# Oberon Tarana Heritage Railway

# Engineering Standard

## Geotechnical

# OTCS 420

# TRACK DRAINAGE

Version 1.0

Issued August, 2018

Approved by:

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# Document control

| Revision | Date of Approval | Summary of change |
|---|---|---|
| 1.0 | August, 2018 | First Issue. Includes content from the following former RIC standards: RTS 3433, TS 3421.and CRN CS 420 V1.0 |

# Summary of changes from previous version

| Section | Summary of change |
|---|---|
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# Contents

# 1 Purpose, scope and application

This Standard establishes the design requirements for track drainage systems.

It covers drainage of the track formation, supporting embankments, access roads adjacent to the track and cuttings.

This standard does not cover drainage from platforms, buildings, overbridges, footbridges, airspace developments, external developments, access roads away from the track, roads outside the rail corridor, Council drains or properties adjacent to the rail corridor.

This standard does not include culvert design or selection.

# 2 References

## 2.1 Australian and International Standards

| | |
|---|---|
| AS 1289 - 2003 | Methods of testing soils for engineering purposes |
| AS 3706 - 2003 | Geotextiles – Methods of test |
| AS 3725 -1989 | Loads on buried concrete pipes |
| AS 5100 - 2004 | Bridge design |

## 2.2 OTHR documents

| | |
|---|---|
| OTCS 310 | Underbridges |
| OTCS 320 | Overbridges and Footbridges |
| OTCS 410 | Earthworks and Formation |

## 2.3 Other references

CRN CM 421 Track Drainage Manual

Australian Rainfall and Runoff, Institution of Engineers Australia 1987

## 2.4 Definitions

| | |
|---|---|
| Cess drain: | located at formation level at the side of the track |
| Catch drain: | intercepts overland flow or run-off before it reaches the track and related structures such as cuttings or embankments |
| Mitre drain: | connected to cess and catch drains to remove water or to provide an escape for water from these drains |
| Track drainage: | drainage of the track formation including diversion of water away from cuttings and embankments |
| Subsurface drainage | A pipe and sump drainage system to convey surface water underground |
| Subsoil Drainage | A slotted pipe and/or aggregate drainage system to intercept ground water or seepage. |

# 3 Engineering authority

Design and selection of infrastructure detailed in this standard may only be undertaken by persons who have been granted appropriate Engineering Authority by the Engineering Manager.

# 4 Drainage design - General

## 4.1 Introduction

This document sets out design requirements for surface, sub-surface and subsoil track drainage.

This standard should be read in conjunction with Engineering Manual CRN CM 421 "Track Drainage" which details more fully the design process as well as installation and maintenance aspects.

Track drainage shall be designed to capture water flows calculated in accordance with this standard.

No other drainage shall be discharged into the track drainage system without the approval of the Engineering Manager.

## 4.2 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 types of drainage systems are surface and subsurface.

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

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
- bridges.

Subsoil Drains are used where ground water or seepage is adversely impacting on the track formation. They are also used in combination with subsurface drains in cuttings.

## 4.3 Design life

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

## 4.4 Design Average Recurrence Interval (ARI)

The average recurrence interval (ARI) shall be as detailed in Table 1 below.

| Track Class | Recurrence Interval |
|---|---|
| Class 1 | 50 years |
| Class 2 | 25 years |
| Class 3 / 3G | 10 years |
| Class 5 | 5 years |

*Table 1 - Recurrence intervals*

The recurrence intervals may need to be modified in the following cases:

- If flood hazards in the vicinity of the site are unusually severe.
- If the track classification is likely to be upgraded or downgraded.
- If the track has a low traffic volume.

## 4.5 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 and Runoff, adopting the design average recurrence interval.

A range of storm events representing varying rainfall durations 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.

## 4.6 Other design considerations

When selecting a pipe, the type of environment shall be considered (i.e. is the water abrasive, acidic or alkaline). The manufacturer"s specifications should be consulted regarding the pipe"s suitability to various environments.

The possible effects of non-standard ballast profiles shall be considered.

Geometry effects of laying longitudinal pipes adjacent to track around curves shall be considered (e.g. may require reduced sump centres).

The permanent effects of the drainage system located alongside existing structures such as retaining walls, platforms, embankments, shall be taken into account. The possibility of causing instability of an existing structure during the excavation stage must also be highlighted and accounted for.

Conflict with existing services shall be considered. Service searches shall be conducted and the locations of these services indicated on the design documentation.

## 4.7 Prohibited configurations

The following configurations are not approved for track drainage:

- unplasticised polyvinylchloride (UPVC); polypropylene
- inverted syphon systems.

# 5 Surface drainage design

## 5.1 Cess drains

The flow capacity of the open channel cess drain shall be greater than the peak flow rate.

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

The minimum dimensions of an open channel shall be: A = 200, B = 200, C = 300 as detailed in Figure 1.

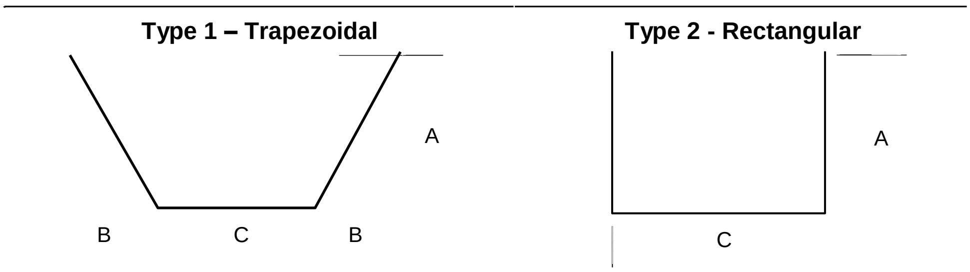


*Figure 1 – Minimum channel sizes*

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

The location of the open channel shall comply with the formation shoulder distance specified in Engineering Standard BCS 410 "Earthworks and Formation". Where track drainage is incorporated within existing track constraints (e.g. cuttings) and the shoulder distance cannot be achieved, open channels shall be located at 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 (rail size, sleeper type, ballast depth) and track curvature.

The material forming the open channel shall to be capable of withstanding the maximum permissible design velocity. Table *2* below gives maximum velocity values for varying lining types.

| Channel Type | 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 (100-150mm) | 2.50 |
| Asphalt | 3.00 |
| Boulders (250mm) | 5.00 |
| Hard packed rock | 6.00 |
| Concrete | 6.00 |

*Table 2 - Maximum permissible velocities*

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

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

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

## 5.2 Catch drains

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.

A training or levee bank 500mm high shall be provided where the slope of the drain is between 1 in 100 and 1 in 200. (See Figure 2)

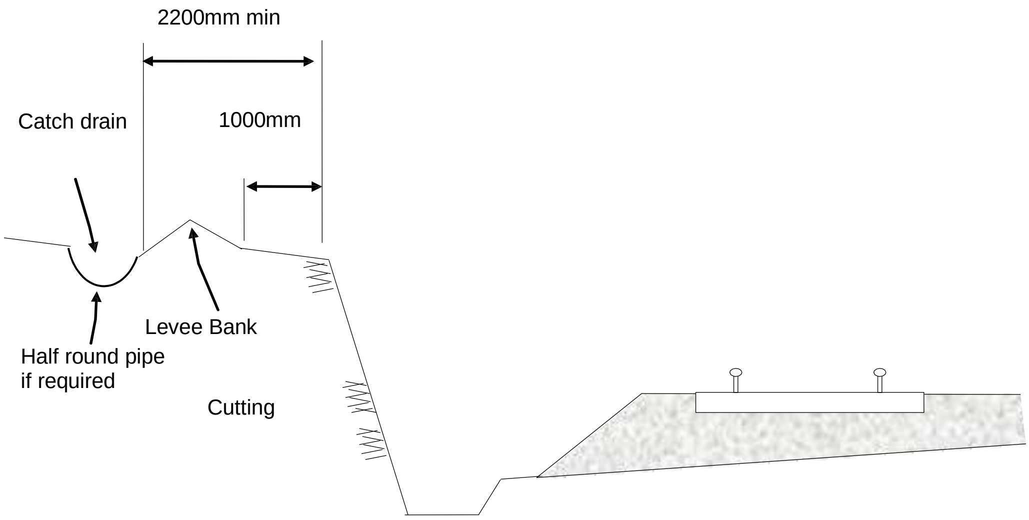


*Figure 2 – Catch drains in cuttings*

Catch drains shall be provided on the uphill side of embankments to divert water from the embankment toe towards a watercourse or culvert. 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. Half round pipes or dish drains may be used instead of lined channels.

### 5.3 Mitre 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.

## 6 Subsurface drainage design

### 6.1 General

Subsurface drainage generally consists of a combination of any one of the following:

- Pipes
- Inlets and outlets
- Sumps, grates, and sump covers or cages.

Subsurface drains shall be installed 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 double tracks, the requirement is that the water from one track shall not cross another track to get away. Drainage shall be provided by sumps and pipes in the „six-foot‟ as required.

Subsurface drainage systems shall be designed to take surface runoff and water collected from other drainage systems to which the new system is being connected.

Some subsurface drainage systems (e.g. in cess drains in a cutting) are designed to take both surface water, and ground water and seepage.

If a drainage system is required to remove ground water and seepage in addition to surface water, 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.

### 6.2 Pipes

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 slope 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 the approval of the Principal Civil Engineer.

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 pipe depth requirements and achieve an effective drainage system design, the pipe depth may be reduced to:

- 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.

Acceptable pipe materials are:

- reinforced concrete
- fibre reinforced concrete
- steel
- Approved products listed in Appendix 1.

Approved proprietary products shall be designed and installed in accordance with the manufacturer"s specifications.

Both slotted and unslotted pipes may be used depending on the system type and its means of collecting and carrying water.

Slotted pipes and perforated pipes are not suitable for under track pipe work.

Minimum strength requirements are detailed in Table 3. The strength of reinforced concrete and fibre reinforced concrete pipes shall be determined in accordance with AS 3725.

| 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 |

*Table 3 – Acceptable pipe types and minimum strength requirements*

If railway live loads are applicable, then the pipes shall be designed for train loads specified in BCS 310 “Underbridges”. 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).

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

## 6.3 Trench excavation

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

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

## 6.4 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. Most under track drainage is constructed during track possessions where the more stringent requirements for placement and compaction of bedding material cannot always be achieved.

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.

## 6.5 Inlets and outlets

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

Appropriate structures include rip-rap, grouted rip-rap, sand bags, wire baskets (i.e. gabions & reno mattresses), revetment mattresses, precast concrete units and cast in place concrete.

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.

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

## 6.6 Sumps

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

Sumps shall be spaced at 30 to 50 metre centres, except through platforms where spacing shall be 20 to 30 metre centres. Reduced centres may be applicable in the 6-foot between tracks to account for track curvature.

Where slotted pipes are used for cess drainage in cuttings, flushing points shall be installed at 20m intervals.

The minimum internal plan dimensions of a sump shall be 600mm x 600mm for depths greater than 1m. Minimum internal plan dimensions of 450mm x 450mm are acceptable for depths less than 1m.

Precast sumps with risers used to accommodate varying depths shall be adopted in preference to cast-in situ sumps.

All sumps shall be provided with a heavy-duty cast iron grate cover

In addition, a ballast cage (lobster pot) shall be installed over all sumps within 2800mm of a track centre, or where site restraints dictate the possibility of ballast covering a pit.

Ballast cages shall 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. When installed the cages shall not extend above the top of sleeper level.

Where the internal sump height (including risers) exceeds 1200mm, the following requirements shall be met:

- Step rungs shall be provided at 300mm vertical centres. If possible, the step runs shall be located on the face looking at the oncoming train traffic (ie either Sydney face for the Down track or Country face for Up track).
- Sump riser heights shall be selected such that step rungs do not come within 50mm of the top or bottom of the riser.
- Where sumps are located in the 6-foot between tracks, the internal dimensions of the sump shall be increased 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.
- The internal dimensions of the sump in areas excluding the 6-foot, shall to be increased to a minimum of 900mm x 900mm to accommodate inspection access.

# 7 Subsoil drainage

## 7.1 General

Subsoil drainage generally consists of a combination of any one of the following:

- Slotted pipes
- Aggregate filter
- Geotextile
- Flushing points
- Outlets

Subsoil Drainage is installed where ground water and seepage have been found to have adverse impact on track formation performance.

Advice should be sought from the Geotechnical Engineer before designing and installing sub-soil drainage.

## 7.2 Slotted pipes

The capacity of the proposed drainage system shall be determined on the advice of the Geotechnical Engineer. Slotted pipes shall be installed in an aggregate filter material wrapped in a geotextile.

Outlets for subsoil drains shall be treated in a similar way to those for subsurface drains, and shall be clearly identified.

Acceptable pipe materials are

- Fibre Reinforced concrete
- Approved products listed in Appendix 1.”

## 7.3 Flushing points

Ground water and seepage drains shall have flushing points at appropriate intervals.

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 sub-surface drain of fouling material.

## 7.4 Aggregate drains

Aggregate drains are only suitable for use where small flow of ground water or seepage is expected such as remediation of embankment slope stability or ballast cut off drains. They shall not be used for the collection of surface water.

The design of permeable drains may be carried out using Darcy"s equation.

The permeability of clean gravel can range from 0.01 to 1.0 m/s. The aggregates used in aggregate drains shall be either 20mm nominal diameter or 53mm diameter (ballast), the permeability of these aggregates is:

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

Aggregate drains shall be lined with a geotextile except when used as ballast cut off drains. Use of Geotextiles under the track in this situation is not appropriate.

## 7.5 Geotextiles

The main purpose of a geotextile used in subsoil drainage is to act as a filter, which helps prevent silting-up of the drain it is protecting.

The selected geotextile shall 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.

The selected geotextile shall 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 300mm at the top. The wrapped trench shall be covered by a minimum of 100mm of aggregate.

# 8 Documentation requirements

## 8.1 Drawings

All drawings shall comply with the drawing standards

Design records shall include details of:

- site survey and plan

- track alignments and levels
- 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
- 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
- temporary support of existing structures.

## 8.2 Hydrology/hydraulic reports

Where a hydrology report is required, it shall include:

- site description & background
- catchment details
- design methodology
- hydrologic parameters adopted for the analysis
- hydraulic parameters adopted for the analysis
- analysis results
- output from computer modelling
- photographs of the site.

# Appendix 1 Approved track drainage products

| Type | Manufacturer | Supplier |
| --- | --- | --- |
| High density polyethylene (HDPE) | ADS | Cubic Solutions |