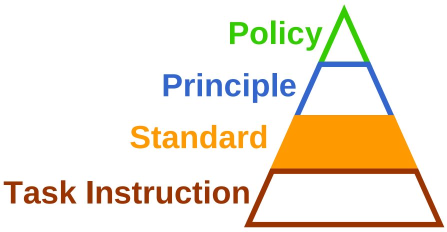

Civil Standard

Corridor Drainage

Purpose

This Standard establishes the design requirements for track drainage systems to be installed on the KiwiRail network for operating railway lines.

Document Control

Document No.	C-ST-CD-4102	**Issue No.**	Issue 1.0
Date Effective	30/06/2016	**Author**	Evan Giles, Hamish Smith, Daniel Headifen
Prepared (P) Reviewed (R) Amended (A)		**Checked and Approved By**	Civil Engineering – Technical Committee
		Authorised for Release By	Professional Head – Civil Engineering

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1. Revision Procedure and History

This is a 'living' document, that will be up dated every five years or whenever KiwiRail determines that changes to it and processing requirements documented herein are appropriate.

If changes arise from the review this document will be reissued, however, if no changes arise from the review, the current version of this document will remain in force.

Refer to the **Briefing Note(s) for C-ST-CD-4102 Corridor Drainage**

and **Document History** (at the end of this document) for full document changes.

Issue No	Prepared (P) Reviewed (R) Amended (A)	Authorised for Release By	Date Effective

1.1 Changes in this issue

Issue No	Section	Description	Page(s)

1.2 Withdrawn, closed and superseded

Old Reference	Title	Replaced by

2. Associated Documents

Level	Number	Title
1	G-PO-AL-9001	Infrastructure Engineering Policy
2	G-PR-AL-9002	Infrastructure Engineering Principle
2	C-PR-GN-4011	Civil Principle
3	C-ST-CU-4103	Culvert
3	C-ST-RW-4104	Retaining Wall
3	C-ST-GE-4105	Ground Engineering
3	C-ST-RP-4106	River Protection
3	C-ST-CP-4107	Coastal Protection
3	C-ST-TU-4108	Tunnel
3	C-ST-PL-4109	Platform
3	C-ST-FO-4110	Formation
3	C-ST-GN-4111	Civil Compliance
3	C-ST-GN-4115	Civil Engineering Inspection

Level	Number	Title
3	C-ST-GN-4117	Civil Engineering Audit
3	C-ST-HY-4116	Small Catchments Hydrology Assessment
	T003	Track Code
	T200	Track Engineering Handbook
3	T-ST-AM-5360	Level Crossings
	W004	Structures Code
	W200	Structures Inspection Manual
	W201 (Issue 6)	Structures Railway Bridge Design Brief
3	E-ST-AE-0101	AEA Earthing and Bonding Design
	CE 100795	Culvert Renewal Standard Details Drawing
	DWG 100862	Drainage and Formation Standard Detail Drawings
	DWG 120535	Sand Blanket Separation Layer Standard Detail Drawing

2.1 New Zealand and International Standards

The design of corridor drainage shall comply with this standard and relevant New Zealand Standards and codes. Other international standards may be referred to for guidance where specific information is not available in the referenced standards.

Where any discrepancy exists between the different standards, the Professional Head – Civil Engineering, shall be consulted to provide a ruling on applicability.

For culvert design refer to the Civil Engineering Culvert Standard C-ST-CU-4103.

For drains formed in the ground, the Civil Engineering Standard for Ground Engineering (C-ST-GE-4105) forms the earthworks base standard. The TNZ F1 Specification for earthworks Construction is the reference for construction works.

For level crossing drainage requirements refer to the Level Crossings Standard (C-ST-LX-5360).

The principal design standards are listed below. Refer on line for the latest editions. The designer is expected to refer to other specific specifications as required, for example NZS 3109 Specification for concrete construction.

New Zealand Standards

TNZ F1 (1997) Specification for Earthworks Construction

NZS 4402:1986 Methods of Testing Soils for Civil Engineering Purposes.TNZ F2 (2000) Specification for Pipe sub-soil drain construction

TNZ F5 (2000) Specification for Corrugated Plastic Pipe in Sub-Soil Drain Construction

TNZ F6 (2006) Specification for Geotextile Wrapped Aggregate Subsoil Drain Construction

TNZ F 7 (2003) Specification for Geotextiles

NZS 3101 Concrete Structures Standard

Joint Australian/New Zealand Standards

Australian Standards

AS/NZS 2566 Buried Flexible Pipelines – Part 1: Structural Design

AS 3725 Loads on Buried Concrete Pipes

Other Standards and Guidelines

BS 5480:1990 Specification for Glass Reinforced Plastics (GRP) Pipes, Joints and Fittings for Use for Water Supply or Sewerage

NZTA Erosion and Sediment Control Guidelines for State Highway Infrastructure – Contstruction Stormwater Management (2014)

Building Code Verification Method E1 (2014)

Federal Highway Administration, 2005. 'Design of Roadside Channels with Flexible Linings, Third Edition' Hydraulic Engineering Circular No. 15, FHWA-NHI-05-114.

2.2 Statutory requirements

Statutory documents which should be referred to include, but are not limited to the following New Zealand Statutory Requirements:

- The Railway Act 2005
- The Building Act
- The Building Regulations and Building Codes
- Health and Safety at Work Act 2015 and Regulations
- Code of Practice for Safety in Excavations and Shafts for Foundations
- Compliance Document for New Zealand Building Code Clause B1, Structure
- Compliance Document for New Zealand Building Code Clause B2, Durability
- Plumbers, Gas Fitters and Drain Layers Act
- Resource Management Act 1991
- Territorial and Regional Authority Policy Documents and by laws as appropriate

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3. Acronyms and Definitions

Acronyms	Definition
Cess Drain	A surface drain, generally in cuttings, located at formation level at the side of the track, to remove water longitudinally to the nearest downgrade exit point. Other common names used are 'swale drain', 'side drain' and 'table drain'
Subsoil Drain	A **drain** installed to collect subsurface or seepage water and convey it to a point of disposal.
Interceptor Drain	A surface drain, generally located on the uphill side of a cutting to intercept overland flow (run-off) and remove it prior to it reaching the cutting. Sometimes called top drains, catch drains, and cut off drains
Mitre Drain	A cross-cut drain connected to cess and/or interceptor 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
Multiple Tracks	More than two tracks
Third Party Discharge	A third party including councils, roading authorities, and private land owners by law (according to the Railways Act) must have a Grant of Right covering point discharges (e.g. pipe outlet) into the corridor
Grant of Right	A legal document capturing an agreement between KiwiRail and an external entity to allow the occupation of KiwiRail land. Often with a utility/service/asset into or crossing the rail corridor and/or to permit water to be conveyed through or onto KiwiRail property
Tomo	A term used in New Zealand (from Māori) that means sink hole

3.1 Notes, caution and warnings

Icon	Definition
	Note(s) to point out something of special importance
	Caution or warning – drawing special attention to anything of important reminder or a safety message

4. Scope

This Standard establishes the design requirements for track drainage systems to be installed on the KiwiRail network.

This standard has two main purposes:

1) To present design standards that enable track and related structures to be drained effectively using surface and/or subsurface drainage.
2) To present maintenance and upgrade requirements to keep drainage provisions functioning effectively.

It covers the track formation, supporting embankments and cuttings.

Multiple tracks (more than two) as found in yards require special design and should be referred to the Professional Head – Civil Engineering. The general rule for multiple tracks is that the water from one track shall not cross another track to reach a drain

This standard does not cover drainage from platforms, buildings, container transfer sites, overbridges, footbridges, airspace developments, external developments, access roads (except where the road is immediately adjacent to the track, requiring joint drainage of both to remove water), roads outside the rail corridor, Council drains or properties adjacent to the rail corridor.

This standard does not include culvert design or selection.

4.1 Use in the field

This document has been designed to be used in the field. It is expected that this document will be opened in an iPad via 'Briefcase' and used as reference to complete the task. Note as written on the front cover the controlled version is held on SharePoint. **Printed copies of this document are uncontrolled**.

5. General Requirements

Effective track drainage allows water to drain away from the bottom of the **full ballast bed** and is a critical factor in achieving high levels of service of the track asset.

For new works, the minimum dimensions and drainage details provided on drawing set 100 862 Sheets 1 – 6 shall be adheard to. Any deviation shall be suitably justified and a Code Exemption obtained from the Professional Head – Civil Engineering.

Insofar as is practicable, all drainage upgrades must likewise conform to the details and dimensions given in the above mentioned drawing set.

Care must be taken that other work such as ballast drops and regulating do not block drains, and leave the cess area clear. Drains must be left clean, tidy and flowing.

Track drainage is to be designed to capture and remove free water (rainfall runoff, groundwater seepage) from the track zone to a point of safe discharge. No other drainage is to be discharged into the track drainage system without the approval of the Professional Head – Civil Engineering. Importantly no external party may do likewise without an authorized Grant of Access in place. The requirements of the Railway Act Section 73 and 74 (refer to Appendix 2 for full clauses). should be consulted with reference to external parties draining into the railway corridor or preventing drainage from the rail corridor.

Where drains and earth works take place outside the rail corridor consultation and agreement of the landowner is required. Boundaries can be checked on the KiwiRail GIS Portal and KiwIRail RMA and Legal Team personal can assist with relevant issues.

5.1 Safety-in design

A Safety-in-Design (SiD) register shall be recorded and submitted to KiwiRail for all designs. The designers are accountable for a 'safe design' for all assets. A safe design means the implementation of control measures early in the design process to eliminate or, if this is not reasonably practicable, minimise risk to health and safety throughout the life of the structure that is being designed.

A 'safe design' of a drain must address issues such as adequacy of provisions against flooding, construction safety, safety of utilities/services, maintenance staff safety and impacting the slope stability. This is particularly important where the cutting or embankment cross section dimensions are sub-standard.

5.2 Existing structures (assets)

Over much of the network, the standards that prevailed for cuttings and embankments and for drainage provisions at the time of construction are now substandard in terms of drawing set 100 862.

Therefore, whenever trackwork necessitates physical intervention of the formation, all practicable efforts must be taken to simultaneously improve the provision of drainage structures (side/cess drains, interceptor drains, mitre drains and sub-surface drains) and to improve drainage run-off, both track crossfall and longitudinal flow.

5.3 Protection of the environment

The design of surface and sub-surface drains including the refurbishment of existing structures must take into account environmental impacts during construction and maintenance activities, with a view to minimising any such impacts.

Construction sedimentation runoff to natural waterways can be mitigated using sediment control methods outlined in the NZTA Erosion and Sediment Control Guidelines – Construction Stormwater Management (2014) if required.

In certain cases, if drainage construction or maintenance impacts on natural water courses in environmentally senstive areas, a Resource Consent may be required. Advice must be sought from KiwiRail Resource Management Advisors.

5.4 Inspections

For culverts (particularly small openings) and earth structures cess drains, mitre drains, interceptor drains and sub-surface drains) inspections are best carried out at the start of the wet season (April/May) so that blockages and debris can be cleared before the onset of the wet winter months.

Where a resource consent covering drainage system or outlet exists, inspections shall include any compliance inspections outlined in consent conditions. The need for compliance inspections should be incorporated into the asset record in Maximo. Records of inspections for consent requirements must be recorded in KiwiRail's consent database CSVue.

Reference should be made to:

- T003 (P20 – P29) for an overview of track inspections and frequencies
- Track section 21 clause 3 for items to check and record.
- T200 clauses 201 – 210 when planning inspections. Planning for inspections must include perusal of available data for the route to be covered so that sub-surface drains, culverts and other provisions are noted and thus can be located and checked when in the field. Culverts and the outlets of drains including subsurface drains must be identified by implanting a sturdy orange coloured marker stake annotated with the kilometre chainage (check services locations before insertion).

The referenced documents quoted above (T003; T200) are track focussed. From a drainage perspective, it is of particular importance that side drains be clean (free of debris and organic growth), that the entrance to small openings (pipes/culverts) be free of debris and sub-surface drain outlets be identified and checked for functionality. When free water is present in a cutting that has a sub-surface drain, the system must be checked and programmed for flushing when appropriate.

Aspects to observe and note during inspections include:

1) Slips and slumping of slopes (saturation of slopes).
2) Mud pumping up through ballast, top and line problems (water not moving outwards to drains).
3) Foul ballast plus top and line problems.
4) Water ponding alongside track or at the base of earth structures.
5) Erosion of cutting face (i.e. ineffective interceptor drains).
6) Minor blockages and sediment build-up.
7) Rubbish lying in drains.

The Professional Head – Civil Engineering, shall be notified when a sub-standard structure is identified. Management of the identified sub-standard structure shall be discussed and recorded for on-going monitoring. At-risk drainage assets need to be included in the Civil specific risk register.

5.5 Maintenance

Earth structures **will** require maintenance. Maintenance must be scheduled following an inspection. One or a combination of the following are normally required on surface drains:

1) Weed and vegetation control.
2) Removal of debris from other track maintenance activities.
3) Removal of sediment.
4) Regrading.

Track grades are 'flat' in terms of effective water flow; therefore if regular ponding occurs, consideration should be given to installing mitre drains to remove water at appropriate locations. Mitre drains (refer to section 7.2.4) can, however, initiate new issues when cut into the surrounds. Mitre drains shall not be constructed without prior consultation with, and the concurrence of the Professional Head – Civil Engineering.

Maintenance regimes for open channels, particularly earth lined ditches are strongly dictated by, and will vary with, climate and geography. Drainage maintenance regimes will need to be adjusted to suit.

5.6 Heritage

Heritage considerations and classifications must be observed in all drainage designs. This may have particular application in circumstances where an existing historically significant asset is being refurbished or modified, or where a new asset is being proposed in the vicinity of existing heritage items.

In all instances, safety is the main priority and unsafe assets/components should be replaced if they do not satisfy the KiwiRail requirements for the safe running of trains.

Where required, advice on heritage and archaeological values can be sought from KiwiRail Resource Management specialists.

5.7 Documentation requirements

All drainage activities shall be documented. Appropriate documents must be prepared at the following stages:

- Investigation and planning;
- Design and specification;
- Construction.

Documentation is an important consideration in all drainage projects. The relevant documents should include:

5.7.1 Design and specification

The functional requirements of the design must be documented in the specification and drawings. The documentation must be sufficiently complete to allow the constructor to unambiguously carry out the works, and for those supervising to be able to interpret the design and administer the works.

Reference should be made to KiwiRail requirements for documenting of geotechnical testing - KiwiRail Task Instruction for Geotechnical Investigation Requirements CT-TI-GE-4201.

5.7.2 Drawing standards

Construction drawings must comply with the KiwiRail standard procedures and formats, and any relevant information to ensure that the new asset is constructed and maintained in accordance with the design.

Drawings shall include details of:

- Site survey and drainage plan showing flow paths and directions, and key drainage features (ie culverts if relevant)
- Track alignments and levels. Any offsets should be referenced horizontally from track centre line and vertically from top of rail level
- 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 – especially inlets and outlets
- 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.

5.7.3 Construction

Adequate records need to be kept during construction, including conditions encountered, works as executed, as built drawings, testing records and any alterations to the specification and drawings.

Site records, such as daily diaries and detailed drawings of works as executed, should be maintained by site staff to a level of detail appropriate for the scale of the works.

5.7.4 Hydrology/hydraulic reports

Where a hydrology report is required (for piped, large, or specialised systems) it shall include:

- site description and background
- catchment details
- figure(s) showing flow paths and hydraulic features
- design methodology
- hydrologic parameters adopted for the analysis
- hydraulic parameters adopted for the analysis
- figure(s) showing design features and changes in flow path and site hydraulics
- analysis results incorporating figures, tables and graphs
- output from computer modelling
- photographs of the site
- computer model files and spreadsheets which shall be packaged and transferred to KiwiRail by external designers following report completion.

5.8 Electrical requirements

For new work in electrified areas and those with high likelihood of being electrified in future, designs must provide for earthing and bonding of metallic components within drainage systems to mitigate touch potential hazards and corrosion of steel.

The design strategy should be to ‘design out’ (eliminate) earthing and bonding issues by separation and isolation of metallic structures. Where this is not possible, the design must achieve an appropriate balance of the risks associated with touch potentials and with corrosion due to stray currents.

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

All designs shall be in accordance with the requirements of KiwiRail Electrical Systems.

6. Design Investigation

A design investigation must preceed the design of any new drainage works or significant drainage upgrade works. The rail corridor and surrounds is a dynamic environment. Urbanisation, population density changes, and in rural areas agricultural land use changes, lead to changed runoff patterns and intensities. Changes and possible future changes over the whole design life of the asset must be considered.

6.1 Scope of investigation

The objective is to establish and/or affirm the requirements of the drainage system and any restrictions that may need to be imposed on the system.

Aspects to be covered in the design investigation include:

1) Identification of the problem and thus the drainage objective. (i.e. what area is to be drained and for what reason).
2) Determination of the information required. (ie location, outside influences, fall available, possible outlets, access, site safety requirements, etc) Collection and study of all available existing/historical information. Other types of information that may be of use are aerial photographs, maps (topographic, geological, soil, ground cover etc), charts, meteorological and hydrological information.
3) A full service search must be conducted and must include all KiwiRail divisions as well as other utility suppliers.
4) A site inspection must be made, guided by a checklist prepared prior to the actual investigation.

Items that should be observed and recorded (notes and photographs) during the site inspection include:

- Access to and from the proposed site and any possible restrictions.

- Type and location of any existing drainage systems; their condition and functionality and malfunctions/failures seen together with opinion on probable cause.
- The position and condition of any existing low points and drainage outlets (including sub-surface drain outlets, nearby culverts and bridges).
- Adjacent structures that may impact on the drainage design, or where the drainage design may cause instability to the structure.
- Sub-horizontal drains on retaining walls
- Where the design needs to avoid undermining cuttings and embankments

5) A catchment area estimation must be made from topographical maps or other suitable published data and verified as practically possible whilst on site.

6.2 Determination of the type of drainage system required

On completion of the design investigation, information gathered shall be compiled and a decision made on the type of drainage system that is most suitable.

The type of system chosen for each location is dependent on the site constraints, water source, track structure and long-term maintenance issues.

If possible surface drains should be used in preference to subsurface drains since they are easily inspected and maintained. Where continuous wet conditions prevail, it could be related to high groundwater issues. This should be investigated and mitigated by providing subsurface drains where appropriate.

6.3 Site accessibility

The accessibility to the rail corridor should be considered both from a physical access perspective and from a rail access one. Physical access will cause potential design limitations due to plant and methodologies that can be used in the works. Likewise rail access (protection requirements and Block of Line availabilities) will affect the design for the same reasons. **In rail what you can build often governs what you design.**

7. Design Criteria

7.1 Drainage design – general

The corridor geometry is set by many factors and is currently defined on drawing set CE 100 862. These drawings define the running line formation widths (single and twin/double tracks), cross fall requirements, cess drain (side drain) dimensions and sub-surface drain dimensions. These standards have proven adequate for many conditions (except for large catchments or areas with a history of drainage related problems).

For new works, a hydrology report is necessary to size and position water conduits crossing the corridor. Corridor runoff must also be checked and the provisions in drawing set CE 100 862 verified as adequate. The dimesions in drawing set CE 100 862 are minimum requirements.

For significant track and/or drainage upgrades, some verification is similarly necessary to verify that the measures provided will be adequate. Refer to section 6 Design investigation for expectations.

Should any inadequacy in the standard details be found, the matter must be raised with the Professional Head – Civil Engineering for approval of any required departures.

7.1.1 Design life

All units constructed from durable materials (eg concrete/plastic) must be designed for a minimum design life of 50 years.

Soil structures such as cess drains, v-drains, interceptor drains as well as subsoil drains shall be designed with a target life of 20 years. It must be noted that such soil structures will require periodic maintenance and ad hoc checking after severe storm events as breaching and erosion damage may impact functionality.

7.1.2 Design annual exceedance probability (AEP)

The Annual Exceedance Probability (AEP) shall be 10% for pipes or enclosed systems with two percent for scour and overflow. Where scour of the ballast section is a high risk, alternative options of flood management must be considered.

Proposed variations to the design AEP due to site constraints or other factors shall be supported by a risk assessment and shall be approved by the Professional Head Civil Engineering.

Where drainage plays a critical role in another structure’s reliablity, such as an engneered slope, the design AEP shall meet the greater requirements of either that structure or this clause.

7.1.3 Peak flow rate

Estimation of the volume of surface water to be removed shall be determined using the Rational Method, adopting the design average recurrence interval. Alternative methods may be used for specific design following justification from the designer and approval by the Professional Head – Civil Engineering. In certain cases locally derived methods in alignment with published Regional and Terrirtorial Authority guidance may be used.

Building Code Verification Method E1 (2014) provides an acceptable methodology for making design flow estimations using the Rational Method, provided the catchment is not large. It is better suited for small urban catchments.

Heavily forested, steep and large (>100Ha) catchments may require careful consideration and alternative methods. 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. All practical measures must be taken to eliminate or mitigate such inflows.

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

7.1.4 Scour protection for channel inverts

Detailed design guidance for larger or high risk drainage works can be found in FHA HEC-15, Design of Roadside Channels with Flexible Linings.

Site observations of soil types and erosion at site are critical to making design decisions.

In highly erodible environments with loose sands, grass or cobble erosion protection may be necessary in slopes steeper than one in 200 or even one in 400 in sensitive soils.

In non-erosive cohesive soil environments where good grass growth can be expected, channels with slopes up to one in 50 should not need special erosion protection. This excludes loess soil environments in the South Island.

Figure 7:1 Scour protection of interceptor drains above Wingatui Tunnel MSL

7.2 The drainage system

7.2.1 Surface control and drainage of track formation

The most common provision is surface drainage measures only.

Surface drainage targets removal of surface runoff before it enters the formation soil layers, with water percolating out of the ballast being led by a crossfall to run into the cess drain.

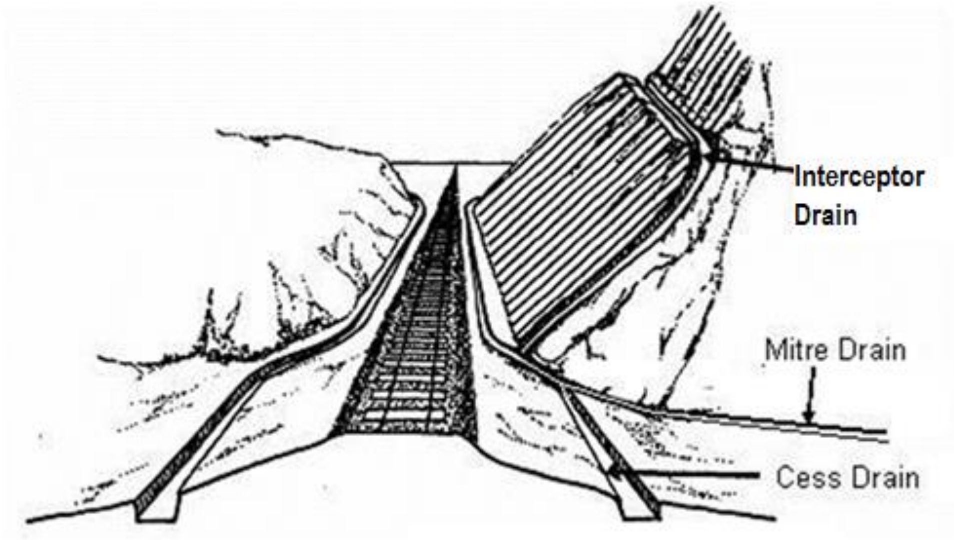

Figure 7:2 Surface drainage types

For new work, the track formation must be graded to shed water at a minimum crossfall of three percent. For single track the fall is outwards from the centre of the track. For twin track the fall is outwards from the centreline of the two tracks. This fall must be maintained across any maintenance road immediately adjacent to the track so that no ponding arises. Refer to Figure 7.3 and also DWG 100862.

If local site restraints prevent installing of peaked centre formation then three percent across the entire ballast width is acceptable providing it falls towards the primary drainage path for the ballast. Formation fall shall be recorded on design drawings.

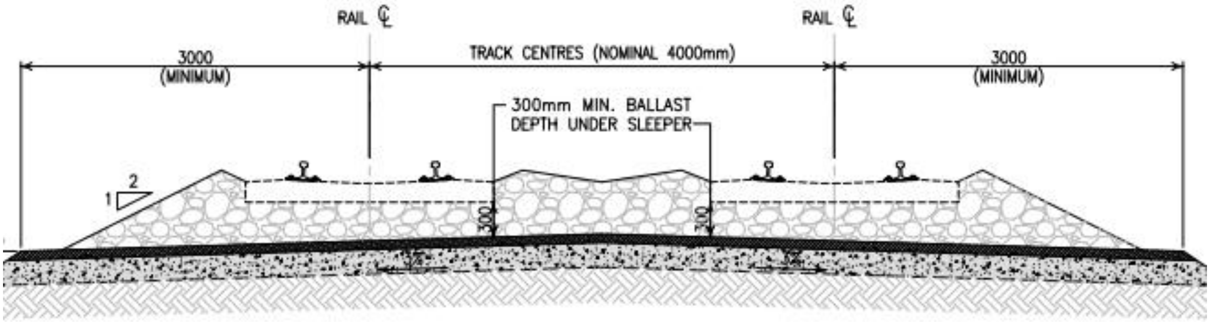

Figure 7:3 Formation cross fall for double track

For drainage upgrade works, if associated formation improvements require complete ballast section and/or track removal the rebuild must include provision of a crossfall as for new work. If the track and ballast under it remains in place, whenever possible a crossfall should be introduced from the head of the sleeper outwards, given that this is practicable with the track in place.

Figure 7:4 Cross fall of formation cess/shoulder, 31km MNPL, to assist ballast drainage

For cuttings, the crossfall runoff is collected in the cess drain (side drain) and transported downgrade to suitable discharge points where it is transferred into the natural drainage or into special stormwater provisions in urban environments. Provision of a crossfall and a cess drain is thus the minimum required in cuttings.

For tracks at grade or on an embankment, drainage is generally limited to the provision of a three percent crossfall from the centreline of the track or the centre of a twin track provision. Runoff exits the top of the formation as sheet flow across the surrounds or down the embankment sideslopes. In some circumstances, particularly ‘at grade’ or near ‘at grade’ situations, a cess drain may be required to collect and direct water to a suitable discharge point.

7.2.2 Interceptor drain

The purpose of interceptor drains (also known as top drains and catch drains) is to intercept overland flow or runoff before it reaches the track. They reduce the possibility of causing damage to the track or related assets, such as cuttings or embankments (refer to Figure 7.5).

Interceptor drains are generally located on the uphill side of a cutting to intercept water flowing down the hill and remove it in a lateral direction prior to it reaching the cutting.

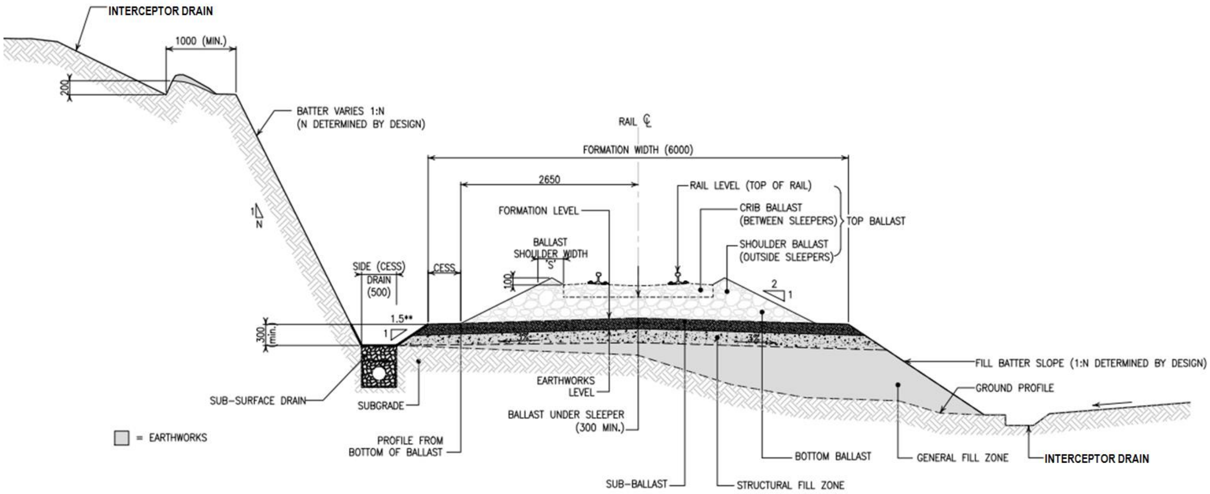

Figure 7:5 Interceptor drains for up and down slope locations

Drains shall be 1000 mm minimum back from the face of the cutting.

It is highly desirable to have a 3m set back where feasible to minimise the risk of saturation-induced slope failures (shoulder sloughing). In granular soils such as the pumice deposits of the central North island and the silt-rich loess deposits in Otago, interceptor drains must be lined (clay or man-made products) to minimise infiltration, erosion risk and tomo (sink hole) formation. Where new interceptor drains are proposed in these areas, the Professional Head – Civil Engineering should be approached for advice. Note that:

- Interceptor drains may be used alongside tracks that cut across a slight downhill grade.
- Interceptor drains may be required on the uphill side of embankments to divert water from the embankment toe. Drains shall be 3000mm (and if not possible 1000mm minimum) from the toe of the embankment (refer to Figure 7.5).
- Interceptor 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.
- Due to the drains being potentially located out of sight from personal at rail track level, the location of catch must be recorded. (There are numerous examples of slope failures resulting from interceptor drains not being maintained due to no records of them being held.)
- Discharge locations for catch drains will need site specific design. Fluming and energy dissipation may be required to prevent scouring.

Figure 7:6 Interceptor drain above 389km MSL blocked and then after cleaning

The most common topographical drainage configuration is a dendritic pattern - like veins in a leaf leading to a central artery. It is not uncommon for lengths of a rail route to cut across such a system, with the cut intercepting the feeder channels. In this type of situation, special design is required because a standard interceptor drain may not be adequate. Refer to Figure 7.7, photo from cutting on the Main South Line near Crichton, Southland.

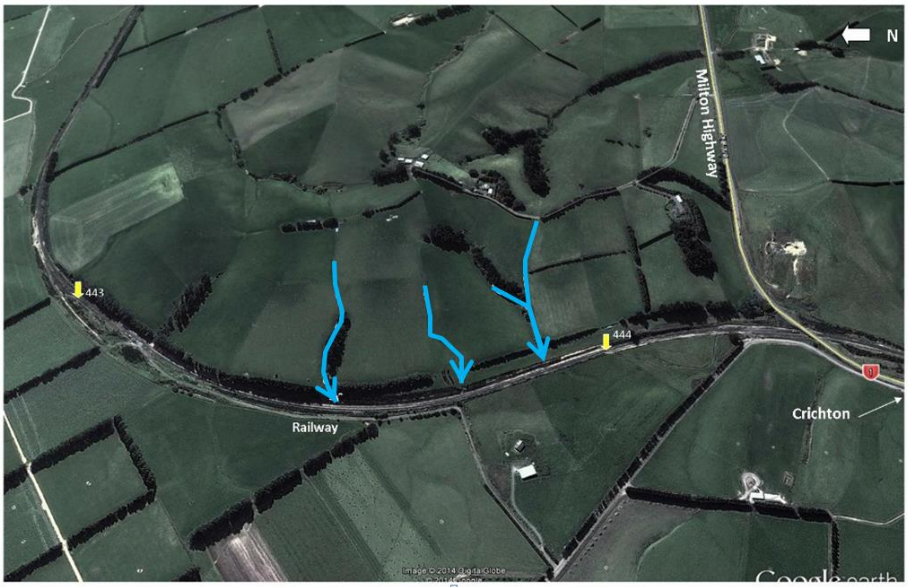

Figure 7:7 Crichton cutting, 444km MSL, surface water discharge

7.2.3 Cess (side) drains

Cess (side) drains are surface drains located at formation level at the sides of the tracks, to remove water that has percolated through the ballast and is flowing along the capping layer (sub-ballast layer) towards the outside of the track formation. Cess drains are primarily intended for the protection of the formation by keeping the formation dry.

Figure 7:8 Cess drains at 198km Midland Line before and after upgrade work

In theory, surface drains can be constructed on fairly flat grades, as they are easily cleared of any sediment or debris that may collect in them. In practice, at grades flatter than 1:50, the unlined side drains tend to require a small head build up to initiate flow and a residue remains post rainfall. Drains must be regularly maintained (cleaned) to optimise water removal.

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. The minimum physical dimensions in mm of an open channel shall be: A= 300, B= 450, C= 500 as shown in Figure 7.9. However these shall not be less than those required by the design AEP in section 7.1.4.

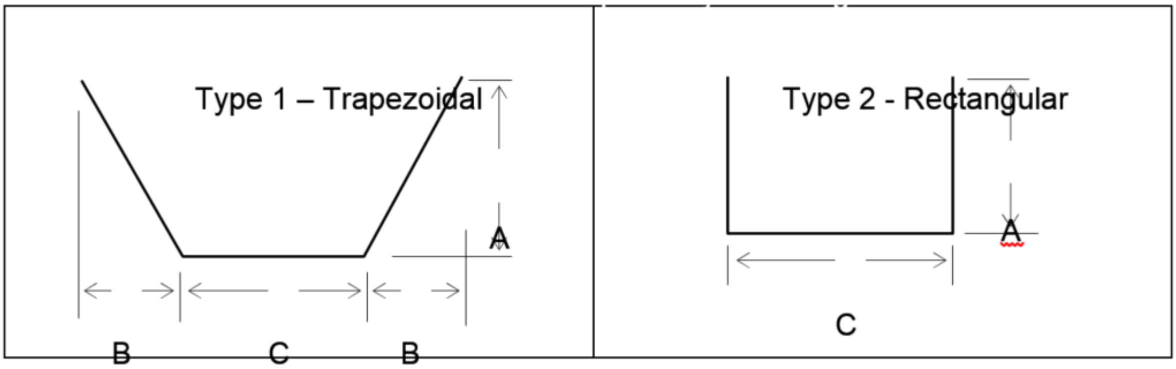

Figure 7:9 Minimum channel sizes

The minimum slope for an open channel is preferred to be 1:200. As rail grades are generally much flatter than 1:200, site constraints may prevent this from being achieved. In such cases, best practicable options together with additional mitigation measures (more frequent use of mitre drains or other types of formal outlet) must be tabled and a departure obtained from the Professional Head – Civil Engineering.

Figure 7:10 Cess/formation shoulder and V type drain at base of slope at 47km NIMT

The location of the open channel must comply with the formation shoulder distance (also known as the cess) specified in drawing set 100 862 (minimum 350mm).

Where track drainage improvements are introduced within existing tracks all practical measures must be taken to prevent ballast spill into the channel area. Extra width must not be gained by oversteepening the cutting batter near the cut toe to accommodate a side drain without a proper stability evaluation by the Professional Head – Civil Engineering. Oversteep slopes will fret and erode and can lead to cutting slope failure over time.

Half-round and/or rectangular boxed channels may be used to form a lined cess drain if hydraulic or grade issues warrant it. The top of lined channels shall be no higher than the top of the adjacent track formation(s) (generally 725mm below top of rail – the bottom of the ballast layer).

All cess/side drainage systems shall be designed to discharge to an approved watercourse or existing drainage system, and the approval of the appropriate authority (NZTA, Territorial Authority, Regional Authority) shall be obtained for new discharges.

7.2.4 Mitre drains

Figure 7:11 Mitre drain at 30.8km MNPL

Mitre drains are connected to side/cess and interceptor drains to provide an escape for water from these drains. (Refer to Figure 7.2 for illustrative layout and Figure 7.12 for typical plan view.)

Mitre drains should be considered if grades are sufficiently flat to start sediment deposition or if cuttings are long and local topography is favourable for a mitre drain to be constructed to deviate flows and reduce the volume of water reaching the end of the cutting.

Mitre drains can cause local cutting instability and/or erosion and all factors must be considered prior to their installation. Thus, where new mitre drains are proposed, the Professional Head Civil Engineering shall be approached for advice and approval.

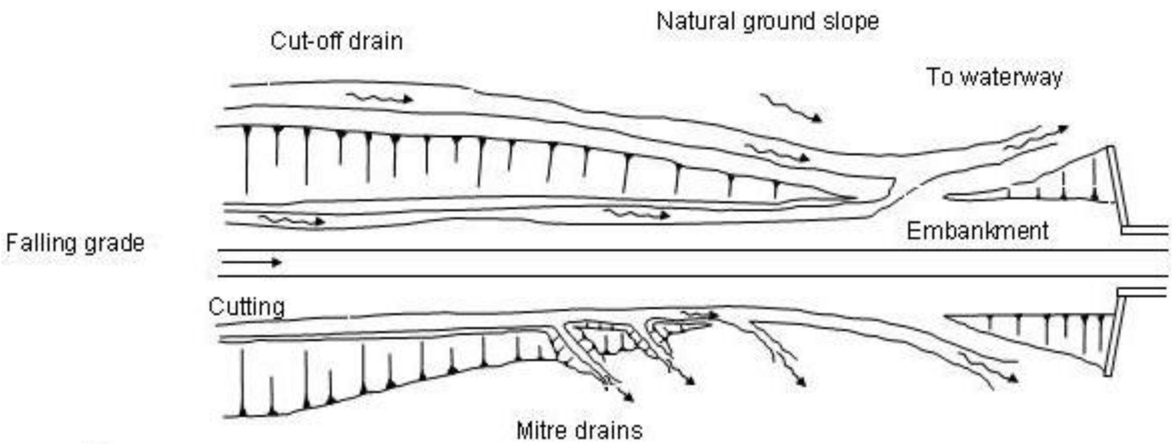

Figure 7:12 Mitre drains

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

Mitre drains shall not discharge onto steep embankments where they can initiate slips.

In some locations it may be possible to use a piped mitre drain thusted through an embankment to create a discharge point for side drains.

7.2.5 Subsurface drains

Figure 7:13 Example subsurface drain (photo courtesy of Maccaferri)

Subsurface drains are primarily used to lower the groundwater level where situations require it, as illustrated in Figure 7.14, so that the formation soil layers remain comparatively dry. Such drains are only effective if placed at an adequate depth and if an adequate grade and outlet can be achieved. Therefore Civil Engineering should be aproached for assistance to confirm that free water observed is caused by a high water table and that the planned system will be effective at the locality.

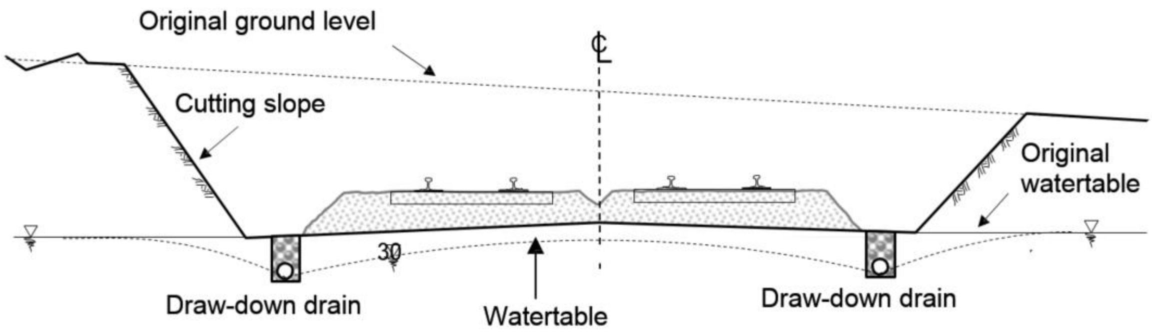

Figure 7:14 Lowering the water table

Sub-surface drains may also be 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:

- Track in between platforms

- Cuttings
- Multiple tracks or yards
- Track approaching bridges
- Level crossings

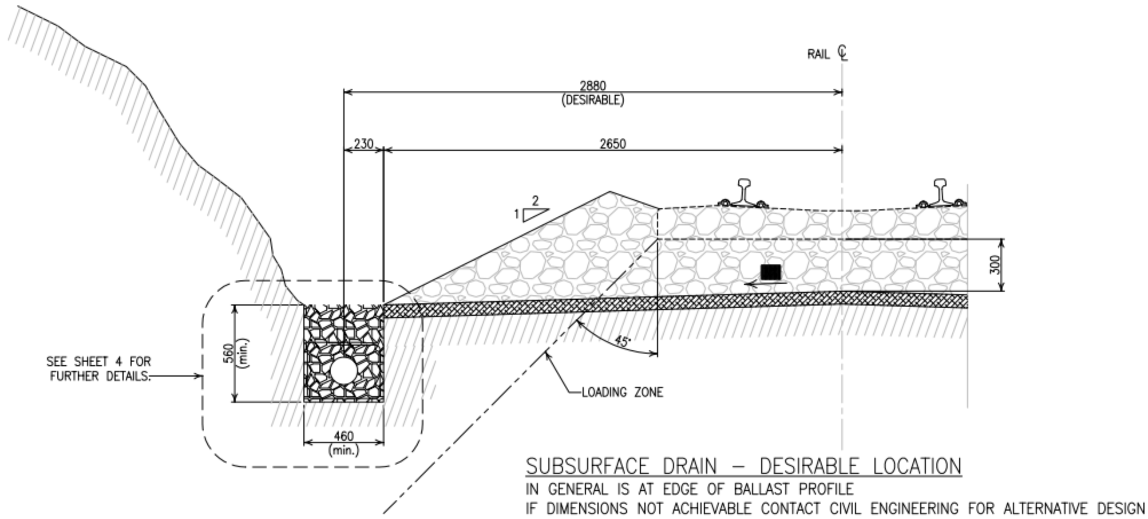

Figure 7:15 Subsurface drain in restricted cut width geometry

Where cutting widths are limited on existing lines, the desired minimum dimentions are as shown in Figure 7.15. Further reductions in these dimesions are illustrated in DWG 100862.

Subsoil Drains

Subsoil drains are piped subsurface drains. Site specific issues must be addressed and that anticipated volumes, the drain length and related factors may change the dimensions from the depicted minimums in Figure 7.16.

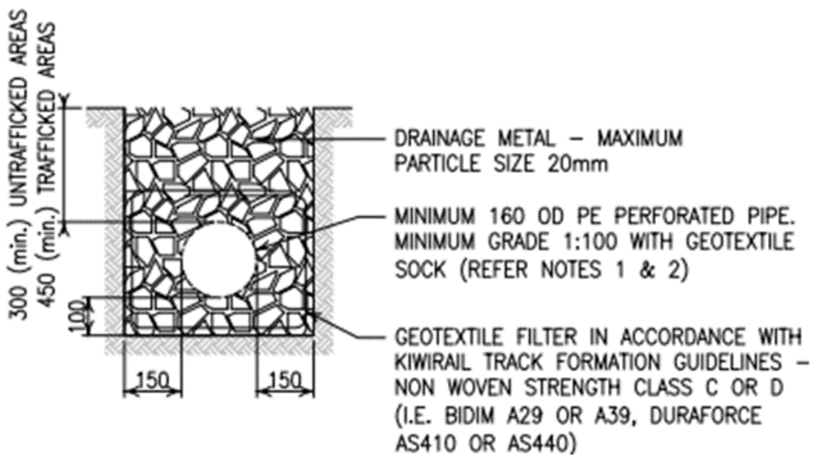

Figure 7:16 Subsoil drain detail

Subsoil drains shall have flushing points at appropriate intervals. Figure 7.16 shows typical confirgurations for these with more details found on DWG 100862.

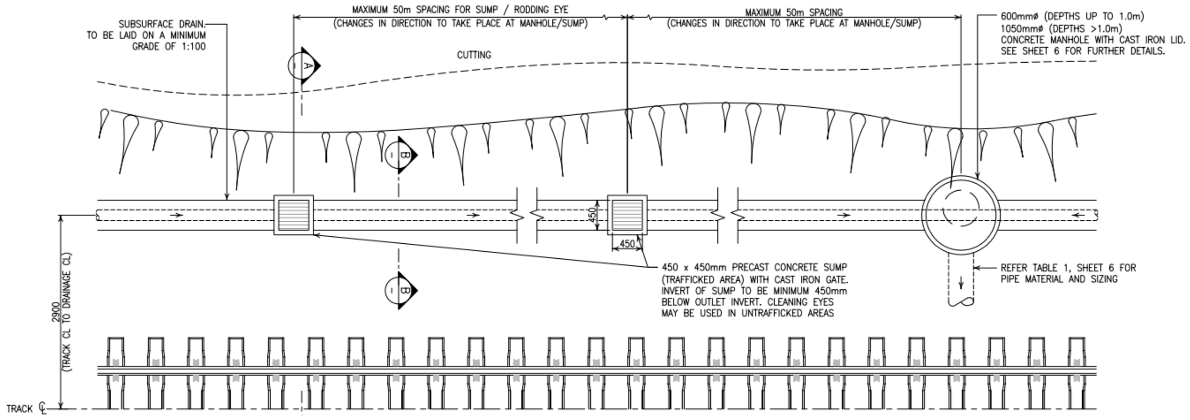

Figure 7:17 Plan view of typical longitudinal drain

Flushing points shall consist of 'Y' connections in the sub-surface pipe (intervals of 50m), with pipe connections extending to the surface for regular flushing with water to clear the sub- surface drain of fouling material.

Figure 7:18 Y' Connection of cleaning eye to Nexusflo pipe, Caversham Tunnel MSL

Aggregate Drains

Aggregate drains are an alternative subsurface drainage arrangement to piped subsurface drains. An indicative arrangement is illustrated in Figure 7.19. They should be considered in locations where loading may cause pipe drains to deform. However aggregate drains are only suitable for use where small flow of ground water or seepage is expected. They are not to be used for the collection of surface water.

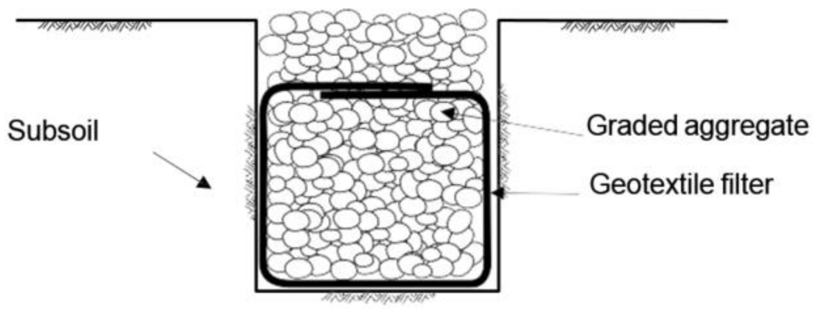

Figure 7:19 Cross-section of an aggregate subsurface drain

7.2.6 Carrier pipes

Where large volumes of water may need to be removed by subsurface drains, a carrier pipe may be used in conjunction with a collector drain, An example is shown in Figure 7.20. With this arrangement the subsoil/collector drain does not need to carry all the water. The advantage of this arrangement is that excess (large volumes) water is removed from the collector drain thus preventing it seeping into the subgrade again at a point further down the drainage route.

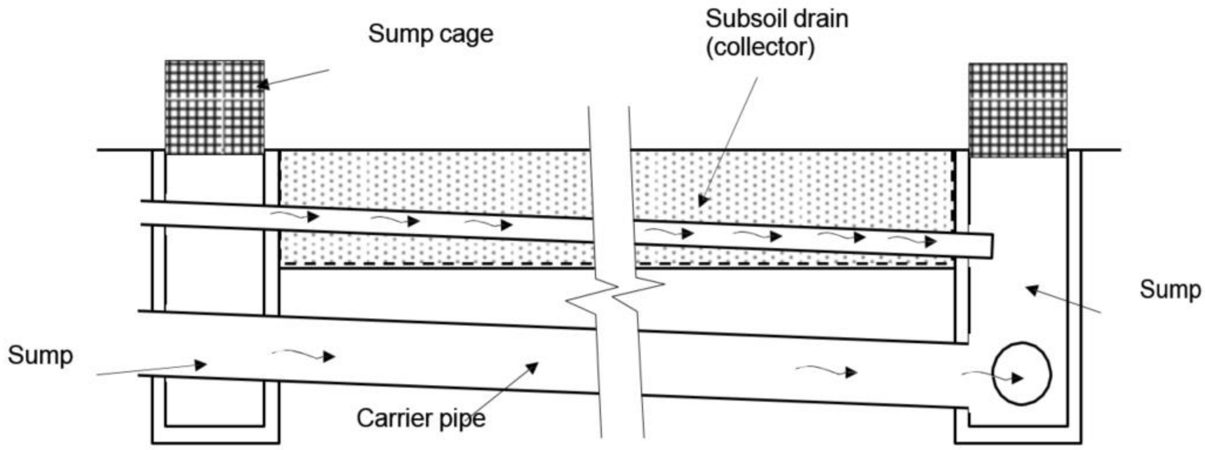

Figure 7:20 Subsoil collector drain plus a larger carrier pipe

7.3 Other design considerations

7.3.1 Inlets and outlets

There are various types of inlets and outlets in use for subsurface drains.

The main purpose of inlet and outlet protectors is to reduce erosion. Where outlet velocities are expected to be high, some form of energy dissipater should be installed. Refer to Culvert C-ST-CU-4103 for details of appropriate inlets and outlets.

7.3.2 Pipes and sumps

Refer to Culvert C-ST-CU-4103 for appropriate pipe details.

Figure 7:21 Installation of approved PH carrier pipe under main line, Reefton Yard, SNL

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

Figure 7:22 Grated sump, Reefton Yard, SNL

7.3.3 Level crossings

Requirements for level crossings are given in Level Crossings T-ST-AM-5360.

Drainage at level crossings is important as inadequate drainage around them is the cause of a large percentage of premature roading surface and track component failures.

Specific requirements for level crossing drainage are detailed in section 10.3 of Level Crossings T-ST-AM-5360. Additional overall drainage standards are found in this document.

The Property Team holds up to date records and agreements for third party services within the rail corridor that are deemed legal.

7.3.4 Miscellaneous items

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

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

7.3.5 Prohibited configurations

The following configurations are not approved for track drainage on the KiwiRail network:

- plastic pipes: polypropylene
- inverted syphon systems

Drainage cell systems shall only be used with the approval of the Professional Head – Civil Engineering.

8. Construction

8.1 General approach

The drainage elements in this standard are all common use items. Aspects that must be highlighted in the construction phase include:

- Preferred use of high-rail vehicles and plant to increase mobility and minimise the potential for damage to the track. Such special purpose vehicles are more readily adaptable to excavating trenches parallel to the cutting in the confined geometry.

- Where possible, construction should be preceeded by vegetation clearing (cutting and removal of dense growth). If practicable this should preceed the tender as the physical work will be more apparent.
- Site inspections should be mandatory so that tenderers are fully informed regarding access limitations and haulage requirements.
- Spoiling of vegetation, strippings, soil/ballast on cutting and embankment slopes must be prohibited.
- The appropriate level of KiwiRail staff oversight to ensure assets are not damaged, especially buried assets.
- Construction shall avoid undercutting steep embankments and destabilising slopes. This must be addressed at the design stage. If issues are discovered during construction consult with a geotechnical engineer.

8.1.1 Pipe drains

These consist of perforated or slotted pipes, installed by trenching and backfilling. Some type of filter material (AP 20-7) around the pipe or permeable backfill is normally required to minimise clogging of the drain perforations or slots. Approved subsurface pipe drain materials include Nexus 150ND, Nexus Highway 150ND, Megaflo 150, 300, 450.

8.1.2 Aggregate drains

These drains consist of permeable granular material. The aggregate should be coarse enough to be free draining, but not so coarse as to allow the migration of fines into or through the permeable material. Unless a special grading is specifically required, the common drainage aggregate (AP 20-7) should be used. The graded aggregate is to be wrapped in a geotextile (refer to Figure 7.19).

8.2 Product approval specification – plastic drainage products

For approval of new plastic drainage products, details should be provided as to the use of it by other railway or transport infrastructure providers and additionally how it is equivalent or better than existing approved products. Specific calculations for strengh and long term durability may also be required.

Approved subsurface pipe drain materials include Nexus 150ND, Nexus Highway 150ND, Megaflo 150, 300, 450.

Appendix 1 Approved Track Drainage Products for Under Track Crossing

Pipe Material and Class	Minimum Nominal Pipe Diameter (mm)	Min Depth Below Top Rail to Top of Pipe (mm)
PVC U PN16	375 NB	800
PE100 PN16 (Series 1)	400 OD	800
PVC-U DWV SN8	375 NB	950
PE100 PN10 (SDR17)	400 OD	950
RCRRJ Class 4	600mm when used as an open culvert, 300mm when used in an enclosed drainage system	1200mm
RCRRJ Class 6	600mm, use as open culvert only	1000
RCRRJ Class 8	600mm, use as open culvert only	750

Appendix 1 Clauses Relating to Drainage from Railway Act

The full Railway Act 2005 is available on line.

http://www.legislation.govt.nz/act/public/2005/0037/latest/DLM341568.html

Clauses 73 and 74 of the Act are included in full below due to them having specific relation to drainage in the railway corridor.

73 Trespass Relating to Railway

6) A person must not, without the express authority of the appropriate licensed access provider (in the case of railway infrastructure) or railway premises owner (in the case of railway premises),—
   a) encroach on any railway infrastructure or railway premises by constructing or placing a building, fence, ditch, drain, or other obstacle, or planting a tree or shrub, on the railway infrastructure or railway premises; or
   b) dig up, remove, alter, or undermine the soil or surface of any railway infrastructure or railway premises; or
   c) fill up, divert, alter, or obstruct any ditch, drain, or watercourse that directly carries water off any railway infrastructure or railway premises or is made to protect that railway infrastructure or those railway premises; or
   d) do any act in which—

(i) a ditch, drain, or watercourse that directly carries water off any railway infrastructure or railway premises or is made to protect railway infrastructure or railway premises is stopped; or
(ii) the natural flow of water in that ditch, drain, or watercourse is obstructed; or

   e) interfere with or divert a ditch, drain, or watercourse in a manner that damages any railway infrastructure or railway premises; or
   f) fell or remove a tree, shrub, or timber growing on any railway infrastructure or railway premises; or
   g) interfere with or damage a rail vehicle or container or other property carried on a railway; or
   h) interfere with, change, or move a building, structure, or property in a manner that causes damage to railway infrastructure or railway premises; or

(i) cause or procure to be done any of the acts specified in paragraphs (a) to (h).

7) A person must not enter any railway infrastructure or railway premises,—
   a) in the case of railway infrastructure, without the express authority of the appropriate licensed access provider; and
   b) in the case of railway premises, without the express or implied authority of the appropriate railway premises manager.

8) The owner of stock, or a person in charge of stock, must prevent the stock from trespassing on a railway or on any part of a railway.

9) If stock is found trespassing on a railway,—

   a) rail personnel may impound that stock:

   b) the relevant rail participant, or its rail personnel, may, in respect of that stock, exercise any of the functions or powers conferred on an occupier of land by the Impounding Act 1955 (and the provisions of that Act, except section 26(1), apply accordingly).

10) The provisions of this section are in addition to, and not in substitution for, the provisions of the Trespass Act 1980.

74 Railway Drains

11) If a drain on, above, or under any railway infrastructure or railway premises forms part of, or is used in connection with, a sewerage or stormwater drainage system that is under the control of a road controlling authority or a local authority,—

   a) the cost of maintaining the drain must be borne by that road controlling authority or local authority; and

   b) if the maintenance work is carried out by a licensed access provider, infrastructure owner, or railway premises owner, the cost is recoverable from the road controlling authority or local authority as a debt due to the licensed access provider, infrastructure owner, or railway premises owner.

12) Nothing in this section confers on a road controlling authority or local authority the right to enter any railway infrastructure or railway premises for the purposes of maintaining a drain without the prior consent of the licensed access provider or railway premises owner, which may be granted on the terms and conditions that the licensed access provider or railway premises owner thinks fit.

13) For the purposes of subsection (2), a licensed access provider or railway premises owner may not withhold consent in an emergency if doing so would be unreasonable.

Briefing Note(s) for C-ST-CD-4102 Corridor Drainage

Date Effective	30/06/2016	**Issue No.**	Issue 1.0

Background

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Key changes / compliance

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Implementation

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Applicability (Select relevant boxes)	**General**	**Civil**	**Signals and Telecommunications**	**Structures**	**Track**	**Traction and Electrical**
Zero Harm	☐	☐	☐	☐	☐	☐
Learning and Development	☐	☐	☐	☐	☐	☐
Project Management Office	☐	☐	☐	☐	☐	☐
Manager Property Revenue and Grants	☐	☐	☐	☐	☐	☐
National Train Control Centre	☐	☐	☐	☐	☐	☐
Engineering Services Manager	☐	☐	☐	☐	☐	☐
National Supply Chain and Distribution Manager	☐	☐	☐	☐	☐	☐
Professional Head		☐	☐	☐	☐	☐
Network Services Managers		☐	☐	☐	☐	☐
Region Operations Managers		☐	☐	☐	☐	☐
STTE Managers		☐	☐	☐	☐	☐
Production Managers		☐	☐	☐	☐	☐
Asset Engineers		☐	☐	☐	☐	☐

Document History

Note page numbers relate to the document at the time of amendment and may not match page numbers in current document.

Issue No.	Section	Description	Page(s)