crossing the reserve.[2]	10% minimum
13	Drainage basins and sumps.	10% (and dry after 96[3] hours)
14	Piped system with 150 mm of freeboard from HGL to FSL.	20% (4.48 years)
15	Groundwater level (dry subgrade).	2% (50 years)
16	Drainage system overflows that might cause erosion or scour.	10% (10 years)

[1] Unless otherwise agreed with the Water Corporation
[2] Unless otherwise agreed with the Local Authority
[3] To prevent mosquito / midge water quality issues

Table 7: Drainage Annual Exceedance Probabilities for Outside the Rail Reserve

Item	Situation	AEP % (Approx. ARI)
1	Major system check: TWL to property and railway building floor levels with 300 mm freeboard.	1% (100 years)
2	Stormwater drainage contained in principal shared path (PSP) corridor: PSP crossfall shall be away from the rail reserve. For larger storms and major storm overland flow paths, and where discharge into PTA rail reserve is unavoidable, this shall be communicated with and accepted by the PTA prior to construction.	20% (4.48 years)
3	Water Corporation main / branch drains.[4]	In accordance with DS66
4	Kerb overtopping.	10% (10 years) 20% (4.48 years) (local government roads only)
5	Drainage basins and sumps.	10% (10 years) (and dry after 96[5] hours)
6	Swales and open drains.	20% (4.48 years) (and dry after 96 hours)
7	Gutter flow spread limits.	10% (10 years) 20% (4.48 years) (local government roads and shared paths only)
8	Piped system with 150 mm of freeboard from HGL to FSL.	20% (4.48 years)
9	Groundwater level (dry subgrade).	2% (50 years)
10	Drainage system overflows that might cause erosion or scour.	10% (10 years)
11	Drainage basin backwater onto pavement.	5% (20 years)
12	Swales and open drains backwater onto pavement.	10% (10 years)

2.3.6 Gutter Flow Spread Limits

2.3.6.1 Gutter flow spread limits for the busway and road sections shall comply with Austroads Guide to Road Design. The rainfall intensity used to calculate gutter flow spread limits shall be limited to a maximum of 100 millimetres per hour.

2.3.6.2 For PSPs, gutter flow spread of 0.75 m into the trafficable lanes can be allowed for the 20% AEP design storm.

2.3.7 Scour Protection

2.3.7.1 Drainage systems shall be designed to minimise future maintenance and provide new or additional scour protection to all areas susceptible to scouring, such as

[4] Unless otherwise agreed with the Water Corporation

[5] To prevent mosquito / midge water quality issues

drains and batters. Designs shall be in accordance with PTA Specification: 8880-450-074 Earthworks, Slope Stability, Geotextiles and Erosion Protection.

2.3.7.2 Rock pitching shall be designed as per the Main Roads WA Specification 406, except that all rock pitching in the station precinct shall be mortared rock pitching.

2.3.8 Open Drains

2.3.8.1 The base level of all open drains and swales shall be set at least 300 mm above the design MGL as detailed in section 2.3.4.

2.3.8.2 Table drains shall be targeted to be a minimum of 600 mm deep in cuttings and a minimum offset to centreline of the drain of 1.2 m from the edge of formation. Where widening is required for infiltration swales, site-specific modelling shall be required.

2.3.8.3 The minimum grade of table drains shall be 0.3% wherever formation and surrounding topography allow. Grades of less than this are permitted for open drains where and when maximum design water levels can be achieved without compromising the formation or rail, and while also ensuring the requirements of Table 6 or Table 7 (whichever is applicable) are met.

2.3.8.4 Catch drains shall be designed at the top of cuttings where adjacent land slopes towards the alignment.

2.3.8.5 All drain designs shall consider the connection of each to adjacent drains or structures with respect to erosion protection and drain capacity.

2.3.8.6 The use of appropriate vegetation shall be considered to control erosion and maintaining infiltration within the drainage.

2.3.8.7 Toe drains shall be designed at the base of embankments, particularly where required to take flow from table drains. These may not be required for low embankments where the track grade is flatter than 1V:200H, and with open space downstream.

2.3.8.8 Drain blocks installed to provide increased infiltration capacity are permitted as long as they ensure compliance with the requirements detailed in Table 6 or Table 7 (whichever is applicable).

2.3.8.9 Flow paths, other than table drains, shall meet the following requirements:

a. The use of appropriate vegetation to control scour shall be maximised;

b. Riffle zones constructed from loose well graded rocks selected based on flow velocities shall be used in preference to concrete drop structures where energy dissipation is required;

c. Where a natural flood fringe exists, excavated channels shall be sized for minor events of 1 or more exceedances per year (EY); and

d. For all flow paths, flow velocities shall be minimised and flow compensation and infiltration shall be maximised.

2.3.9 Road Drains in Flat Areas

2.3.9.1 Trench drains and/or kerb drains may be designed in flat areas.

2.3.9.2 Kerb drains shall be a slotted kerb type or similar approved by the PTA.

2.3.9.3 Pits shall be provided at maximum intervals of 40 m along trench drain runs or as required by the supplier, whichever interval is smaller.

2.3.9.4 For all drains, access points shall be provided to allow for maintenance requirements.

2.3.9.5 In sag areas, a secondary drainage pit located 50 mm above the level of the primary pit(s) should be designed to reduce the risk of flooding.

2.3.10 Drainage Grates

2.3.10.1 Drainage grates shall not be located in primary pedestrian routes.

2.3.10.2 Drainage grates shall not create hazards for high heels, bicycles, walking canes or wheelchairs, and shall comply with the safety requirements of AS 3996 and AS 1428.

2.3.10.3 Drainage grates in areas accessible to pedestrians shall be slip resistant as per AS 4586.

2.3.10.4 Trench and kerb drain covers and grates shall be selected to be of the appropriate load class as per AS 3996.

2.3.10.5 Removable grates in areas subjected to vehicle traffic shall be securely fastened using a locking mechanism approved by the PTA.

2.3.10.6 Where kerb inlet units have grates, these shall be positioned taking into account the direction of surface flow.

2.3.11 Culverts and Pipe Drainage Networks

2.3.11.1 All pipe drainage which passes under the rail formation shall be constructed from concrete pipework or encased in accordance with relevant utility protection standards.

2.3.11.2 Drainage pipe networks shall be self-cleaning.

2.3.11.3 Pipe lengths, apron lengths and headwall heights shall be designed to suit the embankment batter. Inside the rail reserve, headwall faces shall be parallel to the rail wherever possible.

2.3.11.4 For transverse drainage systems passing under the rail formation on which trains traverse, the minimum pipe culvert size shall be 450 millimetres nominal diameter or height for reinforced box culverts.

2.3.11.5 Stormwater pipe networks shall meet the following requirements:

a. To enable the pipe to be capable of self-cleaning during dry weather flows, the velocities shall be at least 1.0 m/s for the pipe running full and at least 0.7 m/s for a 1 EY event;

b. The minimum pipe size shall be 300 millimetres in diameter;

c. The maximum separation length of pipe without an intermediate pit shall be 100 m for all sizes up to and including 450 mm nominal diameter. For sizes above this separations shall be in accordance with Water Corporation Design Standard DS 66 Urban Main Drainage Standard, Table 1 requirements;

d. The maximum full flow velocity shall be no more than 6.0 m/s to minimise wear on the pipe invert; and

e. Minimum and maximum pipe grades for varying sizes shall be in accordance with Table 6.3 of Austroads Guide to Road Design Part 5A Drainage – Road Surface, Networks, Basins and Subsurface.

2.3.11.6 Pits shall meet the following requirements:

a. All drainage pits shall be to MRWA standard and selected from MRWA drawing 200231-084 unless otherwise approved by the PTA;

b. No drainage pit shall have a nominal diameter less than 1050 millimetres;

c. Drainage pits and soakwells shall be reinforced concrete and include easily accessible step irons for all pits deeper than 1.2 metres. Access lids shall be off-centre for larger pits so step irons can be accessed easily; and

d. Pit access lids and covers shall be designed to comply with the requirements of AS 3996.

2.3.11.7 Culverts shall meet the following requirements:

a. All culvert outlets to open drains shall have suitable concrete headwalls. Mortared rock pitching shall be provided behind headwalls and wing walls and at outlets, including toe protection of at least 500 mm deep;

b. All box culverts shall have cast in-situ concrete base slabs unless otherwise accepted by the PTA; and

c. All culverts and pipe systems shall have concrete end treatments which comply with the overall dimensions shown in MRWA standard drawings 200131-0061 and 200531-0010 unless otherwise approved by the PTA.

2.3.12 Subsoil and Sub-pavement Drains

2.3.12.1 Subsoil drainage systems shall be provided where the rail limestone capping layer is below the design maximum groundwater level (MGL) or where required by a Geotechnical Interpretive Report. Design MGL shall be the 2% AEP phreatic surface.

2.3.12.2 The design of subsoil drainage shall be endorsed by the DWER. The design should consider for both protection of PTA's infrastructure from elevated groundwater and protection of groundwater including groundwater dependent ecosystem from urban form. It shall:

a. Commence at the surface, with a removable cap/rodding point which enables flushing. This terminal point shall be indicated with a marker post;

b. Have suitable rodding / flushing access locations at 60 metre maximum intervals to allow for flushing and inspection; and

c. Be managed for quality in the same manner as surface runoff, except that an oil spill trap / basin is not required.

2.3.12.3 All subsoil drains shall be graded at 0.5% or steeper unless otherwise accepted by the PTA.

2.3.12.4 The need for subsoil drains may otherwise become apparent during the construction process, due to changes in site moisture conditions or to areas of

© PUBLIC TRANSPORT AUTHORITY OF WESTERN AUSTRALIA 2019

poorer subgrade being uncovered that were not identified in the geotechnical investigation. The design drawings shall be suitably annotated to the potential need for subsoil drains in addition to those shown on the drawings.

2.3.12.5 Trench widths shall be a minimum of 300 mm with a minimum of 50 mm of separation from sidewalls to any installed subsoil pipework, with a minimum depth below finished subgrade level of 600 mm in earth and 450 mm in rock, and below the invert level of any service crossings.

2.3.12.6 Outlets shall be spaced at maximum intervals of 150 m into gully pits or outlet headwalls. As a salinity prevention measure and where practical, discharge shall be on the downhill side of the embankment or in the cut-fill area so as to reduce the risk of recharge to the subsurface water table.

2.3.12.7 Subsoil drain design should consider to avoid any discharging or disposal of polluted groundwater (e.g. legacy nutrients) into the environment. Where this cannot be avoided, polluted groundwater should have appropriate treatment prior to discharging into the environment.

2.3.13 Ballast Drains

2.3.13.1 Ballast drains may be proposed only where sufficient open drainage to manage surface runoff is not possible due to site constraints.

2.3.13.2 Ballast drains shall be provided with internal pipework dependent on the site constraints.

2.3.13.3 Slotted pipes used in longitudinal ballast drains shall be minimum 300 mm diameter.

2.3.13.4 Drain blocks installed to provide increased infiltration capacity are permitted as long as they ensure compliance with the requirements detailed in Table 6.

2.3.13.5 Determination of ballast drain capacities for storage and infiltration shall account for impacts from reduced void ratio and infiltration capacity due to clogging as per the requirements set out for other infiltration systems.

2.3.14 Foundation Drains

2.3.14.1 Foundation drains shall be designed to drain excessive ground water areas within the foundation of an embankment or the base of cutting, or to intercept water from entering these areas.

2.3.14.2 The need to provide foundation drains may be apparent from the results of the geotechnical survey along the proposed rail formation alignment, and in this case the location shall be shown on the plans. The need to provide foundation drains may also be determined during construction.

2.3.14.3 Where the rail formation traverses known swampy, flood-prone, salt affected areas or water charged strata, the design drawings shall be suitably annotated to the potential need for foundation drains at various locations, in addition to those shown on the drawings.

2.3.14.4 The minimum design grade shall be 0.5% unless otherwise accepted by the PTA.

2.3.14.5 Foundation drains shall be a minimum trench width of 300 mm, with a variable trench depth to suit the application and ground conditions on site.

2.3.14.6 Outlets shall be spaced at maximum intervals of 150 metres.

2.3.14.7 Where practicable, cleanouts shall be provided at the commencement of each run of foundation drain and at intervals not exceeding 60 metres. Where not practicable to provide intermediate cleanouts, outlets shall be spaced at maximum intervals of 100 metres.

2.3.15 Management of Surface Run-off

2.3.15.1 In addition to WSUD principles and environmental conditions, the drainage system shall meet the following requirements:

a. Stormwater generated by frequently occurring rainfall events (less than 1 EY) shall not enter receiving water bodies or rivers without treatment to remove pollutants;

b. Any discharge into existing drains shall be compensated to reduce peak flows to pre-development flows or limits acceptable to the controlling authorities; and

c. Existing patterns of surface water flows on surrounding property shall be maintained by redirection of flows without loss of capacity or increased backwater effects.

2.3.15.2 Stormwater run-off from within the site, including the project works and PTA land, shall be managed in one of the following ways – listed in order of decreasing preference:

a. Infiltration into natural surface: If the soil permeability is adequate and no adverse environmental or community effects will result from standing water up to 96 hours, the run-off shall be managed in open drains and swales to infiltrate. Drain blocks at regular intervals and based on hydraulic calculations can be used to maximise infiltration. Excess run-off shall be treated by passing through a vegetated detention basin or approved treatment system. In the sites with potential high-risk pollution (e.g. fuel filling or storage areas, station open carparks, open train and other vehicle depot), first flush runoff should have appropriate treatment before infiltrating to groundwater or discharging to downstream environment when infiltration is not feasible;

b. Infiltration areas: Run-off may be directed, via pipes or swales, to an infiltration area. Excess run-off shall be treated by passing through a vegetated detention basin or approved treatment system; and

c. Discharge into rivers, creeks, wetlands, local authority and Water Corporation drains is not allowed unless approved by the controlling authority and shall first be treated by passing through an appropriate treatment area approved by the controlling authority.

2.3.15.3 Regardless of the management method, removal of stormwater shall be augmented as much as possible by infiltration, evaporation and absorption by plants – to achieve the desired outcomes.

2.3.16 Oil Spill Traps / Gross Pollutant Traps (GPTs)

© PUBLIC TRANSPORT AUTHORITY OF WESTERN AUSTRALIA 2019

2.3.16.1 Oil spill traps / GPTs shall effectively treat the 1 exceedance per year (EY) rainfall event and shall incorporate a baffle or pipe overflow system for all rainfall events up to the 10% AEP event, and be capable of being accessed and maintained as per the asset owner requirements.

2.3.16.2 Oil spill traps / GPTs shall be located upstream of natural waterways and constructed drainage basins, unless an approved alternative stormwater treatment upstream can be demonstrated to the acceptance of the PTA.

2.3.16.3 Oil spill traps / GPTs shall be designed with sufficient internal storage capacity for oils and other collected pollutants such that they minimise the maintenance and cleaning requirements for the device to no more than four (4) eduction / pollutant operational removal events per annum, unless otherwise specified.

2.3.16.4 Designs prepared for GPTs shall include details of targeted water quality performance of the unit for the critical 1 EY event or annually based upon water quality objectives specific for the site. Typical details expected to be included (but not limited to) include:

a. The overall target level of treatment being targeted with reference to primary, secondary or tertiary levels of treatment based upon industry standards;

b. The targeted gross pollutant, total suspended solids, total phosphorus, total nitrogen, total petroleum hydrocarbon and free oil load reductions;

c. The overall expected performance of the proposed units shall be assessed through modelling using acceptable modelling packages with results provided to the PTA for acceptance; and

d. Minimum overall storage requirements for gross pollutants and oil / fuels shall be detailed.

2.3.17 Infiltration / Detention Basins / Flood Storage Areas

2.3.17.1 Infiltration basins shall have average maximum depths limited to 1.5 metres, a base level minimum 300 millimetres above the MGL (design MGL defined as the 2% AEP phreatic surface), and fencing (where required) for reasons of safety, security and protection or as required by the asset owner. All infiltration/detention basins in PTA land and/or maintained by the PTA, shall be fenced in accordance with PTA Specification: 8880-450-069 Fences and Noise Walls.

2.3.17.2 Batter slopes shall be no steeper than six (horizontal) to one (vertical), unless it can be demonstrated to be impracticable in which case PTA may allow batter slopes no steeper than three (horizontal) to one (vertical) up to a level 1.5 m maximum above the base level. Retaining walls may also be proposed by the contractor.

2.3.17.3 Access routes for maintenance vehicles shall be provided to all basins. These shall be at least three metres wide limestone access paths, with a maximum grade of 1V:4H.

2.3.17.4 All infiltration / detention basins shall be landscaped with suitable low height plants for purposes of stormwater treatment with plants selected based upon the requirements detailed in Vegetation Guidelines for Stormwater Biofilters in the South-west of Western Australia.

© PUBLIC TRANSPORT AUTHORITY OF WESTERN AUSTRALIA 2019

2.3.17.5 Infiltration / detention basins shall be designed to include a stormwater biofilter (where treatment of runoff is required) unless otherwise approved by the PTA. Biofilters shall be designed and installed in accordance with the Adoption Guidelines for Stormwater Biofiltration Systems produced by the CRC for Water Sensitive Cities. Where treatment of runoff is not required, basins/flood storage areas shall be designed with vegetative retention/detention systems noting that the root systems of vegetation help to minimise potential soil clogging and maintain infiltration of runoff.

2.4 Materials Requirements

2.4.1 Culverts and Pipes

2.4.1.1 Drainage pipes shall be reinforced concrete pipe (RCP) to AS/NZS 4058, with calculations confirming the required load class. Any other pipe material shall be approved by the PTA prior to use.

2.4.1.2 All concrete pipes shall conform to AS/NZS 4058, and any additional requirements of Austroads Technical Specification ATS2210. Should any inconsistencies arise, the following order of precedence shall apply: this specification, AS/NZS 4058, ATS2210.

2.4.1.3 All concrete pipes shall be rubber ring joint type, unless otherwise specified. Rubber ring joints shall conform to the requirements of AS 1646 - Elastomeric Seals for Waterworks Purposes. Strength class shall be at least "2" unless otherwise noted on the drawings. All pipes crossing rail tracks shall be at least Class 4.

2.4.1.4 Should unplasticised polyvinyl chloride (uPVC or PVC-U) pipes be required for low flow outlets from basins or other approved applications, they shall comply with the requirements of AS/NZS 1477 and be a minimum of 150 mm nominal diameter and with a pressure rating of no less than PN6.

2.4.1.5 Fibre reinforced cement (FRC) pipes with Adcol couplings shall comply with the requirements of AS 4139 and AS/NZS 4058. Rubber ring joints for use with FRC pipes shall comply with the requirements of AS 1646.

2.4.1.6 The contractor shall confirm the existing ground conditions at drainage locations as “aggressive” or “non-aggressive” and shall use the pipes and precast components with the appropriate cover to the reinforcement.

2.4.1.7 All reinforced concrete pipes and precast components to be installed adjacent to or within 10 m of the final as-constructed shoreline, as defined by mean sea level, shall be manufactured for use in marine and aggressive soil conditions in accordance with the manufacturer’s recommendations.

2.4.1.8 All pipes shall also be compliant with AS/NZS 2566.1 where it applies.

2.4.2 Ballast Drains and Subsoil Drain Pipe

2.4.2.1 Slotted FRC pipes shall be required for ballast drains where these are used to capture surface stormwater runoff within constrained areas of the rail reserve.

2.4.2.2 Slotted FRC pipes shall be Class 4 (AS 3725) or Class 2 for 450 mm diameter and larger. Slots shall be 5 mm wide minimum with a total slot area per pipe length of 11,800 mm2.

2.4.2.3 Coarse material used in ballast drains shall be ballast with a minimum nominal diameter of 50 mm or as approved by PTA.

2.4.2.4 Slotted uPVC pipe shall be used only in groundwater management applications or where otherwise approved by the PTA.

2.4.2.5 Slotted rigid uPVC pipe shall be of a type and class approved by the PTA in accordance with AS 2439.1and AS/NZS 1254.

2.4.2.6 All slotted pipe shall be fitted with a suitable geotextile filter tube, except for cleanouts and outlets through fill batters which shall be unslotted pipe. Geotextile specification shall comply with PTA Code of Practice: 8190-400-002 Narrow Gauge Main Line Track and Civil Infrastructure, (section 4.9), with the following amendments applying:

a. Geotextile type shall be selected based on soil properties and filtering requirements to approval of the PTA; and

b. The length and width of overlap between adjacent rolls of geotextiles shall be no less than 300 mm.

2.4.3 Precast Reinforced Concrete Box Culverts

2.4.3.1 Precast reinforced concrete box culverts shall comply with the requirements of AS 1597.

2.4.3.2 Each batch of culvert section shall be subjected to the proof loading test as prescribed in AS 1597.

2.4.3.3 Box culvert sections of size equal to or larger than 600 mm x 450 mm shall be fitted with suitable attachments for lifting gear.

2.4.4 Precast Concrete Pits and Headwalls

2.4.4.1 Precast concrete components shall be manufactured in accordance with the dimensions and details shown on the drawings in accordance with the relevant Australian Standards, including AS/NZS 4058 and AS 4198. Proprietary components, where specified or shown on the drawings, shall be in accordance with that manufacturer's latest published information.

2.4.4.2 Precast concrete liners for junction pits, grated gully pits and side entry pits shall, unless otherwise specified, be constructed of 1050 mm minimum nominal diameter reinforced concrete pipe segments. The segments shall have minimum equivalent strength of Class "2" pipes and shall have interlocking joints. For pits exceeding 1.2 m depth, the segments shall have cast-in holes to accept step-irons. Under no circumstances shall step-iron holes be made with a hammer and/or chisel.

2.4.4.3 Load classes of all components shall be consistent with the load class of the cover unless otherwise specified or as detailed on the drawings, whichever is greater.

2.4.4.4 All drainage pits shall be provided with approved trafficable covers or grates which are also accessible for maintenance purposes.

2.4.5 Concrete

2.4.5.1 Concrete used for in-situ work shall conform to AS 3600 and be provided by a pre-mix concrete supplier conforming with AS 1379. All formwork used in the construction of in-situ concrete shall conform to AS 3610.

2.4.5.2 Concrete for manholes, headwalls, endwalls, and keels shall be:

a. Minimum Grade N40 in accordance with AS 1379;

b. Minimum design cover to reinforcement 50 mm;

c. All concrete shall be compacted to be free of honeycombed or voided areas, and to achieve a minimum Class 2 finish. Manufacture of precast components under “intense compaction” in accordance with AS 5100.5 shall be preferred;

d. Maximum size of aggregate shall be 20 mm; and

e. Concrete shall be cured for a minimum of seven days in accordance with AS 3600.

2.4.6 Cement

2.4.6.1 All cement used shall be Type GP or Type GB cement in accordance with AS 3972 and obtained from an approved manufacturer.

2.4.6.2 Cement shall be delivered to the site fresh and in sealed bags and there stored in a weatherproof shed until such time that it is to be used. Any bag showing signs of deterioration or setting shall be rejected.

2.4.7 Lean Concrete Mix

2.4.7.1 Lean mix concrete for bedding and/or backfill (where required) shall be 5 MPa compacted concrete with a maximum particle size of 20 mm.

2.4.7.2 No density testing of lean mix concrete shall be required.

2.4.8 Mortar

2.4.8.1 Mortar when used shall be in accordance with AS 3700 or Main Roads WA specifications as listed in Table 8. Air-entraining admixture shall not be used.

2.4.8.2 Mortar mixed on site shall be used within 30 minutes of mixing the dry ingredients with water. Re-tempering of mortar shall not be permitted. Any mortar which has begun to set shall be rejected.

Table 8: Mix Proportions for Mortar

Mortar type / location	Mix proportions by volume			Proportion of water
	Cement	Sand	Hydrated lime	
Mortar for jointing of conduits and jointing of conduits to structures MRWA Specification 405	1	3	0	Sufficient to produce a stiff mortar of workability that is satisfactory for each particular type of work
Mortar for bedding of box culverts MRWA Specification 404	1	3	0	
Mortar for masonry AS 3700 Class M4	1	4	0	

2.4.9 Aggregate

2.4.9.1 Aggregates used for concrete shall comply with the provisions of AS 2758.1.

2.4.9.2 Aggregates used for mortars shall comply with the requirements of AS 3700.

2.4.9.3 Fine aggregate shall be well graded, clean, sharp and free from clay and organic impurities in accordance with AS 1141.

2.4.9.4 Coarse aggregate shall be crushed granite or diorite clean and free from all impurities and dust in accordance with AS 1141.

2.4.9.5 The maximum particle size shall not exceed 20 mm except where railway ballast is specified.

2.4.10 Water

2.4.10.1 Water for use in concrete and mortar shall be of potable quality, free from any impurities harmful to concrete, mortar or steel.

2.4.11 Sand

2.4.11.1 Sand for mortar shall be crushed stone or natural sand free from all deleterious substances and have a uniform grading.

2.4.11.2 Sand for bedding or backfilling shall be clean sand free from roots, clay or any deleterious matter.

2.4.11.3 Sand for other purposes unless otherwise specified shall be natural sand with a percentage of fines not greater than 12% and free from organic material, rocks, stones, roots and other hard or sharp objects that would be retained on a 19 mm sieve.

2.4.12 Bedding Material

2.4.12.1 Materials and compaction of bedding material for pipes, pits, culverts and other structures shall comply with the following while also adhering to the manufacturers recommendations where specified:

© PUBLIC TRANSPORT AUTHORITY OF WESTERN AUSTRALIA 2019

a. Bedding material shall be granular material of low plasticity such as natural or crushed sand or gravel or crushed rock that can be compacted to provide a uniform firm bedding and can be shaped as specified hereinafter. The materials shall comply with the particle size distribution indicated in Table 9 when tested in accordance with AS 1289.3.6.1 using the wet preparation method;

b. The portion of the materials passing the 0.075 mm sieve shall be of low plasticity as described in Appendix D of AS 1726. The bed zone shall be compacted by tamping, rolling and/or vibration to a minimum Density Index (DI) of 70; and

c. Alternatively, select fill as defined in AS/NZS 3725 which does not conform with Table 9 grading limits may be used provided that it is cement stabilized. Where controlled low strength materials are used they shall comply with Appendix A of AS/NZS 3725 to achieve 28 day compressive strength in the range of 0.6 to 3.0 MPa.

Table 9: Particle Size Distribution Envelope for Bedding Material

AS Sieve Size (mm)	Percentage of Total Sample Passing (by mass)
19.0	100
2.36	50–100
0.60	90–20
0.30	60–10
0.15	25–0
0.075	10–0

2.4.13 Steel

2.4.13.1 Steel reinforcing fabric and steel reinforcing bars for concrete shall comply with the requirements of AS 4671, be free from loose rust or matter likely to impair the bond with concrete and designed in accordance with PTA specification: 8880-450-020 Design of Reinforced Concrete.

2.4.13.2 Structural steel shall comply with the requirements of AS 4100.

2.4.14 Biofiltration Systems

2.4.14.1 All media associated with the construction of bioretention areas shall be installed as detailed in the design drawings in compliance with the latest version of Appendix C: Guideline for Filter Media in Stormwater Biofiltration Systems contained within the Adoption Guidelines for Stormwater Biofiltration Systems (2015) produced by the CRC for Water Sensitive Cities. A copy of this document can be accessed at https://watersensitivecities.org.au/content/-stormwater-biofilter-design/. This document details the specifications for biomedia soils, transitional layer soils and drainage layer materials and shall be complied with at all times unless otherwise detailed, on the drawings or agreed with the PTA.

2.4.14.2 The filter media (soil) used for water quality treatment within bio retention areas shall be as detailed in the design drawings. The areas shall be filled with a soil, which has the following characteristics:

a. Less than 3% clay and silt by mass;

© PUBLIC TRANSPORT AUTHORITY OF WESTERN AUSTRALIA 2019

b. Less than 5% but greater than 3% organic matter by mass;

c. Have a total nitrogen content of between 200 and 800 mg/kg;

d. Have a total orthophosphate content of between 40 and 80 mg/kg;

e. Have a target laboratory and field tested saturated hydraulic conductivity of between 100 and 300 mm/hr targeting 200 mm/hr;

f. Be well-graded with particle sizes present in the range of 0.075 mm to 4.75 mm;

g. Have a pH within the range 5.5 to 7.5;

h. Have an electrical conductivity less than 1.2 dS/m;

i. Be free of rubbish, toxicants, declared plants and local weeds;

j. Have sufficient trace nutrients and minerals to support native plant species; and

k. The contractor shall supply testing results for the above in accordance with the following standards unless otherwise specified: AS 1289, AS 4419, AS 4454 and AS 3743.

2.4.15 Gross Pollutant Traps (GPTs)

2.4.15.1 The contractor shall seek approval from the PTA on the intended GPT and comply with the manufacturer's requirements for installation, access and maintenance.

2.4.16 Underground Storage

2.4.16.1 Underground storage shall be an approved reinforced concrete system and may be used where practical to reduce stormwater discharge and increase local groundwater recharge.

2.4.16.2 Thermoplastic (polyethylene or polypropylene virgin material) stormwater arch units shall not be allowed in PTA land or form any part of PTA assets unless approved by the PTA.

2.4.16.3 Recycled plastic crate systems shall not be allowed in PTA land or form any part of PTA assets.

2.4.17 Trench Drains

2.4.17.1 Trench drains shall be securely fastened using lockdown bolts.

2.4.17.2 All materials used in trench drain systems shall meet the specifications of the manufacturer.

2.5 Construction Requirements

2.5.1 General Requirements

2.5.1.1 Drainage shall be installed by a competent contractor to the specifications in the design. As-constructed surveys of the drainage shall be carried out during and after construction and presented to the PTA, as part of the Entry Into Service

© PUBLIC TRANSPORT AUTHORITY OF WESTERN AUSTRALIA 2019

Documentation. All construction shall adhere to the requirements of the documents listed in Table 1 to Table 4 of this document.

2.5.2 Removal of Existing Drainage Structures

2.5.2.1 Where detailed on the drawings, redundant drainage structures shall be removed and disposed of by the contractor to an authorised waste disposal site as approved by the PTA in accordance with this specification.

2.5.2.2 Voids left from the removal of drainage structures that are not intended to be replaced shall be backfilled and reinstated to the natural state prior to excavation of the structure. Ordinary backfill material shall have 100% compaction effort if excavation occurs within 1.5 m of the finished surface, and 95% compaction effort if the excavation is below 1.5 m below the finished surface, according to AS 1289 for standard compactive effort.

2.5.3 Breaking into Existing Structures

2.5.3.1 Where shown on the drawings, existing structures shall be broken into and new pipes installed. When breaking into the structure, holes of sufficient size to accommodate the new pipes shall be cut or punched out without causing any unnecessary damage to the structure. The hole to accommodate the pipe shall be no greater than the pipe diameter plus 100 mm. Cement mortar or an approved mortar shall be used in sealing holes around the new pipe to affect a watertight closure.

2.5.3.2 Any damage to the structure during the installation of new pipes shall be repaired by the contractor at no cost to the PTA.

2.5.4 New Structure with Existing Pipes

2.5.4.1 Where shown on the drawings, new drainage structures shall be constructed on existing drainage lines. When breaking into existing drainage lines, cutting of the existing pipes shall be made square to the pipe.

2.5.4.2 The reinforcement exposed at the ends of the cut pipes shall be treated with an approved mortar or sealant.

2.5.4.3 If during construction of the works, the contractor causes damage to any drainage structure that is not to be removed or disturbed, the contractor shall repair the damage or replace the damaged structure to the requirements of the specification at no cost to the PTA.

2.5.5 Stormwater Management During Construction

2.5.5.1 The contractor shall provide for the diversion and control of stormwater during construction and where necessary, provide secure and proper temporary fluming for conducting storm and subsoil water away from the site.

2.5.5.2 The contractor shall make adequate provision for runoff flows at drainage works under construction to avoid damage or nuisance due to scour, sedimentation, soil erosion, flooding, diversion of flow, damming, undermining, seepage, slumping or other adverse effects to the works or surrounding areas and structures as a result of the contractor's activities.

2.5.5.3 The contractor shall prevent any deleterious materials / rubbish entering gullies, access chambers or pipes, and shall remove from the drainage system any such materials (from any source) which may be deposited in the drainage system up to the date of the completion of the works.

2.5.5.4 The contractor shall not implement any proposals to dam up or divert existing watercourses/waterways (either temporarily or permanently) without the prior approval of the PTA and DWER.

2.5.5.5 The contractor's material and equipment shall be located clear of watercourses or secured so that they shall not cause danger or damage in the event of large runoff flows.

2.5.6 Pipe Setting

2.5.6.1 All pipes shall be set in a straight line between pits. On inspection by the PTA, any pipe not placed in a straight line shall be replaced at the cost of the contractor.

2.5.6.2 The acceptable tolerance of pipe setting shall be as specified in Table 10 of this specification.

2.5.6.3 Pipes shall be set in an upstream direction.

2.5.6.4 Pipes shall be set using boning rods and profiles unless alternative methods are approved by the PTA.

2.5.7 Box Culvert Jointing

2.5.7.1 Box culverts shall be placed on a reinforced concrete base slab to the details shown on the project design drawings.

2.5.7.2 The box culverts shall be butt jointed and primed with BITAC® primer and sealed with 150 mm wide BITAC® (or similar as approved by the PTA) prior to backfilling. The lifting recesses shall be caulked with a 3-part sand to 1-part cement mortar.

2.5.8 Concrete Pipe Jointing

2.5.8.1 Spigot and socket pipes shall be jointed with the spigot fully home in the socket and rubber ring jointed, as shown on the drawings. Pipes shall be laid such that the sockets face upstream.

2.5.8.2 Externally flush interlocking pipe shall be jointed with the ends fully butting on the inside face of the pipe and caulked with a 3-part sand to 1-part cement mortar on the outer face of the joint. The mortar shall be neatly struck off flush with the outer surface of the pipe.

2.5.8.3 While waiting for backfilling, all mortar joints shall be covered with damp clean sand to prevent the mortar cracking.

2.5.9 Plastic Pipe Jointing

2.5.9.1 All pipes shall be installed in accordance with AS/NZS 2566.2. All PVC pipes shall be joined in accordance with the relevant standard as applied to the pipe material and application.

2.5.10 FRC Pipe Jointing

2.5.10.1 Pipes shall be jointed with the spigot fully home in the socket and the joint compound cemented. The compound cement used shall be the product recommended by the pipe manufacturer. The pipe jointing compound shall be applied to the spigot of the pipe after both surfaces have been cleaned.

2.5.11 Pipe and Culvert Bedding

2.5.11.1 Bedding for pipes and culverts shall be strictly in accordance with the details on the drawings along with AS/NZS 3725.

2.5.11.2 The bed material shall extend over the full width of the trench and shall be compacted by tamping, rolling and/or vibration to a minimum Density Index (DI) of 60 unless otherwise approved by the PTA.

2.5.11.3 Compaction achieved shall be monitored and reported by field testing in accordance with 2.6 of this specification, as well as AS 1289.

2.5.11.4 In the event that soft, unstable, or unsuitable material is encountered in the trench base, the PTA may direct that this be removed and replaced with approved, well-compacted material.

2.5.11.5 For pipes with sockets protruding beyond the barrel outside surface, chases shall be dug into the bed and foundation if necessary, in the appropriate positions, so that each pipe is supported along the full length of the barrel and the socket is not subjected to point loading.

2.5.11.6 Where socket pipes are to be used, small recesses shall be left under pipe joints to allow the barrels to bear evenly on foundations for their full length.

2.5.11.7 Bedding material shall be sand, gravel or other approved granular material, and shall be free from all stones > 6 mm.

2.5.12 Subsurface Drainage Pipe

2.5.12.1 For slotted pipes, selected 14 mm filter aggregate shall be used for bedding and backfilling to the pipe and shall be not less than 150 mm thickness below and above the pipe and for the full width of the trench, which shall be not less than 150 mm either side of the pipe.

2.5.12.2 Construction of subsurface drains shall be undertaken in accordance with MRWA Specification 403 Sub Soil Drains unless otherwise specified on the drawings.

2.5.13 Precast Concrete Pits

2.5.13.1 Junction pits, grated pits and other drainage pits shall be constructed with the tops of the covers laid flush with the final surface, unless directed otherwise by the PTA.

2.5.13.2 All joints between pit components shall be neatly grouted with 3:1 sand / cement mortar. Pipes entering pits shall be broken off flush with the liners, the reinforcement trimmed back, and the joint neatly grouted. Grouting shall take place immediately following the construction of the joint in order to avoid prolonged exposure of the reinforcement.

2.5.13.3 The lengths of pit liners shall be chosen with particular regard to the design of each pit. The number of joints should be minimised by the use of 0.9 m and 1.2m lengths. Under no circumstances shall the top most section be broken down to a length of less than 300 mm. Any liners which are cracked during installation shall be rejected.

2.5.13.4 Bases shall be founded on a well compacted layer of granular material of minimum 150 mm thickness, meeting the requirements for bedding as described in section 2.4.12. Bases may comprise either precast or cast-in-situ slabs, constructed to the dimensions shown on the drawings and detailed in this specification.

2.5.14 Headwalls and Endwalls

2.5.14.1 These shall be constructed in accordance with the requirements detailed in this specification including the relevant MRWA Standard Drawings and relevant Specification 404 Culvert requirements where applicable.

2.5.14.2 Where temporary or precast headwalls are specified, they shall be standard products as manufactured by a PTA approved supplier.

2.5.14.3 For mortared stonework the size and quality of the stone shall be as specified in MRWA Specification 406 Rock Protection.

2.5.15 Water Safety Signage

2.5.15.1 All open water safety signage specified on the drawings shall be installed in accordance with AS/NZS 2416 at all times.

2.5.16 Tolerances

2.5.16.1 Tolerances shall comply with Table 10. Tolerances for works other than those specified in the table shall be Horizontal ± 0.10 m, Vertical ± 0.05 m.

Table 10: Drainage System Tolerances

Item	Acceptable tolerances (Horizontal)	Acceptable tolerances (Vertical)
Alignment of pipe (line and level), design grade >1%	±20 mm from specified line	+10 mm above or -20 mm below at any point
Alignment of pipe (line and level), design grade <1%	±10 mm from specified line	+5 mm above or -10 mm below at any point level at any point
Pits, Drains and Basins	±20 mm	±5 mm

2.5.17 Survey Requirements

2.5.17.1 The contractor is responsible for any survey work necessary for design and construction of the project works. This work shall include:

a. Digital ground survey of the project corridor for initial detailed design and beyond;

© PUBLIC TRANSPORT AUTHORITY OF WESTERN AUSTRALIA 2019

b. Waterways investigation surveys for all significant watercourses which may influence the final design, and which fall within or contribute to the project corridor;

c. Setting out the works;

d. Monitoring and quality control during construction;

e. Construction audit surveys; and

f. As constructed surveys of completed work.

2.5.18 Completion and Handover

2.5.18.1 Completion and handover requirements shall be in accordance with PTA Procedures: 8110-100-013 Engineering Management for Projects and 8110-400-013 Entry into Service and Final Asset Acceptance,.

2.6 Inspection and Testing

2.6.1 Method Statements and Inspection and Testing Plans

2.6.1.1 Method statements and inspection and testing plans (ITPs) for construction and rectification of non-conformances shall be prepared by the contractor and submitted to the PTA for acceptance, and the works shall not commence prior to close out of all PTA comments.

2.6.1.2 A joint inspection shall be carried out between the contractor and the PTA to agree any non-conformance rectification method.

2.6.2 Testing

2.6.2.1 The contractor shall be responsible for providing verification that all materials and work comply with the requirements of this specification.

2.6.2.2 The contractor shall allow for all testing as required by this specification. Where not specified in this specification, testing shall comply with the minimum testing frequencies specified in MRWA Specification 201 section 2.0 table and section 2.3 Drainage.

2.6.2.3 Inspection and test plans (ITPs) to undertake the monitoring and measurement of the works shall be prepared, accepted by the PTA, and maintained for all works to which this specification applies. The ITPs shall clearly describe the monitoring, verification and validation activities specific to the product and the criteria for product acceptance for each product or service specified in the contract in accordance with ISO 9001.

2.6.2.4 All quality control testing shall be conducted by a laboratory holding current NATA accreditation for the relevant test.

2.6.2.5 Where the tests fail, the work shall be rectified and retested until the work falls within the specified tolerances.

2.6.2.6 The contractor shall be responsible for providing verification that all materials and work comply with the requirements of this specification.

2.7 Documentation

2.7.1 Design Documentation

2.7.1.1 Design documentation shall be prepared for drainage. The design documentation shall include as a minimum:

a. A description of the zone of works to be designed;

b. The design requirements and criteria to be adopted and justification thereof;

c. A description of the method of design (including reference to applicable codes and/or standards);

d. A description of the method(s) of analysis to be used for the design and justification thereof; and

e. Consideration and description of the method of construction.

2.7.1.2 The design documentation shall include a design risk assessment which shall consider the impact on the design, and hence its implementation (not only on the project works but also to third parties), of realistic variations in the design criteria and/or design values adopted, based on the proposed method(s) of construction. The design risk assessment shall take account of potential failure mechanisms and include mitigation / contingency measures appropriate to the anticipated / proposed method(s) of construction. The design risk assessment shall take account of SiD considerations. Design documentation shall describe the proposal, which shall be the optimum solution for the location with respect to form, function, maintenance, aesthetics and whole life cost to PTA.

2.7.1.3 The design documentation shall also include a Water Management Strategy/Plan as per the latest PTA requirements for projects.

2.7.1.4 The design documentation shall also include all specification models, reports, calculations and analyses including all inputs, assumptions and justifications of parameter values and inputs used.

2.7.1.5 The design documentation shall also include electronic copies – in native file format – of design models, as well as summary tables of input and output data and results.

2.7.1.6 The design documentation shall include evidence of analyses / calculation checks and verification.

2.7.1.7 The design documentation shall include all design documentation that the contractor or any other person creates or must necessarily create to implement the project works and temporary works including design deliverables as specified in the specification.

2.7.1.8 Design reports shall be completed in accordance with PTA Document: 8203-000-003 Guideline – Drafting Stage 4 Design Report.

2.7.1.9 Separate design packages shall be delivered for review at preliminary design, detail design and final design stages or as specified in the project SWTC or PRS.

2.7.1.10 Drainage plans shall include the relevant drainage design details as well as catchment areas, overland flow paths, design groundwater contours and WSUD initiatives.

2.7.2 As-Constructed Documentation

2.7.2.1 The contractor shall provide as-constructed records in accordance with PTA document 8190-800-001 Code of Practice: Design, Supply, Construction and Commissioning of 25 kV OLE – section 5.5.1, using the survey grid GDA 2020 for all issued as-constructed drawings.

2.7.2.2 The survey shall be completed by an approved licensed surveyor who shall mark up the information in red ink on a copy of the plans.

2.7.2.3 For drainage infrastructure intended to be buried, the contractor shall notify the surveyor prior to backfilling, that it is available for as-constructed measurements. This work shall remain open until the surveyor has obtained all required information.

2.7.2.4 If the contractor wishes to backfill before as-constructed information has been obtained, they shall be required to re-expose the line at any location for this information to be obtained, at their own cost and expense, inclusive of all materials, labour, dewatering, shoring up, notices, fees and all other payments.

2.7.2.5 Where construction takes place in stages, staged designs shall be superseded with as-constructed documentation, accurately reflecting the final arrangements constructed on site.

2.7.2.6 As-constructed documentation is required for both staged and final arrangements.

2.7.2.7 As-constructed details of the locations of services shall be provided to PTA in hard copy and 3D model format.

2.7.2.8 The drainage information shall be detailed for each reach of pipe with pit numbers as shown on the design plans and shall include:

a. Location – pit centres shall be located in relation to the rail centreline for longitudinal drainage or x-y coordinates. Minimum cadastral boundary offsets shall also be shown;

b. Pit details – size and type of pit with reduced levels to AHD of the pit floor, corbel slab level, cover, trap and pipe invert level;

c. Pipe – pipe type, size, class, length, grade, joint type and type of bedding; and

d. Crossings – location and level.

2.7.2.9 Practical completion shall not be issued until the as-constructed drawings have been checked and approved by the PTA.

3. Glossary

Table 11: Terms and Definitions

Term	Definition
As-Constructed Documentation	As defined in section 2.7.2 As-Constructed Documentation.
Annual Exceedance probability (AEP)	Expresses the probability of an event being equalled or exceeded in any year in percentage terms. For example, the 1 percent AEP design flood discharge (Ball et al. 2016).
Exceedance per Year (EY)	Expresses the probability of how many times in any year that event will occur. Events more frequent than 50 percent AEP should be expressed as X exceedances per year (EY) (Ball et al. 2016).
As-Constructed Drawings	Engineering drawings forming a component of the as-constructed documentation, as defined in Section 2.7.2 As-Constructed Documentation.
Ballast	Strong, durable and free-draining coarse aggregate, with properties as defined in AS 2758.7.
Ballast Drain	A type of drain used to increase surface infiltration and assist in stormwater discharge within a constrained track environment, comprising a slotted pipe surrounded by ballast, wrapped in a geotextile.
Catch Drain	A type of open drain, typically having a trapezoidal or V shape cross-section, used to transport runoff away from cuttings.
Date of Practical Completion	The date by which the contractor shall achieve practical completion as indicated in the contract documentation.
Design Documentation	As defined in Section 2.7.1 Design Documentation.
Design Life	As defined in PTA Specification: 8880-450-010 Design Actions, Asset Design Life and Maintenance Free Period.
Entry Into Service Documentation	As defined in PTA Procedure: 8110-400-013 Entry into Service and Final Asset Acceptance.
Formation	Earthworks structure including all foundation, structural treatment and limestone capping layer.
Foundation Drain	A type of subsoil drain used to manage groundwater near foundations, comprising a slotted pipe surrounded by coarse material, wrapped in a geotextile.
Geotechnical Interpretive Report	As defined in section 2.3.4 Geotechnical Interpretive Report of PTA Specification: 8880-450-074 Earthworks, Slope Stability, Geotextiles and Erosion Protection.
Groundwater Level	The level at which the pressure in the pore water in the subsurface material is atmospheric. The terms groundwater level, phreatic surface, groundwater table and water table may be used interchangeably. If perched groundwater conditions exist there may be more than one groundwater level at any particular plan position.
Limestone Capping	Compacted, specified coarse grained limestone material that provides a sealing layer to the earthworks on which ballast is laid, in accordance with PTA Code of Practice: 8190-400-002 Narrow Gauge Main Line Track and Civil Infrastructure.
Open Space	An area of either parkland or undeveloped land with significant pervious land surface available.

© PUBLIC TRANSPORT AUTHORITY OF WESTERN AUSTRALIA 2019

Term	Definition

Practical Completion	Practical completion is the stage in the carrying out and completion of project works when:
	• the project works are complete except for minor defects:
	  ○ which do not prevent the works from being reasonably capable of being used for their stated purpose;
	  ○ which the PTA's representative determines the contractor has reasonable grounds for not promptly rectifying; and
	  ○ the rectification of which will not prejudice the convenient use of project works;
	• tests which are required by the contract to be carried out for the project works have been undertaken and have passed; and
	• documents and other information required under the contract which, in the PTA's representative's opinion, are essential for the use, operation and maintenance of the project works have been supplied.

Project Works	The physical works that shall be designed, constructed, commissioned, tested, completed and handed over, excluding temporary works.
Property	Property means an asset such as building, structure, piece of infrastructure (for example, pavement, well, sign) or service that is of value to any stakeholder.
Rail Level	The level of the top of the lowest rail at a specific cross section.
Rail Reserve	The electrified area within the boundaries of security fencing, containing overhead and track infrastructure.
Routine Maintenance	As defined in PTA Specification: 8880-450-010 Design Actions, Asset Design Life and Maintenance Free Period.
Significantly Damaged	More than 48 hours recovery time after inundation to resume unrestricted normal train operations.
Table Drain	A type of open drain, typically having a trapezoidal or V shape cross-section, used to transport runoff parallel to the track or road formation.
Temporary Works	Any temporary physical works performed which does not form part of the project works.
Toe Drain	A type of drain used to transport runoff away from low lying land at the base of embankments.
Water Sensitive Urban Design	A planning and design approach that incorporates the sustainable management and integration of stormwater, groundwater, wastewater and water supply into the built form including houses, allotments, streets, suburbs and master planned communities.

© PUBLIC TRANSPORT AUTHORITY OF WESTERN AUSTRALIA 2019

Table 12: Interpretation

Term	Interpretation
Documents	A reference to a document or a provision of a document is to that document or provision as varied, novated, ratified or replaced from time to time, unless stated otherwise in this specification.
Including	The word “including” or any other form of that word is not a word of limitation.
Or	The meaning of “or” will be that of the inclusive “or”, meaning one, some or all of a number of possibilities.
Party	A reference to a party includes that party's executors, administrators, successors and permitted assigns, including persons taking by way of novation and, in the case of a trustee, includes any substituted or additional trustee.
Shall	A requirement or statement that is mandatory.
Singular / Plural	A word importing the singular includes the plural and vice versa.
Statutes	A reference to a statute includes any regulations or other instruments made under it (delegated legislation) and a reference to a statute or delegated legislation or a provision of either includes consolidations, amendments, re-enactments and replacements.

4. Abbreviations and Acronyms

The following abbreviations and acronyms are used in this document:

Table 13: Abbreviations and Acronyms

Term	Definition
AEP	Annual Exceedance Probability
AHD	Australian Height Datum
ARI	Average Recurrence Interval
ARR	Australian Rainfall and Runoff
AS/NZS	Australian Standard / New Zealand Standard
BDC	Basis of Design and Construction
CPE	Coordinating Project Engineer
DI	Density Index
DM	Discipline Manager
DWER	Department of Water and Environmental Regulation
D&C	Design and Construct
EPA	Environmental Protection Act
EY	Exceedances per Year
FRC	Fibre Reinforced Cement
FSL	Finish Surface Level
GB	General Blended
GDA 2020	Geocentric Datum of Australia 2020
GP	General Purpose
GPT	Gross Pollutant Trap
HGL	Hydraulic Grade Line
IPWEA	Institute of Public Works Engineering Australasia
ITP	Inspection and Test Plan
MGL	Maximum Groundwater Level
MRWA	Main Roads Western Australia
NATA	National Association of Testing Authorities, Australia
N&I	Network and Infrastructure
OLE	Overhead Line Equipment
PE	Project Engineer(s)
PM	Project Manager(s)
PSP	Principal Shared Path
PTA	Public Transport Authority
PVC	Polyvinyl Chloride

Term	Definition
RCP	Reinforced Concrete Pipe
SEM	Supplier's Engineering Manager
SiD	Safety in Design
SPP	State Planning Policy
SRE	Supplier's Responsible Engineer
SWTC	Scope of Works and Technical Criteria
TWL	Top Water Level
uPVC	Unplasticised Polyvinyl Chloride
WA	Western Australia
WAPC	Western Australian Planning Commission
WSUD	Water Sensitive Urban Design

© PUBLIC TRANSPORT AUTHORITY OF WESTERN AUSTRALIA 2019