Rail Track Drainage

Technical Guide

Demco

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RAIL TRACK DRAINAGE

1.0 INTRODUCTION

The quality and safety of rail systems depends greatly on the stability of the earthwork structures that it runs on and drainage is a significant part of their long performance. The key issue is the high static and dynamic loads that are present and any drainage pipe must be able to resist these loads and be fully maintainable over a design life in excess of 60 years to provide the best "whole life" costs.

As most drainage systems in the UK are installed during remediation project closures where time is limited speed of installation is also a very significant factor. The **TerraRange** of drainage pipes and catch pits provides products which provide all the requirements in terms of load resistance, maintenance and fast installation.

1.1 KEY REQUIREMENTS FOR TRACK DRAINAGE SYSTEMS

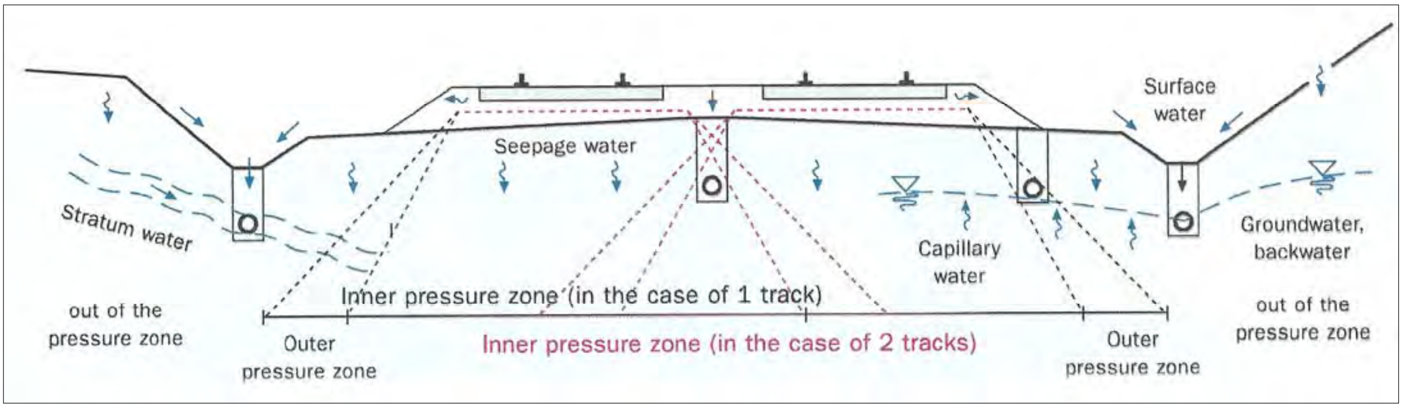
- **STABILISE TRACK SUPPORT SYSTEM**
- **REMOVE TRAPPED WATER IN BALLAST WHICH REDUCES STIFFNESS**
- **MINIMISE SOFTENING OF TRACK BED**
- **CONTROL OF WATER ENSURES SAFE & ECONOMIC MANAGEMENT**
- **ELIMINATE TEMPORARY SPEED RESTRICTIONS OR CLOSURES**
- **1:500 FALL MUST BE ACHIEVABLE**
- **PROVIDE MINIMUM "WHOLE LIFE" COSTS**
- **EASY & QUICK TO INSTALL WITH MINIMUM CIVIL WORK**

2.0 STATIC LOADING

2.1 Active load zone

Any drain classified as “On-Track” (see section?) such as the 4ft, 6ft, 10ft or Cess <1.4m from the running rail will be subjected to active loads which can be as high as 82 tonnes from freight trains.

The diagram below identifies this Active Load Zone (Inner & outer pressure zones) in accordance with the German Railway DBS 918 064 as there is to date no such equivalent specification in the UK.



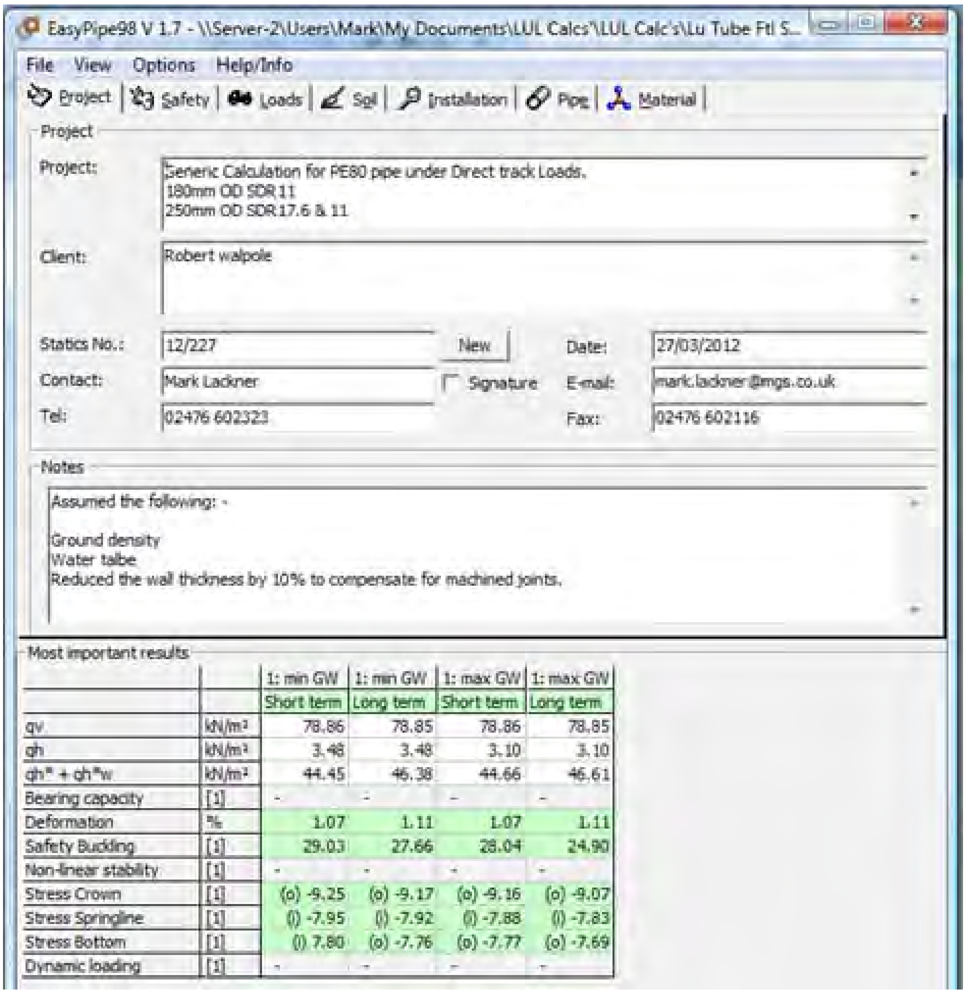
2.2 Static calculations

The suitability of the drainage pipe should always be checked using as a **MINIMUM** the parameters included in the ATV-DVWK-A 127 calculations to ensure long term performance.

The only formal standard for static calculations for buried pipes is the German ATV-DVWK-A 127 which has been developed using standard civil engineering practice and research in various institutes in Germany. This standard takes into consideration all parameters that will affect the performance of any type of pipe in any type of ground under various load conditions including railways.

Special software (EasyPipe) can be used to verify that the selected pipe is suitable in terms of static loading for the project. Typical inputs are shown in the following screen shots.

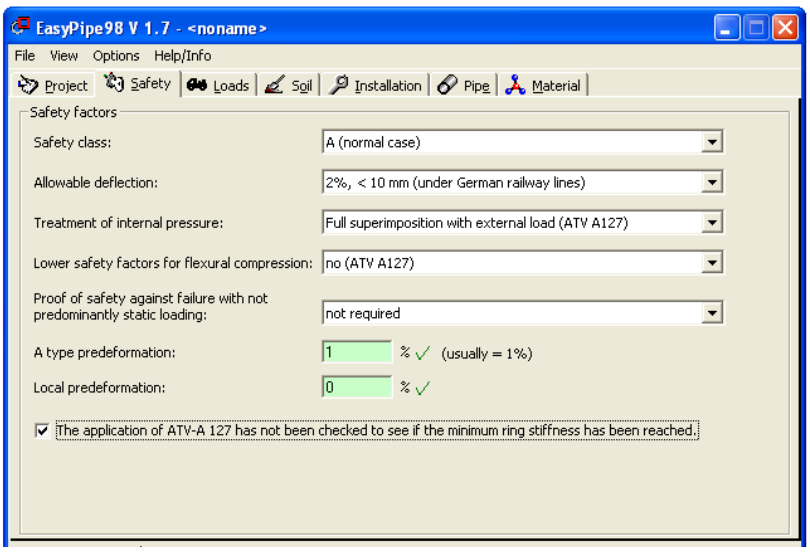
1.) PROJECT DEFINITION



		1: min GW	1: min GW	1: max GW	1: max GW
		Short term	Long term	Short term	Long term
qv	kN/m²	78.86	78.85	78.86	78.85
qh	kN/m²	3.48	3.48	3.10	3.10
qh* + qh*w	kN/m²	44.45	46.38	44.66	46.61
Bearing capacity	[1]	-	-	-	-
Deformation	%	1.07	1.11	1.07	1.11
Safety Buckling	[1]	29.03	27.66	28.04	24.90
Non-linear stability	[1]	-	-	-	-
Stress Crown	[1]	(o) -9.25	(o) -9.17	(o) -9.16	(o) -9.07
Stress Springline	[1]	(i) -7.95	(i) -7.92	(i) -7.88	(i) -7.83
Stress Bottom	[1]	(i) 7.80	(o) -7.76	(o) -7.77	(o) -7.69
Dynamic loading	[1]	-	-	-	-

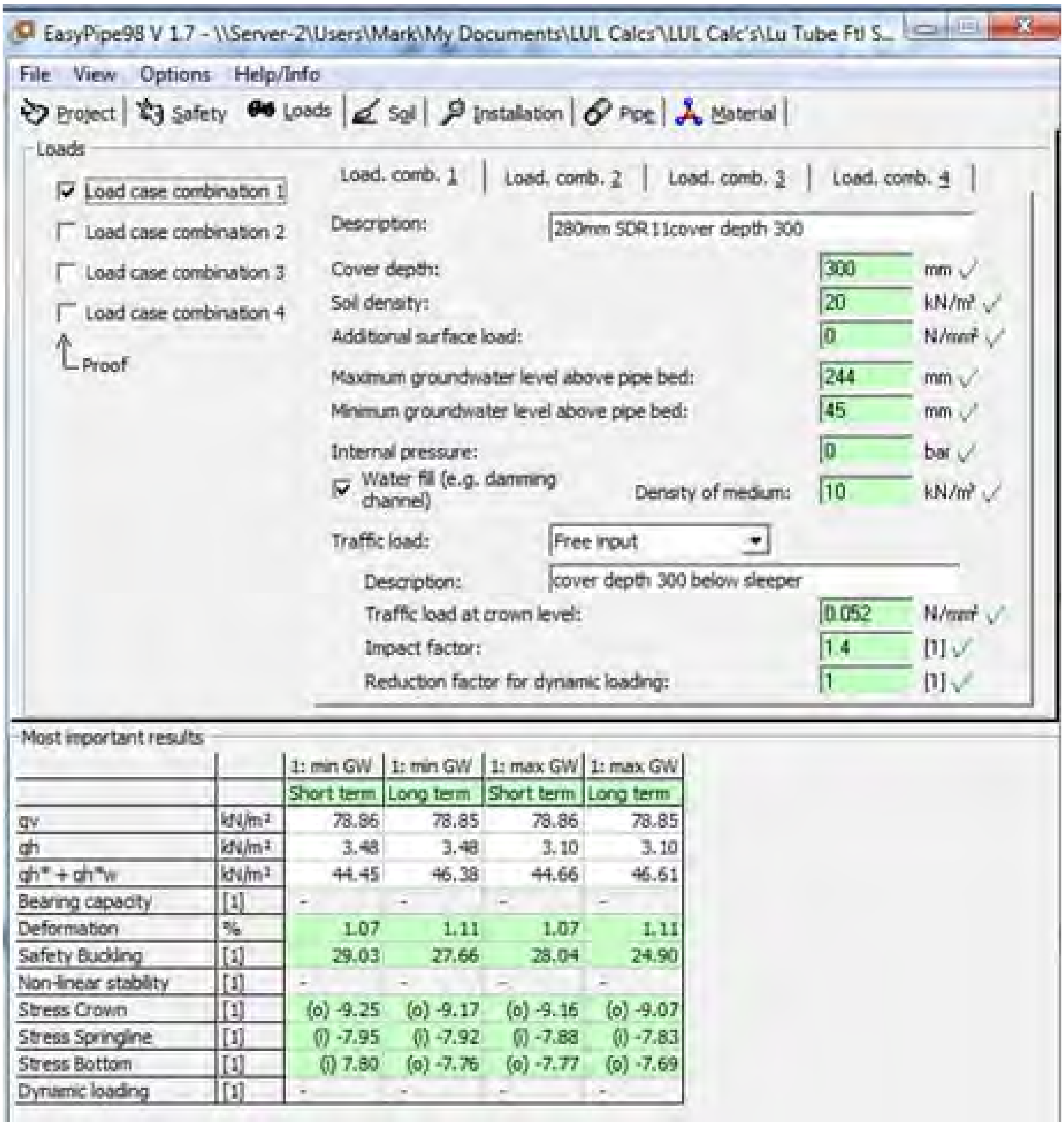
2.) SAFETY FACTORS

Allowable deflection (2% < 10mm normal under railways)



3.) LOADING

Includes depth of cover, soil density, surface and traffic loading



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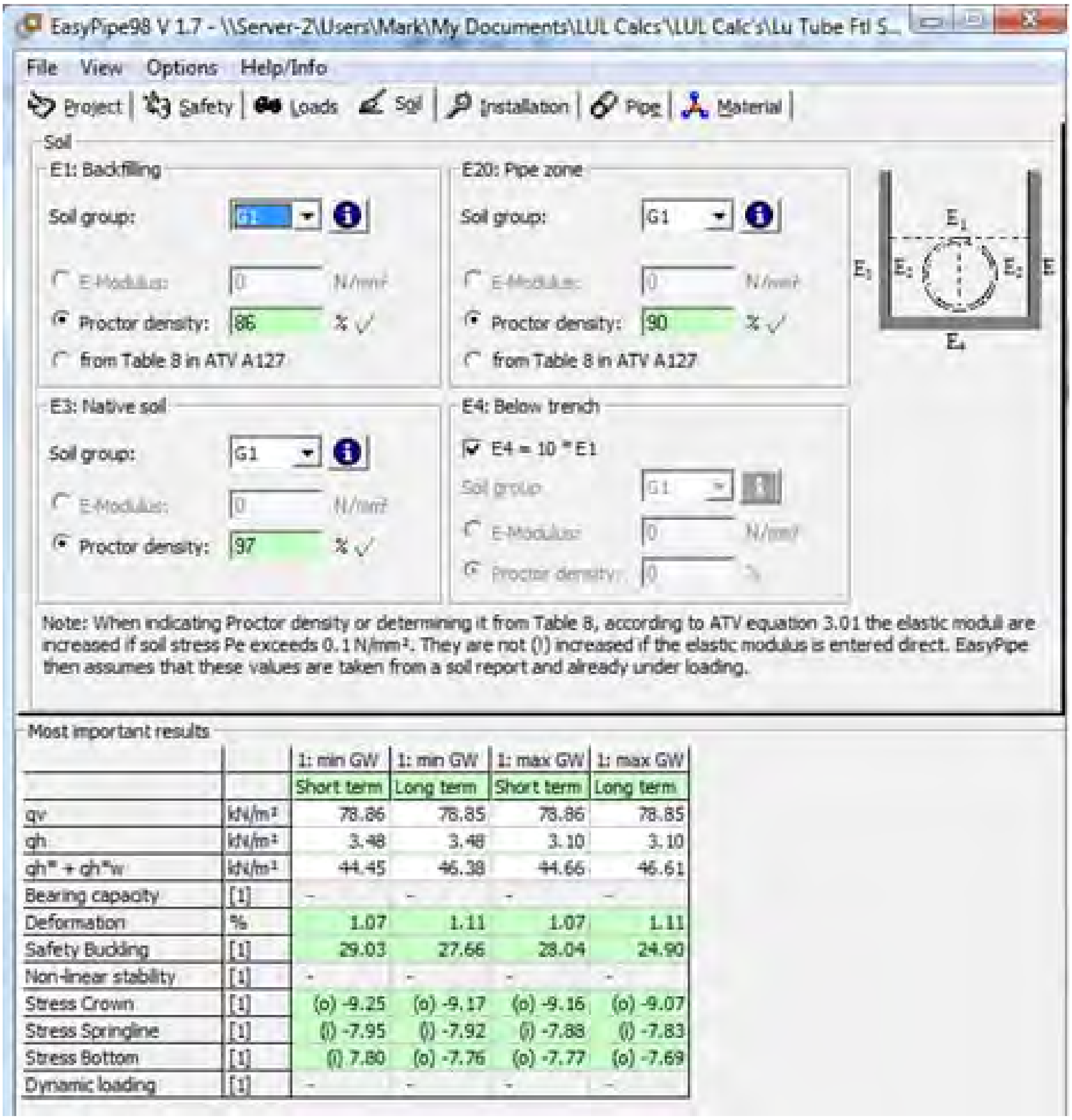
Dynamic loading	[1]	-	-	-	-

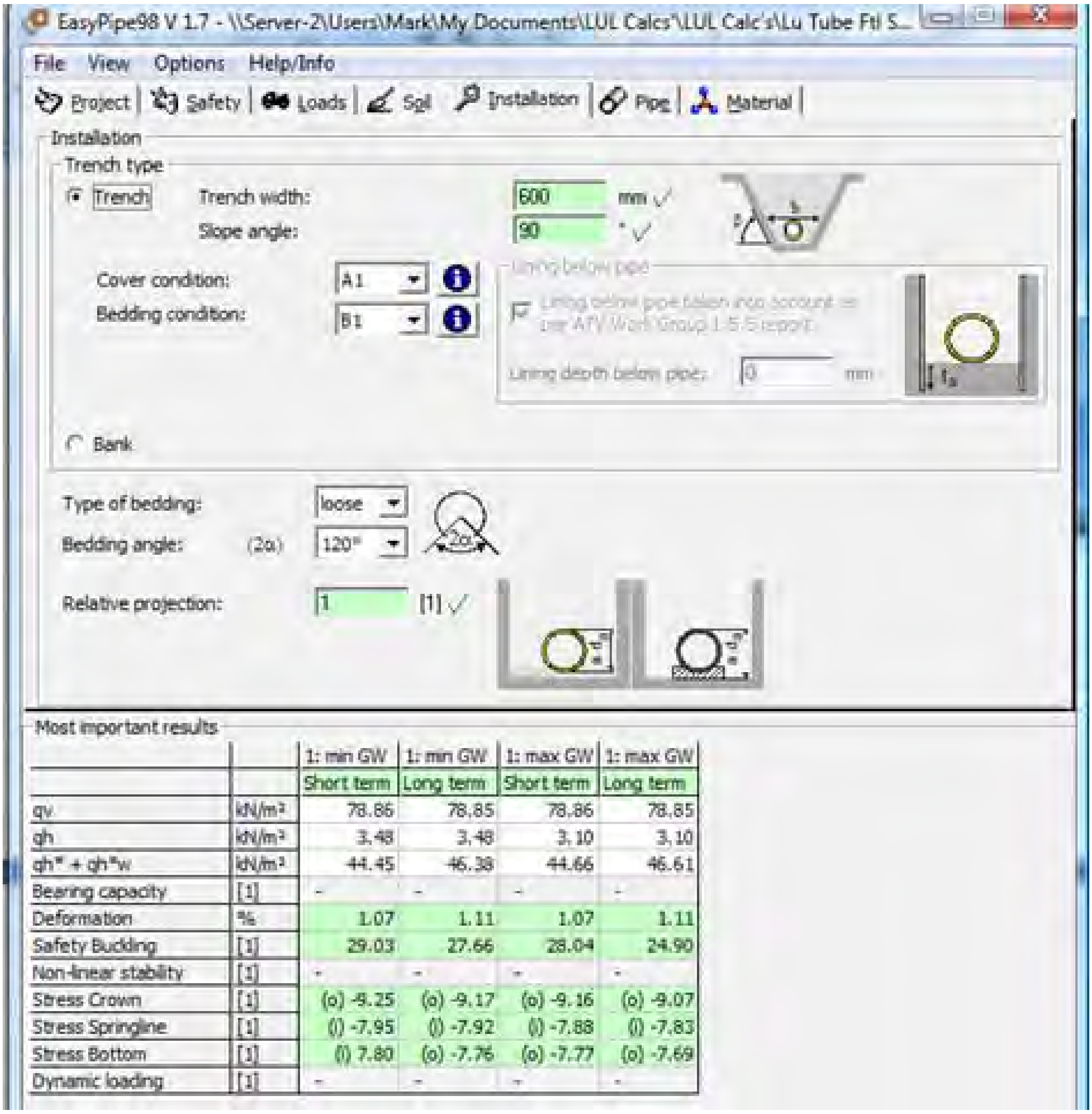
4.) SOIL CONDITIONS

The properties of the individual zones in and around the pipe can be matched



5.) INSTALLATION

Soil properties can be matched in accordance with site conditions in & around the drainage pipe



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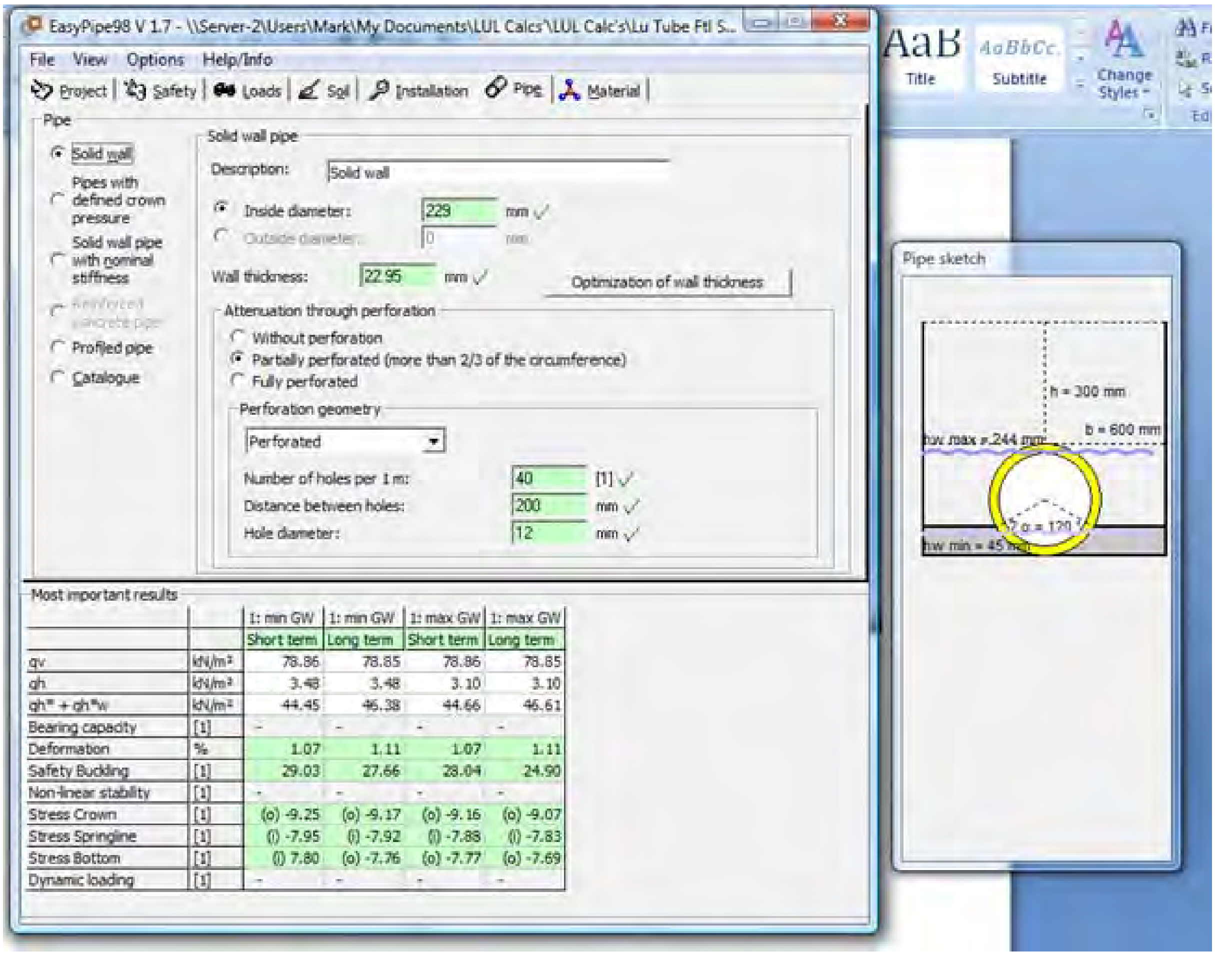
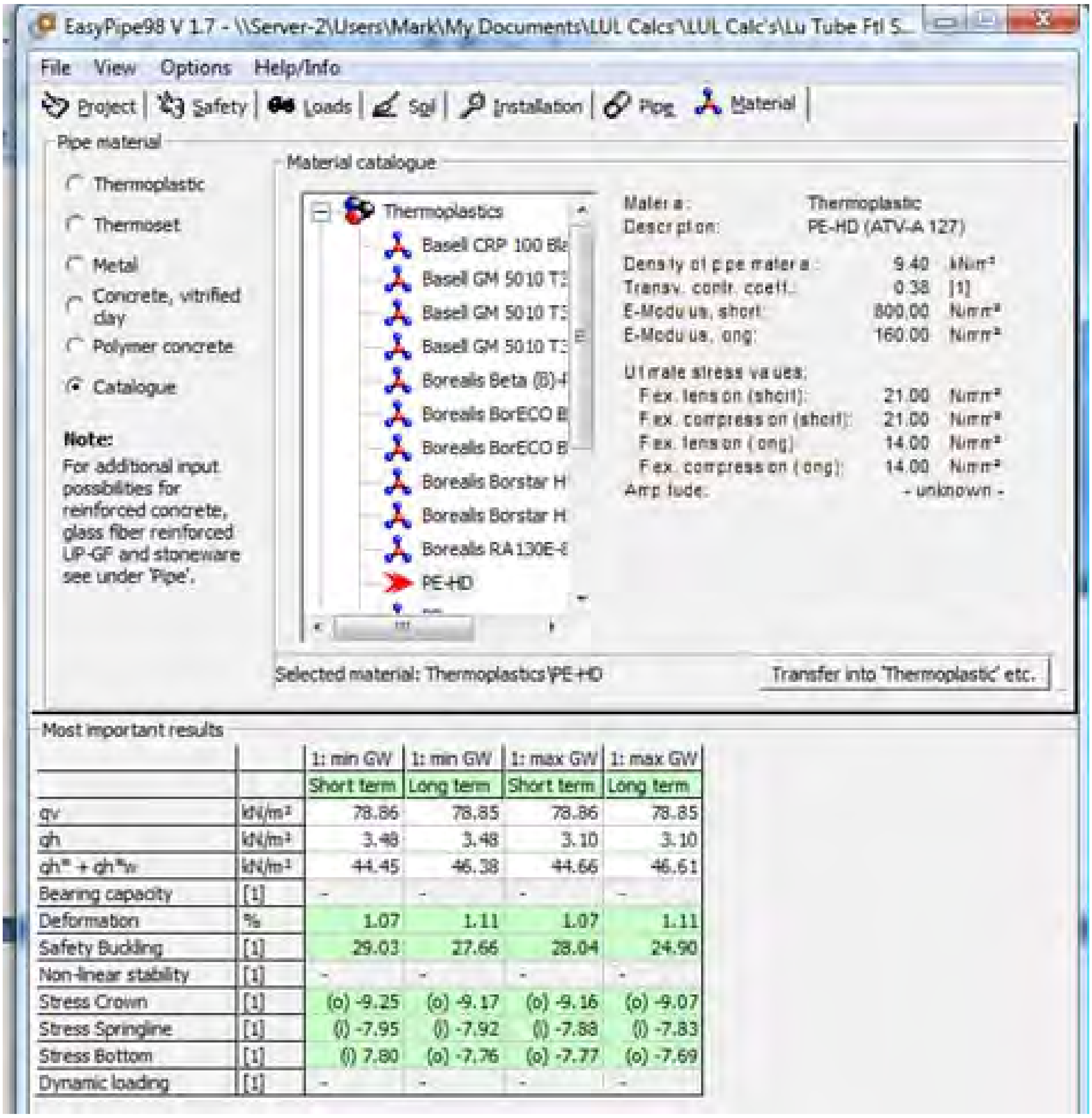
6.) PIPE

Values for pipe geometry including wall type, wall thickness, perforations



7.) MATERIAL

Material of pipe can be matched to provide accurate design calculations



2.2.1 Calculation inputs

In order to carry out the correct calculations to verify the suitability of drainage pipes used in track bed drainage the following inputs should be provided:-

PROJECT DETAILS

Project title:________________________________

Contractor: ________________________________

PIPE **OD** **ID**

☐ TerraDrain (perforated) _______________

☐ TerraLine (non perforated) _______________

INSTALLATION CONDITIONS

Bedding angle °	(2α)	______
Trench width (mm) at pipe crown	(B)	______
Cover height (mm)	(H)	______
Fill type	(1)	______
Bedding type	(2)	______

ACTIVE LIVE LOADS

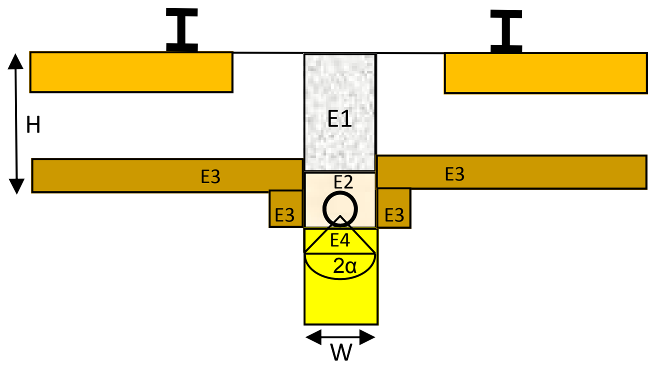
☐ Multi-track (UIC 71)

☐ Single track (UIC 71)

☐ Additional load (specify) __________

Date: ________________________

SOIL CONDITIONS



E1 : Backfill	Dpr %	______
E2 : Pipe zone	Dpr %	______
E3: Natural soil	Dpr %	______
E4: Below trench	Dpr %	______

G1 = non cohesive soil G2 = slightly cohesive soil

G3 = cohesive mixed soil G4 = cohesive soil

(1) - FILL CONDITIONS

A1: Compacted against natural soil without measured compaction value

A2: Gradual filling in layers within support as support is removed

A3: Gradual filling within support which is removed after filling completed

A4: Compacted against natural soil with measured compaction value

(2) - BEDDING CONDITIONS

B1: Compacted in layers against natural soil without measured compaction value

B2: Vertical support within the pipe zone to bottom of trench after filling and compaction

B3: Vertical support within the pipe zone to below bottom of trench after filling and compaction

B4: Compacted against natural soil with measured compaction value

3.1 Purpose of drainage

The purpose of Track Drainage is to remove water from the Track Support System.

The effective control of water is essential to the safe and economic management of railway infrastructure. Water has an important if not dominant role in most degradation mechanisms and can affect the long-term softening of materials that form the Track Support System and Earthworks.

Typical drainage problems can result in:-

- **temporary speed restrictions**
- **temporary closures of the line**
- **increased maintenance costs.**

Many of the problems which arise in the track bed occur where Track Drainage is not operating effectively, or where changes in the position of the water table have created the need for additional drains.

Water trapped below the ballast saturates and reduces the stiffness of the track bed (which can result in top and line faults that affect ride quality), and early deterioration of ballast (characterised by the formation of Wet Beds and broken rails).

The main sources of water that can affect the Track Support System are:-

- **precipitation on the track**
- **run off from areas adjacent to the track**
- **groundwater from underlying permeable layers**
- **perched water tables**
- **infiltration through the ballast and ditches.**

3.2 Drain types

Drainage is carried out during two different types of operation and can be classified in terms of performance criteria as follows:-

3.2.1 New works

The aim is one or more of the following;

- to **achieve** the service life of the Track Support System,
- to **maximise** the performance of the Track Support System,
- to **minimise** the volume and/or cost of maintenance of the Track Support System

3.2.2 Remediation

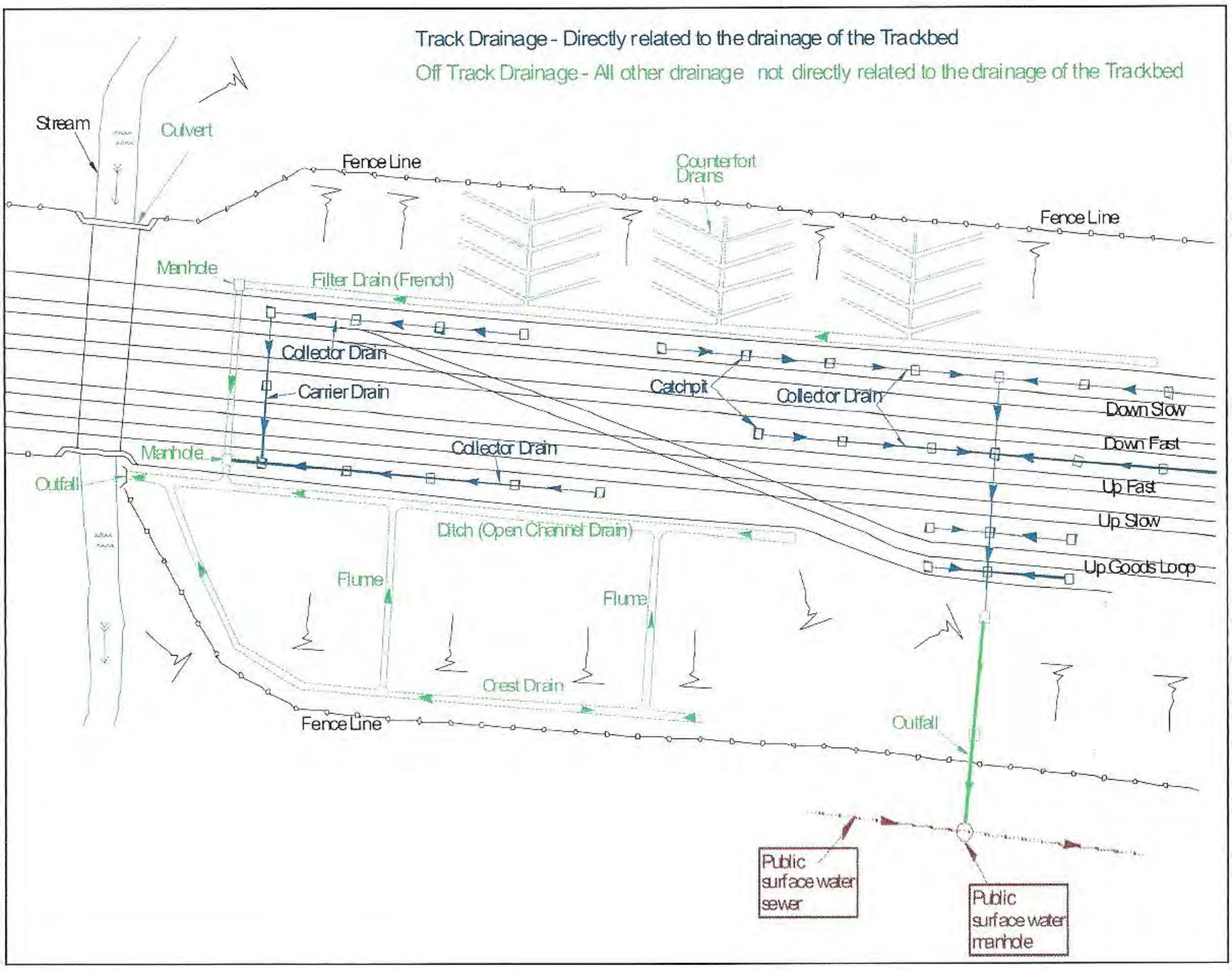
The aim is one or more of the following

- to achieve or **extend** the service life of the Track Support System,
- to **improve** the performance of the Track Support System,
- to **reduce** the volume and/or cost of maintenance of the Track Support System

3.3 Drainage system zones

Drainage of the Track Bed System (also known as On-Track drainage)

This is where Collector drains (TerraDrain) and Carrier drains (TerraLine) together with Catch pits (TerraPit & STAKKAbox) are used to drain the area directly underneath and adjacent to the running rail where high active loads exist up to 82 Tonnes.



OFF-TRACK

Drainage of areas other than the Track Bed System

In this area there are many different types of drains which are installed to minimise the amount of water entering into the Track Bed System and stabilising the area adjacent to the track and include toe, ditch, filter, crest, flume and counterfort drains. No active loads occur in this zone.

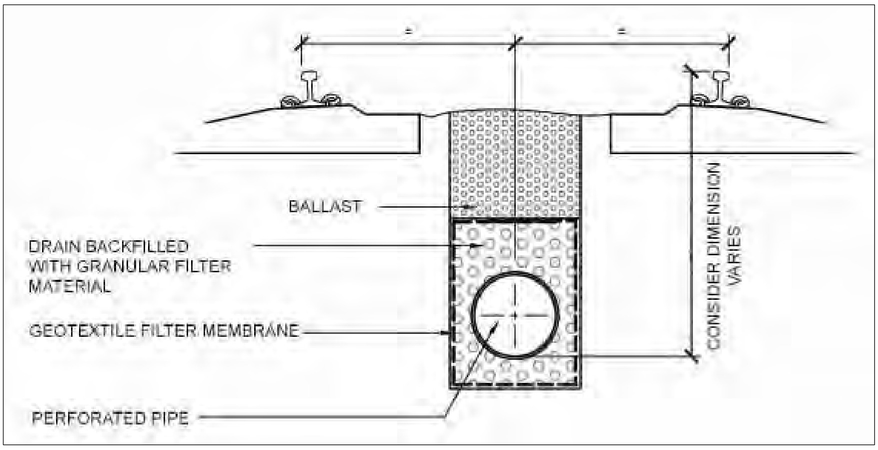
3.4 Elements of drainage systems

3.4.1 Collector drain (TerraDrain

A Collector Drain collects water through open joints and/or perforations in the pipe and is installed in the 4ft, 6ft, 10ft or Cess. Typical joints are flush push fit or external couplers.

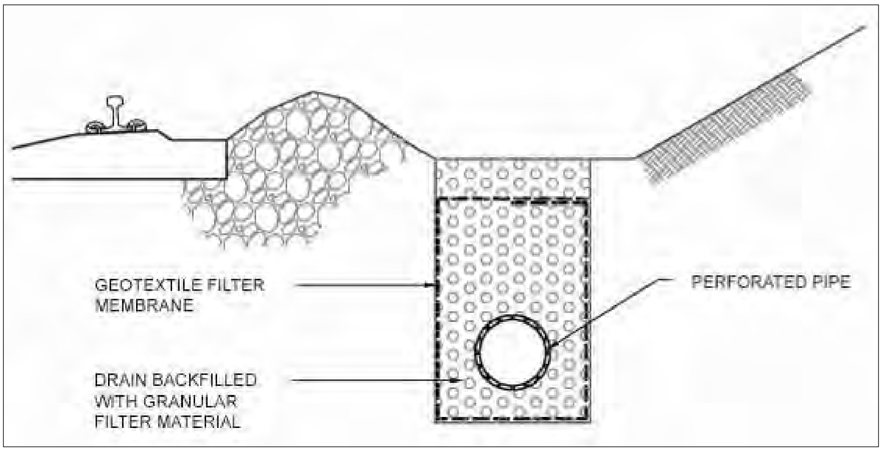
Pipes should be surrounded with granular filter material, and associated permeable geotextile, to reduce the ingress of silt whilst still allowing water to pass freely.

TerraRange pipes are suitable for installing at depths of 300mm or more.



Typical under track drainage installation.

TerraDrain in 6ft drain



Typical Cess drain installation.

TerraDrain in cess drain

3.4.2 Carrier drain (TerraLine)

A drain that receives and carries water from another drain to an outfall. Typically they are installed from the end catch pit to the designated point of discharge.

Typical joints are flush push fit, external coupler with O-rings or electro-fusion couplers.

Can be installed as a UTX.

TerraLine running from outfall chamber

TerraLine installed as a carrier drain as a UTX by trenchless technology equipment

3.4.3 Rodding eyes

To ensure long term serviceability of drainage systems rodding eyes are used to allow inspection and jetting.

Made from polyethylene they are compatible with all other components of the drainage system.

Rodding eyes installed along 10ft drain

3.4.4 Special fabrications

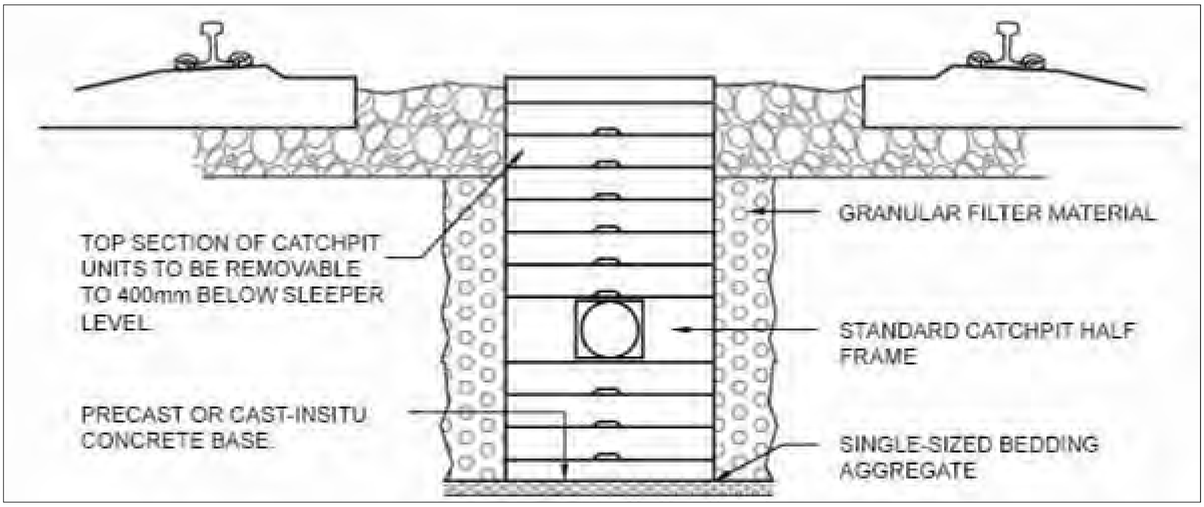
A range of special fabrications to suit special project requirements.

3.4.5 Catch pits and Manholes (TerraPit & STAKKAbox)

A catch pit includes a sump where silt and debris washed through the collector pipes collect and can be removed. Manufactured from lightweight GRP and compatible with TerraDrain and TerraLine drainage pipes.

STAKKAbox with in-line entries

TerraPit with 90 degree entries



Typical catch pit installation

3.4.6 Manholes

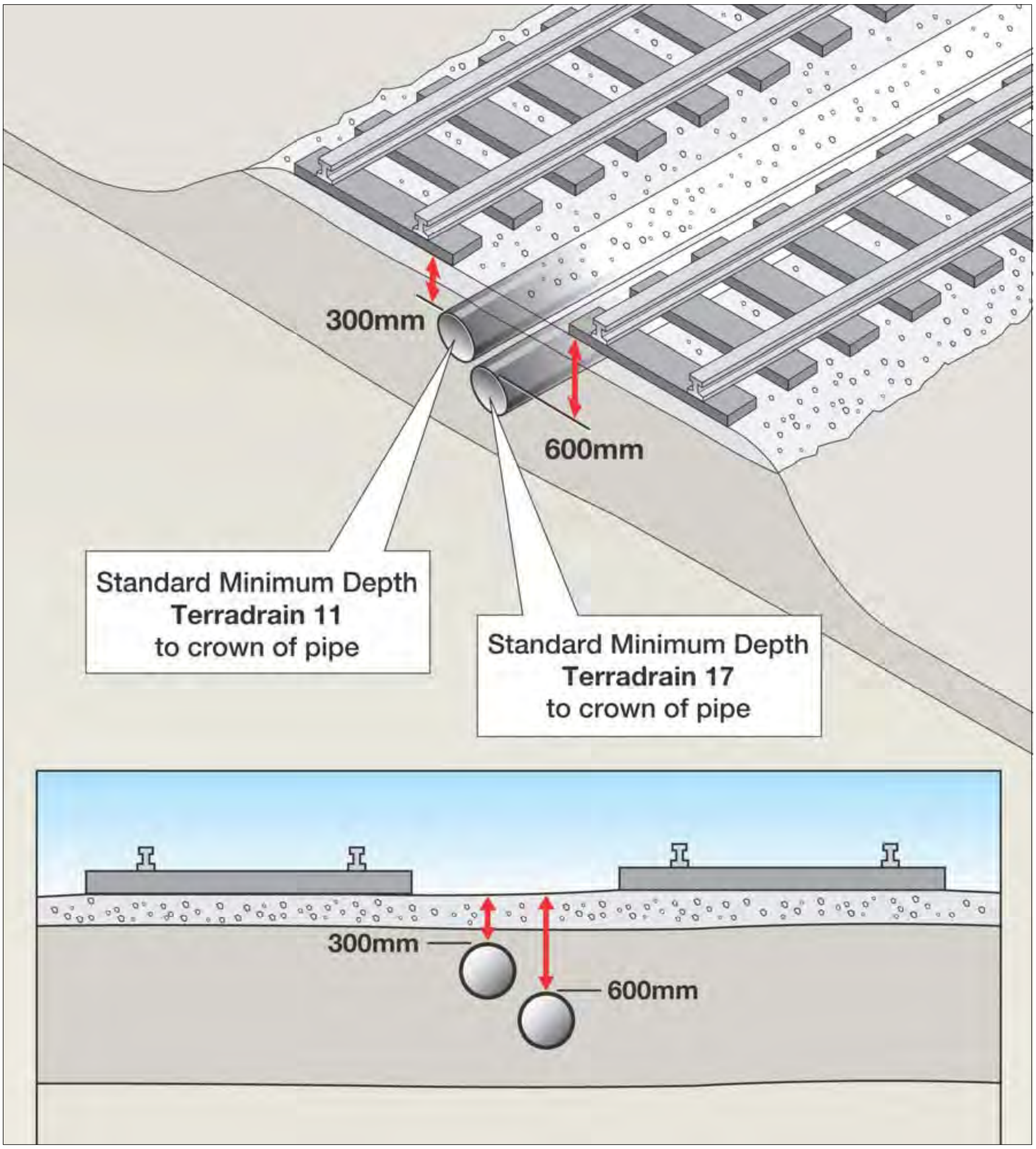
A Manhole has no sump, but the formed invert facilitates access for maintaining the connecting drains. Manufactured from polyethylene and compatible with TerraDrain and TerraLine drainage pipes.

3.5 Installation depths

Illustrated below are typical minimum depths* to which **TerraDrain** can be installed without being adversely affected by the high static and dynamic loads associated with live rail track.

- Calculations such as ATV-DVWK-A 127 should always be used to verify the suitability of products. Please contact Demco for further advice if necessary.

Calculations should be used as part of the submission of forms **A & B** in order to conform to the requirements of the new Network Rail Railway Drainage System Manual **NR/L3/CIV/005** and help towards justifying the **"Whole Life Costs"** statement.



4.0 DESIGN

4.1 General requirements

When designing a track bed drainage system the following key parameters should be considered:-

DRAINS

- drains should be designed to fall to an identified outfall
- the design should take account of whole life costs
- the length of carrier and collector drains
- separate systems for different sources of water, such as groundwater and surface water
- self-cleansing flow
- spatial constraints, such as bridges and tunnels.

The design should also consider:-

- the form of construction of the system and its components
- the risk to the system of railway operations and outside parties, should the design capacity of the system be exceeded or the system become blocked
- maintenance of the system

CATCH PITS

Catch pits should be able to provide the following-

- permit inspection and maintenance of collector and carrier drains
- provide a sump of not less than 225mm, or the diameter of the pipe if this is greater, below the invert of the lowest connected pipe
- the invert of the outlet pipe should be at least 25mm lower than the invert of the lowest inlet pipe.
- be capable of withstanding the imposed loads without distortion or collapse
- the relevant rated covers to prevent the ingress of debris

4.2 Standards

The UK has two main standards to which all rail track drainage systems should comply and are the following:-

Network Rail - NR/L3/CIV/005/1 Railway Drainage Systems Manual

This Network Rail standard includes mandatory requirements that shall **be complied with** by Network Rail and its contractors from 5th March 2011 and comprises of the following:-

Reference	Title	Issue	Date
NR/L3/CIV/005/1	Part 1: Purpose, scope and general management requirements	1	4/12/10
NR/L3/CIV/005/2A	Part 2A: General design requirements	1	4/12/10
NR/L3/CIV/005/2B	Part 2B: Hydraulic design of new Drainage Systems	1	4/12/10
NR/L3/CIV/005/2C	Part 2C: Design of Drainage System components	1	4/12/10
NR/L3/CIV/005/2D	Part 2D: Remediation	1	4/12/10
NR/L3/CIV/005/2E	Part 2E: Installation 1	1	4/12/10
NR/L3/CIV/005/3A	Part 3A: Inspection	1	4/12/10
NR/L3/CIV/005/3B	Part 3B: Maintenance	1	4/12/10
NR/L3/CIV/005/4A	Part 4A: Initial Survey and condition assessment		
NR/L3/CIV/005/4B	Part 4B: Records		
NR/L3/CIV/005/5	Part 5: Guidance for Drainage		

London Underground - The Manual of good practice

Guidance on the design of drainage structures M 3360 A2

Produced by the Chief Engineer's Directorate this document outlines all the requirements of London Underground's drainage specifications and approvals

4.3 Key issues for elements

The key issues for the individual elements of a rail track drainage system is that they must provide:-

- **RESISTANCE TO HIGH STATIC & DYNAMIC LOADING**
- **LONG TERM LIFE (>60 YEARS)**
- **HYDRAULIC EFFICIENCY (k ≤ 0.01mm)**
- **CHEMICAL RESISTANCE TO RAIL ENVIRONMENT**
- **QUICK & EASY INSTALLATION (LOW WEIGHT WITH QUICK JOINTS)**
- **ACCESS FOR CLEANING & INSPECTION**
- **RESISTANCE TO HIGH PRESSURE INTERNAL JETTING UP TO 5000 PSI**

4.4 Hydraulic design

Consideration should be given to improving the hydraulic performance of the existing Drainage System.

To minimise Maintenance, Track Drainage should be designed to run full occasionally to enable any accumulated sediment in the pipes to be removed. Because most Track Support Systems can withstand occasional inundation without undue consequences, the suggested design criterion is that Track Drainage is designed assuming that the drain can run full once a year.

Track Drainage should be designed to take the estimated flows from the Track Support System and key components of the design are:-

- Outline design (separate On-track & Off-track drainage)
- Estimate the discharge capacity required
- Size the components
- Check components comply with design requirements
- Check the capacity of the system

4.5 Whole life costs (WLC)

Defined as the systematic consideration of all relevant costs and revenues associated with the acquisition and ownership of an asset.

Whole life costing is a means of comparing options and their associated cost and income streams over a period of time. Costs to be taken into account include:-

- Initial capital or procurement costs
- Opportunity costs
- Future costs.

Only options which meet the performance requirements for the built asset should be considered - those with lower costs over the period will be preferred.

Initial costs include:-

- Design
- Construction and installation
- Purchase or leasing
- Fees and charges.

Future costs include all operating costs including:-

- Cleaning
- Inspection
- Maintenance
- Repair, replacements / renewals,
- Dismantling, disposal, and management over the life of the built asset.

Opportunity costs represent the cost of not having the money available for alternative investments (which would earn money) or the interest payable on loans to finance work.

Current rail projects are being reviewed to ensure that adequate processes relevant to developing high quality engineering solutions that consider life cycle costs. These should include engineering reviews to check whether the final engineering solution (scope and specification) is in line with accepted good practice relevant to delivering low life cycle costs.

In particular the following key issues should be considered for drainage systems:-

- **INSTALLATION TIME**
- **WASTE VOLUME FOR LANDFILL**
- **VOLUME OF NEW STONE**
- **REDUCTION IN TRAIN MOVEMENTS DURING INSTALLATION**
- **SERVICEABLE LIFE & EASE OF MAINTENANCE**
- **TOTAL PROJECT COST**

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