Drainage – Train System

Engineering Standard

Rail Commissioner

CS1-DOC-001218

Government of South Australia
Rail Commissioner

DOCUMENT CONTROL

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0	First release	November 2018	Royce Mariadas	Keith Charlton	Mark Pronk
1	Maintenance requirements moved to TMP	February 2020	Sophie Wilkinson	Royce Mariadas	Mark Pronk

TABLE OF CONTENTS

1. Introduction

The Department of Planning, Transport and Infrastructure (DPTI) owns, operates and maintains the Adelaide Metropolitan Passenger Rail Network (AMPRN) under the Rail Accreditation assigned to the Rail Commissioner.

This document provides design, monitoring and maintenance requirements for drainage systems on the AMPRN.

This standard supersedes *CP-TS-958: TransAdelaide Code of Practice Volume 2- Train System Drainage.*

2. Purpose

The purpose of this standard is to ensure that:

a) waterways are, designed, constructed, monitored and maintained to provide clear and unobstructed flow of storm water under all normal conditions;
b) if a defined event occurs, specifies actions to be taken in accordance with procedures to keep the track safe; and
c) if storm water damage occurs to the track, specifies appropriate measures to be taken to avoid an incident.

3. Scope

This standard provides requirements for drainage within the rail corridor for the:

a) Design and construction of new storm water drainage infrastructure;
b) monitoring and maintenance of new and existing storm water drainage infrastructure;
c) identification of existing flood special locations; and
d) determination of the related defined events which may lead to potentially unsafe conditions

This standard does not cover drainage from platform, buildings, over bridges, footpaths, culverts, airspace developments, externals developments, access roads, roads outside the rail corridor, council drains and properties outside the rail corridor.

This standard does not include culvert design or selection.

4. References

4.1. DPTI Documents

DOCUMENT NAME	DOCUMENT NUMBER
Infrastructure Management and Principles	CP-TS-953
Structures - Train	CP-TS-957 / TC1-DOC-001642
Formation and Earthworks	CS1-DOC-001538
Drafting Standard for AutoCAD Drawings	AM4-DOC-000364
Stormwater Design – Road Design Standards	DD 300
Identification and Numbering of Technical Documents and Drawings	FR-AM-GE-806
Rail Safety Risk Management	PR-RC-RM-004
Development and Approval of Engineering Waivers	PR-AM-GE-807
Design Decision Records Procedure	PTS-MU-10-EG-PRC-00000016
Type Approval for Railway Products	AM4-DOC-000466
Management of Change	PR-RC-MC-009

Management of Change - AMPRN Asset Baseline	PR-AM-GE-674
Rail Drawings Acceptance Procedure	PR-AM-GE-1013
Procedure for Assessment of Engineering Competence for Rail Safety Workers	PR-AM-GE-1170
Register of Special Locations	KNet # 13060019
Drainage and Earthworks Assets – Train System – Technical Maintenance Plan.	CS1-DOC-002684 KNet # 15177637

4.2. DPTI Drawings

DOCUMENT NAME	DOCUMENT NUMBER
Standard drawing, drainage, formation edge treatment – surface, typical details	TC1-DRG-201322 (KNet #13255040)
Standard drawing, drainage, drainage through roads, typical details	TC1-DRG-201323 (KNet #13255328)
Standard drawing, drainage, inspection point, typical details	TC1-DRG-201326 (KNet #13255572)
Standard drawing, drainage, formation edge treatment – subsurface, typical details	TC1-DRG-200943 (KNet #13254343)
Standard drawing, drainage, subsurface drainage trenching, typical details	TC1-DRG-200945 (KNet #13254758)
Standard drawing, drainage, ballast cage, typical details	TC1-DRG-200592 (KNet #13252744)
Standard drawing, pedestrian maze arrangement, passive control, standard details	S7071-14 (KNet #6918164)
Standard drawing, pedestrian maze arrangement, active control, standard details	TC1-DRG-200000 (KNet #7574863)

4.3. Australian Standards

DOCUMENT NAME
Australian Bridge Design Code
Austroads Waterway Design Manual
Australian Rainfall and Runoff
AS 3500.3 – Plumbing and Drainage - Stormwater Drainage
AS 1289 Methods of Testing Soils for Engineering Purposes
AS 3706 Geotextiles – Methods of Test – General Requirements
AS 3725 Design for Installation of Buried Concrete Pipes
AS 4799 Installation of Underground Utility Services and Pipelines Within Railway Boundaries
AS 2566.1 Buried Flexible Pipelines – Structural design
AS 3996 Access covers and grates
AS 4678 Earth-retaining structures
AS5100.2 Bridge Design – Design Loads

5. Design and Mitigation

5.1. General

Design and mitigation shall meet the following requirements:

Safely manage and discharge all volumes of water generated upstream and on the site, to an approved point of discharge and method of disposal

Provide points of disposal and methods of dispersion for storm water generated by proposed railway infrastructure

Where feasible, maintain the existing flow regime onto adjoining public or private property

Have sufficient structural integrity and erosion protection measures to minimize erosion and carry all external loads that may be imposed

Take consideration of all external site influences, such as the impacts of salt water, acid sulphate soils and expansive soils

Shall be designed in a manner that allows safe and economical ongoing inspection and maintenance

Shall be designed using materials that ensure the required minimum practical design life is achieved

Implement adequate safety assurance measures to ensure that requirements specified for the products or services are fulfilled.

Where possible, design should be undertaken in conjunction with track and other civil design work.

When the drainage system is upgraded, the system should be modified as required to accommodate current condition runoff.

The permanent effects of the drainage system located alongside existing embankments and other railway structures, such as overhead wiring structures, retaining walls, platforms or embankments, shall be taken into account.

The possibility of causing instability to an existing structure during the excavation stage shall be highlighted and considered.

Conflict with existing services shall also be considered.

The design process may consist of several parts each of which shall be undertaken in order to produce the most suitable drainage system for each case. This will include the following:

- Preliminary investigation.
- Determination of the type of system required.
- Estimation of capacity required.
- Sizing components.

- Selection of other components as required.

5.2. Reference Manual and Codes

Catchment parameters, waterway and drainage system capacity design and scour prediction shall be determined in accordance with the following manuals and codes of practice:

- Australian Bridge Design Code;
- Austroads Waterway Design Manual;
- Australian Rainfall and Runoff;
- Australian Standards as applicable.

5.3. Track Drainage Design General

The drainage of the formation and track takes the following forms:

a) Primary drainage of the track is through the ballast and fed to the sides of the track by the slope on the formation.

b) On embankments where erosion is critical and in cuttings, longitudinal drains are to be constructed in the cess.

c) To avoid the cess drains being subject to excessive silting, tops of cuttings shall also be drained with longitudinal drains parallel with and sufficiently distant from the edge of the cutting not to be undermined by subsequent erosion.

d) On large embankments it may be necessary to construct drains with concrete down the sides of the embankment to protect against erosion.

Drainage should be designed so that the formation is adequately dewatered and drained. Where surface drains cannot provide adequate drainage, sub-surface drains should be installed.

External runoff, such as from platforms, roadways, or above cuttings should be directed away from the track drainage system. No other drainage shall be discharged in to the track drainage system without approval by the Unit Manager, Track & Civil Engineering.

Where there are multiple tracks, drainage should be designed such that surface water from one track will not flow under the ballast on an adjoining track. Introduction of subsurface centre drain is recommended when there are multiple tracks.

Track drainage shall be designed to capture water flows calculated in accordance with this document and safely transfer the flows to an approved point of discharge.

Sizes for pipes and open drains may be determined from, as appropriate:

a) Calculations
b) Past or local experience

Pipes under the track shall have a minimum diameter of 375 mm.

The location of drains and the type of drain shall be determined for each location in accordance with the characteristics of the site, soil conditions and potential erosion.

Track drainage shall not be used as service routes.

5.3.1. Drainage System Type

The type of system chosen for each location is dependent on the site restraints, water source, track structure and maintenance requirements.

The two general types of drainage systems are surface and subsurface.

5.3.1.1. Surface Drain

Surface drains may include cess drains, catch drains and mitre drains

Wherever possible surface drains should be used in preference to subsurface drains as they are easily inspected and maintained.

5.3.1.2. Subsurface Drain

Subsurface drains are used where adequate surface drainage cannot be provided due to some restriction or lack of available fall due to outlet restrictions. Locations where these circumstances may occur are:

- Platforms
- Cuttings
- Junctions
- Multiple tracks
- Bridges
- Retaining walls
- Tunnels
- Poor formations
- Yards, car parks and interchanges

Subsurface drainage system generally consists of a combination of pipes, sumps, pits, grates, covers, inlets and outlets.

Subsurface drains shall be designed, as a minimum, to withstand rail maintenance vehicle traffic loads.

5.3.2. Design Life and Average Recurrence Interval (ARI)

The Average Recurrence Interval (ARI) used for new drainage system design shall be 50 years.

Proposed variations to the design ARI due to site constraints or other factors shall be supported by a risk assessment prior to detail design and shall be approved by the Unit Manager, Track & Civil Engineering.

The minimum design life of all track drainage components shall be 50 years with consideration given to site location and groundwater conditions.

5.3.3. Peak Flow Rate

Estimation of the volume of surface water that requires to be drained shall be determined using the Rational Method as detailed in *Australian Rainfall & Runoff*, adopting the design ARI.

A range of storm events representing varying rainfall duration shall be investigated. The drainage design shall be carried out adopting the critical rainfall event.

The catchment areas required for peak flow rate calculations shall be determined using (in order of preference) site survey, site measurements or suitably scaled topographic maps. Account shall be taken of water flowing onto the rail corridor from adjoining properties and streets.

5.3.4. Other Design Considerations

When selecting a pipe, the environmental conditions shall be considered (i.e. is the water abrasive, acidic or alkaline) and the manufacturer's specifications consulted regarding the pipe's suitability to the predicted environment.

The possible effects of non-standard ballast profiles, other track infrastructure and track geometry shall be considered.

Geometric effects of laying straight longitudinal pipes adjacent track around curves shall be considered including reduction in sump spacing to maintain pipe clearance from track.

The permanent effects of the drainage system located alongside existing structures such as Overhead support poles, signal masts and gantries, retaining walls, platforms, embankments, shall be taken into account. The design must also highlight and account for the possibility of causing instability of an existing structure during the excavation stage.

Conflict with existing services shall be considered. Service searches shall be conducted and the locations of these services included in the design.

5.4. Surface Drainage Design

5.4.1. Cess Drains

Cess drains are located at formation level at the side of the track. The flow capacity of the open channel cess drain shall be greater than the peak flow rate calculated for the section of track.

For ease of maintenance, over sized channels can be adopted to allow a certain degree of sediment build up to occur and still work effectively.

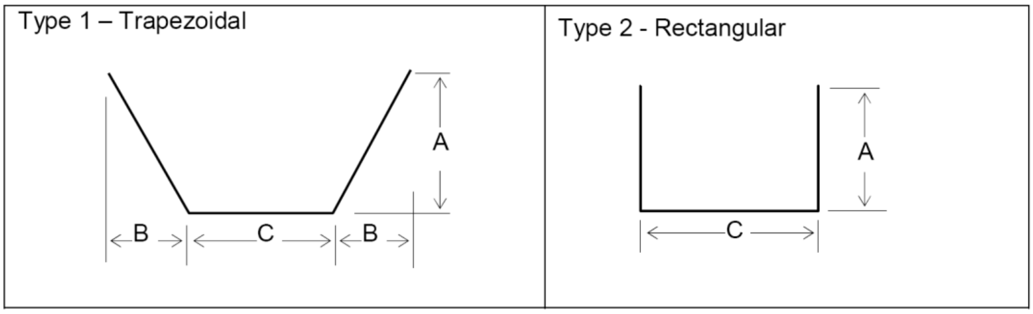

Figure 5.4.1- Channel Types (not to scale)

The minimum dimensions of an open channel shall be (in mm): A= 200, B= 200, C= 300.

The minimum slope for an open channel is to be 1:200.

The location of the open channel shall comply with the formation shoulder distance of minimum 3500 mm from track centre (refer Formation and Earthworks standard, CS1-DOC-001538). Where track drainage is incorporated within track constraints (e.g. cuttings) and the shoulder distance cannot be achieved, open channels are to be an adequate distance from the track to prevent ballast spill into the channel area. In this case, the edge of the channel closest to the track shall be a minimum of 2800mm from the design track centre. This minimum edge distance shall be increased as required based on track configuration.

Any proposed variation to the minimum edge distance shall be approved by the Unit Manager, Track & Civil Engineering.

The material forming the open channel shall be capable of withstanding the maximum permissible design velocity. Table 5.4.1 below gives maximum velocity values for varying lining types.

Table 5.4.1- Maximum Permissible Velocities

Channel Material	Velocity (m/s)
Fine sand	0.45
Silt loam	0.60
Fine gravel	0.75
Stiff clay	0.90
Coarse gravel	1.20
Shale, hardpan	1.50
Grass Covered	1.80
Stones	2.50
Asphalt	3.00
Boulders	5.00
Concrete	6.00

If problems are encountered or an area is prone to erosion, then geotechnical advice should be sought.

If fibre reinforced concrete is specified, synthetic fibres shall be used.

With multiple tracks, drainage may be provided by sumps and pipes in between each alternate track (refer Section 5.5)

All cess drainage systems must be designed to discharge to an approved watercourse or existing drainage system, and the approval of the appropriate authority must be obtained.

5.4.2. Catch Drains

Catch drains intercept overland flow or run-off before it reaches the track and related structures such as cuttings or embankments.

Catch drains shall be provided on the uphill side of a cutting to divert water from the cutting face. Drains shall be 1000mm minimum from the face of the cutting. Catch drains shall be provided on the uphill side of embankments to divert water from the embankment toe. Drains shall be 1000mm minimum from the toe of the embankment.

Catch drains may be either lined or unlined depending on the local soil conditions.

5.4.3. Mitre Drains

Mitre drains connect to cess and catch drains to remove water or to provide an escape for water from these drains.

Where mitre drains are required, they shall be provided at regular centres with a drain located approximately every 100 metres maximum. They should be installed at the ends of cuttings.

The minimum slope of mitre drains shall be 1 in 200.

The ends of mitre drains shall be splayed to disperse water quickly and reduce scouring.

5.4.4. Surface Drain Design

The following steps can be used to correctly determine the required size of surface drainage:

Step A: Determine the required channel capacity

Prior to estimating the size of a surface drain the required capacity must either be known or calculated.

$$\mathbf{Q_{PF} = Q_R + Q_S + Q_C}$$

Where:
Q_{PF} = design pipe peak flow rate (m^3/s) for ARI =50 years
Q_R = peak runoff flow rate for pipe catchment
Q_S = seepage flow coming into pipe
Q_C= Collected flow from another pipe system entering into pipe

For surface drains "Q_S" and "Q_C" can usually be neglected. In this case the equation becomes $Q_{PF} = Q_R$ = Peak flow rate (m_3/s).

Step B: Select a Mannings roughness coefficient

A value of the roughness coefficient 'n" must then be selected.

Table 5.4.4: Manning's roughness co-efficient "n" for different pipe & channel types.

Channel Material	Roughness Coefficient 'n'
Closed Conduits	
concrete pipe or box	0.012
corrugated steel pipe – helical	0.020
vitrified clay pipe	0.012
fibre cement pipe	0.010
P.V.C. pipe	0.009
steel pipe	0.009 - 0.011
Lined open channels	
concrete lining	0.013 - 0.017
gravel bottom concrete sides	0.017 - 0.020
gravel bottom rip rap sides	0.023 - 0.033
asphalt rough	0.016
asphalt smooth	0.013
Unlined channels - Earth uniform section	
clean channel	0.016 - 0.018
with short grass	0.022 - 0.027
gravelly soil	0.022 - 0.025
Unlined channels - Earth fairly uniform section	
no vegetation	0.022 - 0.025
grass plus some weeds	0.030 - 0.035
dense weeds	0.030 - 0.035
clean sides gravel bottom	0.025 - 0.030
clean sides cobble bottom	0.030 - 0.040
Rock	
smooth and uniform	0.035 - 0.040
jagged and irregular	0.040 - 0.045

Step C: Determine the slope of the drain

The preferred slope of a drain is 1 in 100 (i.e. 1 metre fall vertically for every 100 metres horizontally). A slope of 1 in 100 is preferred for self-cleaning purposes. A minimum slope of 1 in 200 can be allowed when the channels are lined. Slope less than 1 in 200 will require approval from the Unit Manager, Track & Civil Engineering.

It should be noted that as the slope of the drain becomes flatter, the tendency for a drain to become blocked due to sediment build-up increases. Consequently the maintenance of the drain also increases.

Step D: Select a trial channel size

Using the value of slope "S" and the roughness coefficient "n" selected previously, the capacity of the trial drain can be calculated using Manning's equation or a simplified version thereof.

$$Q = 1/n \times A \times R^{0.67} \times S^{0.5} \qquad (1)$$

Where;

Q = flow rate or capacity (m^3/s)
n = Manning's roughness co-efficient
A = channel cross-sectional area

R = hydraulic radius
= A/P where P = wetted perimeter
S = slope of the drain.
If X = A x $R^{0.67}$ Equation **(1)** becomes:

$$Q = 1/n \times X \times S^{0.5}$$

Step E: Check channel capacities

Once the capacity of the trial drain is determined “Q” it must be compared with the required capacity found using Equation 1 “Q_{PF}”. If the capacity of the trial drain “Q_{PF}” is considerably greater or lesser than the required capacity “Q”, then a new trial drain should be selected and steps (c) and (d) repeated until the trial capacity is approximately equal to or slightly greater than the required capacity.

Step F: Calculate water velocities

Once the required capacity is obtained, the flow velocity of water within the channel may be calculated.

The velocity is calculated:

V=Q/A
Where:
V= velocity (m/s)
Q= flow rate (m^3/s)
A= area of selected channel (m^2)

Step G: Check channel lining

In some cases it may only be possible to install a small drain and the flow through this drain may have a velocity greater than the maximum permissible velocity and consequently the channel must be lined.

Table 5.4.1 gives the maximum permissible velocity for a range of channel linings.

Lining a channel changes the Manning’s roughness coefficient "n'", and thus the capacity of the channel may be altered either up or down (refer Step B).

A lining is selected such that the allowable velocity for the type of lining is greater than that calculated in Step F, this is used as a first trial value.

Step H: Completion

If the capacity of the channel is inadequate or the ground cover velocity insufficient then modifying the channel size, slope or lining type will need to be done until all aspects are satisfactory.

5.5. Subsurface Drainage Design

5.5.1. General

Subsurface drains are used where adequate surface drainage cannot be provided due to some restriction or lack of available fall due to outlet restrictions.

Subsurface drainage shall be provided in locations where the water table is at or near earthworks level.

Subsurface drainage shall be provided along the cess, between, across, or under tracks as required.

With multiple tracks, drainage may be provided by sumps and pipes in between each alternate track.

Advice should be sought before designing and installing sub-surface drainage as there could be other rail services in the area.

Subsurface drainage systems shall be designed to take surface runoff, ground water and seepage, and water collected from other drainage systems to which the new system is being connected. Most systems will only have to cater for surface runoff.

If a drainage system is required to remove ground water and seepage, a detailed hydrological and geotechnical investigation is required to determine the volume of water for the sizing of drains.

The volume of water from other systems is determined from the outlet capacity of that system.

5.5.2. Pipes

5.5.2.1. Design Requirements

The capacity of the proposed drainage system shall be determined using the peak flow rate calculated by the Rational Method, with adjustment made for subsurface water and water collected from other systems. The peak flow velocity within the pipe shall be less than the manufacturer recommended maximum limits.

Pipes larger than the design size may be adopted to reduce the likelihood of the system becoming blocked and also enable easier cleaning. The minimum pipe diameter shall be 225mm (for ease of maintenance cleaning).

The gradient of pipes shall be 1 in 100. Where this is not achievable, the pipe shall be laid at the maximum achievable slope. Slopes flatter than 1 in 200 require an approved Engineering Waiver.

Depth of pipes under the track shall be 1600mm minimum from top of rail to top of pipe or pipe encasing.

Depth of pipes running parallel to the track shall be 600mm minimum from the design cess level to top of pipe.

At specific sites where it is not feasible to comply with these desirable pipe depth requirements and achieve an effective drainage system design, the pipe depth may be reduced to; and subject to an approved Engineering Waiver:

- 1200mm minimum from top of rail to top of pipe or pipe encasing for under track pipes;

- 300mm minimum from the design cess level or 1000mm from top of adjacent rail (whichever produces the lowest invert level) to top of pipe for pipes running parallel to the track.

Subsurface drainage pipes under tracks shall not pass within 10 m of a turnout or a crossing

5.5.2.2. Design Process

Step A – Determine the required pipe capacity

Calculated the pipe catchment runoff using the Rational Method, refer to AR&R for additional details.

$$\mathbf{Q_{50} = F \times C_{50} \times I_{cr,50} \times A}$$

Where;

Q_{50} = peak runoff flow rate (m^3/s) for ARI =50 years
F = conversion factor to balance units used.
= 0.278 if A is in km^2
= 0.000278 if A is in hectares (ha).
C50 = runoff co-efficient for ARI =50 years
$I_{cr,50}$ = average rainfall intensity (mm/hr) for the critical duration
A = catchment area (km^2 or ha).

The required design pipe capacity equals the Q_{50} for its catchment plus the flows entering from other pipe systems or seepage drains:

$$\mathbf{Q_{PF} = Q_{50} + Q_S + Q_C}$$

Where;

Q_{PF} = design pipe peak flow rate (m^3/s) for ARI =50 years
Q_{50} = peak runoff flow rate for pipe catchment
Q_S = seepage flow coming into pipe
Q_C= Collected flow from another pipe system entering into pipe

Step B – Select the pipe material and type

Pipe material and type shall be selected based on its suitability for the site. Refer 5.5.2.3 for acceptable pipe materials and types.

Step C – Adopt a design Manning's roughness coefficient

A value for Manning's pipe roughness "n" can be obtained from the manufacturer for the product being adopted. Table 5.4.4 details typical values that are also acceptable.

Step D – Determine the slope of the pipe

The pipe slope may be determined from the geometry of the site to best suit site constraints. The minimum pipe slope is 1 in 200, although a slope of 1 in 100 is preferable for self-cleaning purposes. (The steeper the slope, the lesser the maintenance requirements).

Step E – Select a trial pipe size

The capacity of the pipe can be found by using Manning's Equation and selecting a pipe where Q is greater than Q_{PF}.

Step F – Check the flow rates within the pipe
The velocity of flow within the pipe can be determined using the equation given in Step F of 5.4.4

The flow velocity within the pipe shall be at an acceptable level so as not to cause damage to the pipe surface. Pipe manufacturers have recommended maximum limits which must not be breached.

Step G – Determine the required pipe class / strength

The pipe must be checked to see if it is suitable for the design and construction loads that are imposed on it. The method of calculation of pipe strength is to follow the relevant Australian Standard (eg AS 3725 – Design for Installation of Buried Concrete Pipes).

If pipes are designed within a 45-degree projection at the bottom of the outside of sleeper (in any direction), then railway loading must be included. Dynamic loads must also be applied

If pipes are situated within a 45-degree projection of the outside of an access road (in any direction) then the loads applicable to the access vehicle must be included. Dynamic loads must also be applied

Pipe strength is also highly dependent on the type of trench excavation, fill material and compaction technique. When determining the class of pipe to be specified in a drainage system, type "U" bedding should be assumed, even if better bedding is specified on the drawings.

Where slotted pipes are used, strength reductions for the slots shall be included in the design and shall be based on manufacturer's recommendations.

Manufacturer supplied computer software is acceptable for this purpose of pipe strength design, provided it is in accordance with AS 3725.

5.5.2.3. Pipe Materials

Acceptable pipe materials are reinforced concrete, fibre reinforced concrete, steel and approved High-density Polyethylene (HDPE).

Where HDPE pipes are proposed, these shall be approved by the Unit Manager, Track and Civil Engineering.

Steel pipes shall be designed to mitigate the effects of electrolysis and stray track currents.

Both slotted and unslotted pipes may be used depending on the system type and its means of collecting and carrying water. Slotted pipes are preferred, as these do not rely on surface flow between sumps to collect water.

Slotted pipes and perforated pipes shall not be used for under track pipe work.

Minimum strength requirements are detailed in Table 5.5.2.3. The strength of reinforced concrete and fibre reinforced concrete pipes shall be determined in accordance with AS 3725.

Table 5.5.2.3– Acceptable pipe types and minimum strength requirements

Pipe Material Type	Minimum strength class
Reinforced Concrete - Slotted and unslotted	4
Fibre Reinforced Concrete - Slotted and unslotted	4
Steel Slotted - perforated and unslotted	N/A
HDPE pipe – Slotted, perforated and unslotted	Only approved products can be used

Plastic pipes shall not be used in the railway corridor.

If railway live loads are applicable, then the pipes must be designed for train loads specified in CPTS-957 - Structures. The Bridge Design Code, AS 5100.2, does not provide guidance on a suitable impact factor for railway loads distributed on fill. A dynamic load allowance (DLA) shall be adopted which varies linearly from 1.5 at 0.3m depth to 1.0 at 3.5m depth or greater (where the depth is measured from the top of rail).

Pipes located under sections of the rail corridor where they are used for road vehicle access along the rail corridor, shall be designed for 50% of M1600 truck load plus dynamic load allowance (DLA) in accordance with AS 5100.2.

5.5.2.4. Trench Excavation

The width of trenches should only be as wide as necessary to ensure proper installation and compaction.

The minimum trench width shall be pipe diameter plus 150mm on each side.

For longitudinal drains located either within 2800mm of the track centre line or between tracks where track centres are less than 6000mm, the minimum trench width shall be pipe diameter plus 100mm on each side.

When there are pipes running in parallel, a clear space of 300 mm between pipes shall be allowed for compaction purposes.

Trenches shall be backfilled with suitable material and compacted to not less than 95% maximum dry density as determined by *AS 1289* Tests Method 5.1.1 and 5.3.1 (Standard Compaction and Field Density).

5.5.2.5. Pipe Bedding Type

When determining the class of pipe to be specified in a sub-surface drainage system the bedding type assumed should be appropriate for what can be achieved during construction.

For under track crossings that are to be constructed during a limited track possession, type “U” bedding in accordance with *AS 3725* “Loads on buried concrete pipes” shall be used in design and approved by the Unit Manager, Track and Civil Engineering.

5.5.2.6. Inlets and Outlets

To prevent soil erosion, all inlet/outlet points shall be provided with an appropriate size concrete headwall to suit the ground profile.

The ground covering at the pipe exit points shall be capable of withstanding the exit flow rates. Scour protection or energy dissipating devices may be required if existing ground cover cannot withstand the design rate. Potential scour protection includes rock placing, grouted rock, rip rap etc.

Where the sediment load of the water being discharged from a drainage system is high, a silt trap shall be included.

5.5.2.7. Sumps

Sumps are required as access points for surface water as well as for maintenance of the drainage system.

Sumps shall be spaced between 30 to 50 metre centres in the rail corridor. Within platforms sumps shall be spaced between 20 to 30 metre centres. Sumps shall be evenly spaced at platforms, underpasses etc where possible. Reduced spacing may also be applicable in the six-foot between tracks to account for track curvature.

The following shall be adopted for minimum internal dimensions.

Table 5.5.2.7 Minimum internal dimensions for stormwater inlet pits

DEPTH TO INVERT OF OUTLET (MM)	MINIMUM INTERNAL WIDTH (MM)	MINIMUM INTERNAL LENGTH (MM)
≤600	450	450
> 600 ≤900	600	600
> 900 ≤1200	600	900
>1200	900	900

All sumps shall be provided with a minimum Class D grate in accordance with AS 3996. All grates shall be hot dip galvanized.

All sumps within 2800mm of a track centre; or where site restriction dictate the possibility of ballast covering a pit; shall be provided with a ballast cage.

Ballast cages must be of heavy-duty construction, capable of withstanding live loading from construction machinery. The cage shall be positioned to the outside edges of the sump. The top of the cage shall be level with the top of the sleeper level.

At locations where access for off-track equipment is limited, sump grates shall be designed for easy manual removal; for example, grates on a sump shall be manufactured in two sections rather than one. These grates shall be lockable.

All cages / grates shall be locked in the following locations.

- Within a station pit and 50m either side
- 50m either side of a pedestrian crossing
- 50m either side of a level crossing
- At high risk areas determined by the Track & Civil Engineering Unit

Where the internal sump height (including risers) exceeds 1200mm, the following must be provided:

- Step rungs are to be provided at 300mm vertical centres. The step rungs shall be located on the face looking at the oncoming train traffic.
- Sump riser heights are to be selected such that step rungs do not come within 50mm of the top or bottom of the riser.
- Where sumps are located in between tracks, the internal dimensions of the sump shall be adjusted to a minimum of 600mm wide (perpendicular to the tracks) x 900 mm to accommodate inspection access. The width shall be the maximum size available to enable proper placement of the sump and ballast cage (lobster pot) without clashing with the sleepers.

5.5.2.8. Flushing Points / Inspection Points

Ground water and seepage (subsoil) drains shall have flushing points at appropriate intervals. The intervals shall not exceed more than 60 m and shall not be located at abrupt changes of grade or alignment. On long and straight pipe runs of over 1 km, flushing points can be installed at a maximum interval of 120 m.

Flushing points shall consist of "T" or "L" connections in the sub-surface pipe, with pipe connections extending to the surface for regular flushing with water to clear the subsurface drain of fouling material.

All flushing points shall be locked in the locations as noted in Section 5.5.2.7.

5.5.3. Aggregate drains

Aggregate drains are only suitable for use where small flow or seepage is expected. If a larger flow is expected a slotted pipe should be added to the system, and then the drain should be sized as described previously. A typical example of an aggregate drain is a blanket drain. Another type of aggregate drain is a French drain.

Aggregate drains shall not be used for the collection of surface water.

All aggregate drains are to be lined with a geotextile in accordance with section 5.5.5

The capacity of an aggregate drain may be determined using Darcy's equation

$$\mathbf{Q = k \times i \times A}$$

Where:

Q = flow (m^3/s)
k = permeability of the aggregate
i = hydraulic gradient or slope.
A = cross sectional area (m^2)
The permeability of clean gravel can range from 0.01 to 1.0 m/s. The aggregates used in aggregate drains are either 20 mm nominal diameter or 53 mm diameter (ballast), the permeability of these aggregates is:

20 mm aggregate k = 0.15 m/s
53 mm aggregate k = 0.40 m/s

Darcy's Equation may be simplified if K = k × i, and becomes:

Q = K × A

Table 5.5.3 below gives values for "K" for use in order to determine the capacity of aggregate drains:

Table 5.5.3 Values of K = k.i for various slopes.

Drain Slope	**K = k × i (m/s)**	
	20 mm	**53 mm**
1 in 100	0.00150	0.0040
1 in 200	0.00075	0.0020
1 in 300	0.00050	0.0013
1 in 400	0.00038	0.0010
1 in 500	0.00030	0.0008

5.5.4. Track Underpass Drainage System

Track underpasses require the design of suitable drainage network consisting of surface drains, subsurface drains and rising main for pumping system. In this instance the pumping system shall:

- Be designed to provide a minimum of two pumps.
- Be designed with sufficient initial storage prior to activating pump in the pump well to minimize number of pump starts.
- The number of pump starts during minor events is minimized and shall be well within manufacturer's recommendation.
- Be designed not to exceed a minimum of 200 mm freeboard from obvert of the lowest drainage inlet for any 50 year ARI event.
- For any event outside the designed operating conditions such as power failure or pump failure, consideration shall be given to ensure high water level does not reach the top of rail track level.
- High water level alarms shall be installed and activated only for events where the potential exists to inundate the underpass (100 year ARI events)

5.5.5. Geotextiles

The main purpose of a geotextile used in subsurface drainage is to act as a filter, which helps prevent silting-up of the drain it is protecting. The selected geotextile is to achieve the following characteristics:

- good permeability through the fabric material
- good filtering qualities
- resistance to clogging by particle fines
- ability to stretch and conform to the shape of an open trench.
- durability including the ability to remain undamaged during construction

Selection of geotextile filter fabric shall be based on satisfying both the filtration criteria suited to in-situ soils and site drainage conditions

The selected geotextile is to exhibit the following mechanical properties as a minimum when tested in accordance with AS 3706:

- Tear Strength of 400N
- G Rating of 2000
- Grab Strength of 1100N.

Geotextiles used in subsurface drainage must fully line the trench and have a minimum lap of 300 mm at the top. The wrapped trench is to be covered by a minimum of 100mm of aggregate.

6. Documentation Requirements

Drawings shall comply with AM4-DOC-000364 (Drafting standard for AutoCAD drawings)

The format of all drainage reports shall be agreed in advance of submission with DPTI Asset management.

7. Information on Drawings

Drawings shall include a site survey and plan as well as details of the following:

- Drainage run in relation to track alignments, chainage and levels
- Catchment plan
- Details of outlet
- Drainage layout and details, including existing drainage
- Location of structures, natural features and services
- Design average recurrence interval
- Pipe loading design criteria
- Cross sections
- Longitudinal sections
- Depth of pipes
- Trenches and backfilling including material type
- Pipe jacking or boring under tracks
- Pipe or open channel installation details
- Sump and pit details, including a pit table
- Scour protection
- Detention basin details
- Details of nominated maintenance regime (flushing/inspection)
- Waivers granted (if any)

8. Hydrology/hydraulic reports

Where a hydrology report is required, it shall include the following:

- Site description and background
- Catchment details
- Design methodology
- Hydrologic parameters adopted for the analysis
- Hydraulic parameters adopted for the analysis
- Analysis results (both ‘pre’ and ‘post’)
- Safety in design (including risk matrix)
- Output from computer modelling

- Photographs of the site

Where options are considered as part of a report, it shall include the following:

- Sketches illustrating each of the options
- Guide cost for each option
- Comparison of options (advantage and disadvantages)
- Recommendation with justification

When reporting on an existing drainage system, the ARI of that system shall be calculated and be included in the report.

9. Monitoring and Maintenance

For monitoring and maintenance requirements of drainage assets, refer to CS1-DOC-002684 Drainage and Earthworks Assets – Train System – Technical Maintenance Plan.

10. Documentation

For documentation requirements of drainage assets, refer to CS1-DOC-002684 Drainage and Earthworks Assets – Train System – Technical Maintenance Plan.

11. Drainage Assets Owned by Other Organisations

For drainage assets owned by other organisations, refer to CS1-DOC-002684 Drainage and Earthworks Assets – Train System – Technical Maintenance Plan.

12. Decommissioning and Disposal

12.1. Demolition

Demolition work shall be carried in accordance with AS 2601, AS 5100, AS 7636 and/or AS 7640

If the work is not covered by or included in the standards above, it must be done in a manner compliant with legislative requirements and good practice.

12.2. Disposal of materials

The Unit Manager, Track and Civil Engineering should remove any redundant drainage infrastructure from the rail corridor to reduce:

a) Potential for obstruction of the drainage system
b) The number of targets for vandalism