Maintaining Subgrade with Trench Drains

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CRS, inc.
Cantrell Rail Services, Inc.

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Presentation Outline

- What are Trench Drains
- Locations Prone to Drainage Problems
- Where to Install Trench Drains
- Trench Drain Construction
- Shear Keys to Treat Cess Heave

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Trench Drains are …

Gravel filled trenches used to collect and drain subsurface water

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Trench drains are effective because water is a contributor to most (if not all) soft track problems

… and the least expensive way to deal with water is …

DRAINAGE

DRAINAGE

DRAINAGE

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Advantages of Trench Drains

- Remove water
- Easy and economic to construct
- Track can remain in service
- Do not require special equipment
- Use ballast for drainage gravel
- Simple low-tech solution
- Chance to observe subsurface conditions

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GRAVITY

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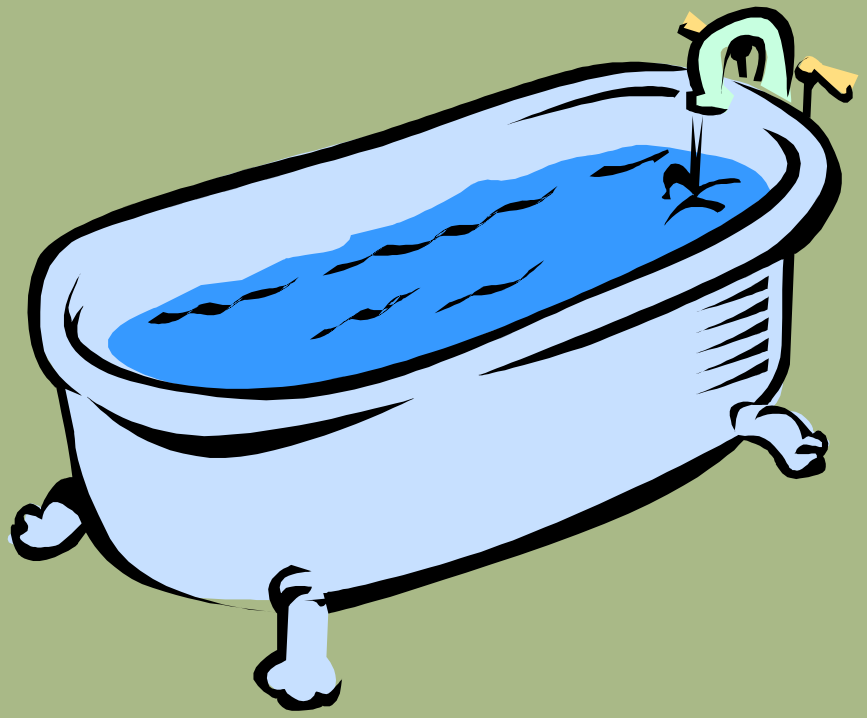
Some Locations are More Prone to Developing Internal Drainage Problems than are Others



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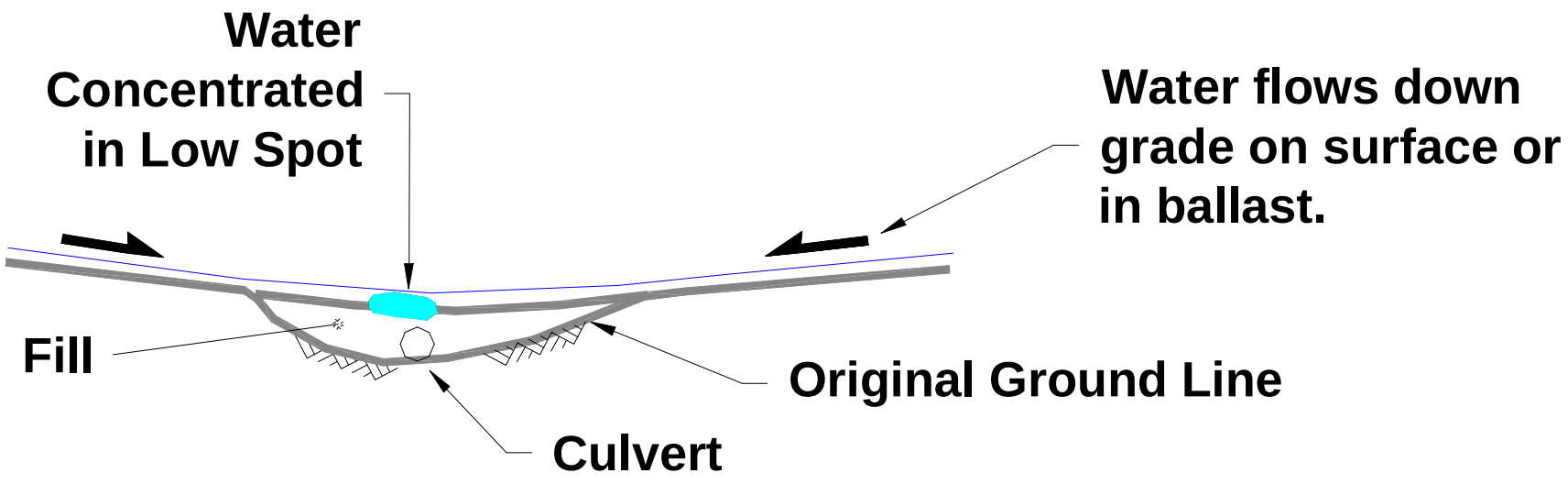
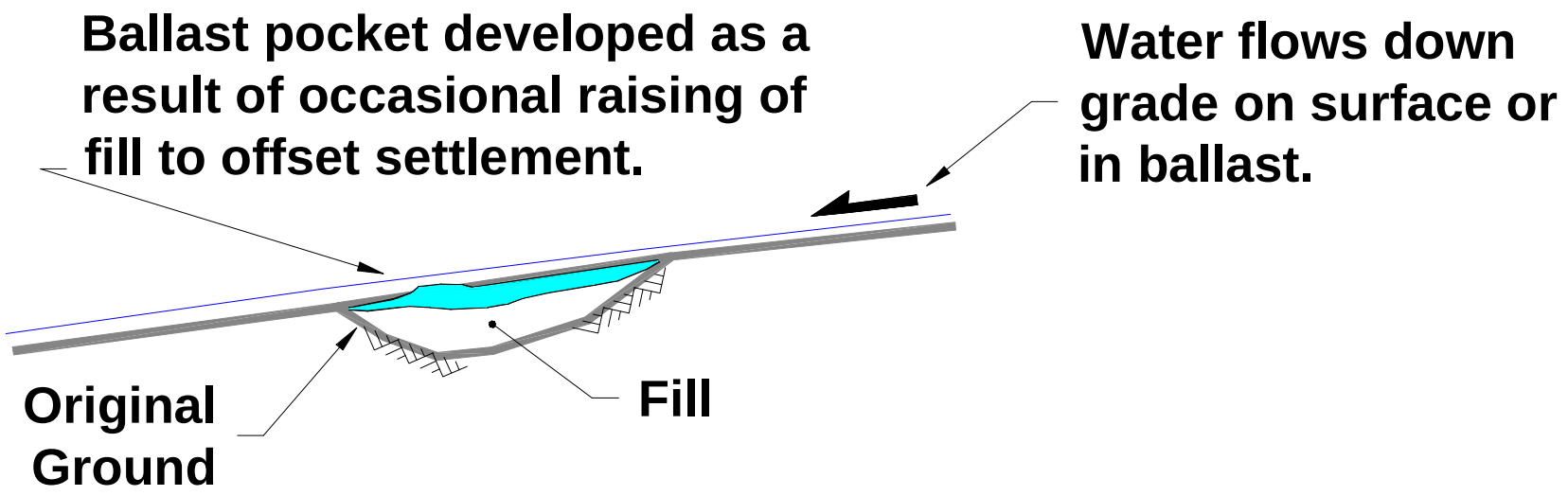
The Bottom of Sags in Vertical Curves (and Fill over Culverts)

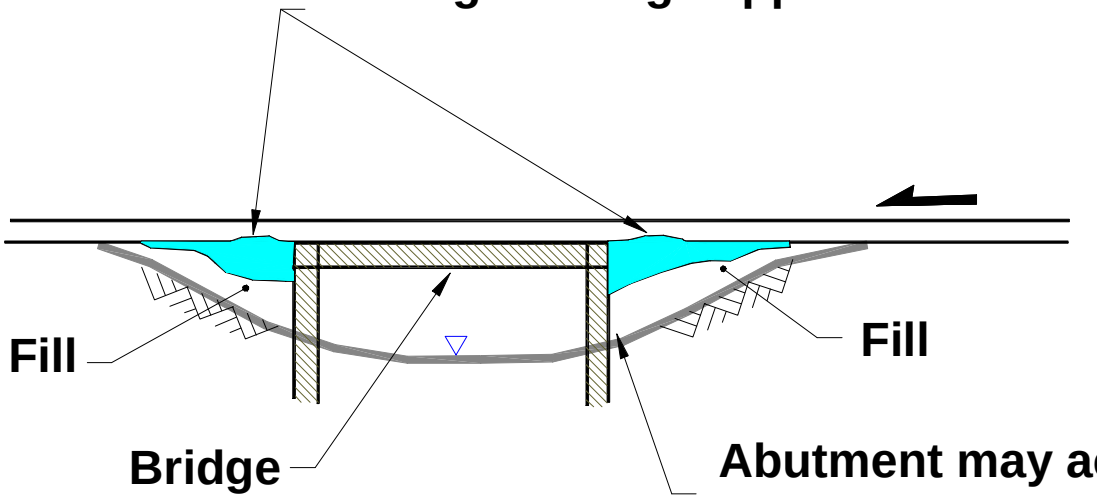


Fills


Ballast pocket developed as a result of occasional raising of fill to offset settlement.
Water flows down grade on surface or in ballast.
Original Ground
Fill

Bridge Approaches

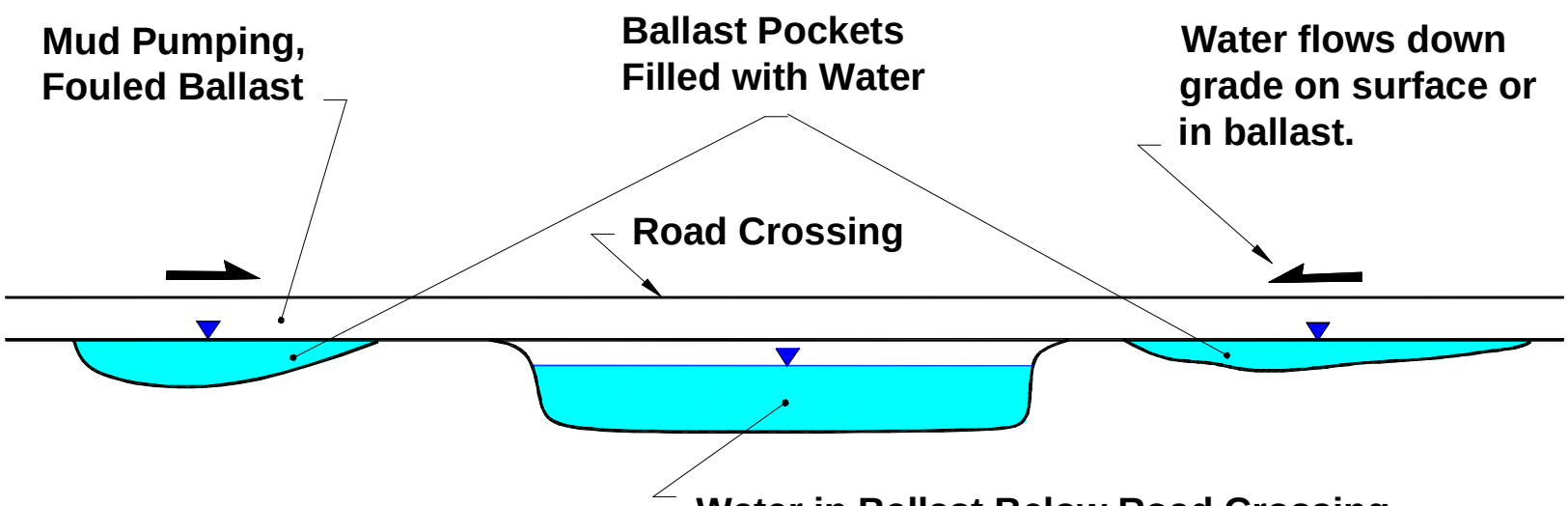
Ballast pocket developed as a result of occasional raising of bridge approach to offset settlement.



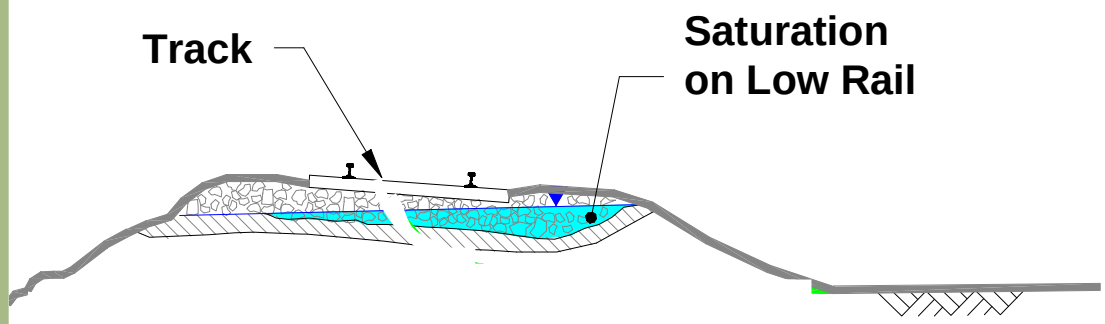
Track grade may slope toward abutment, permitting water to flow down ballast toward bridge approach fill.

Abutment may act as dam trapping water in ballast pocket or fill.

Road Crossings

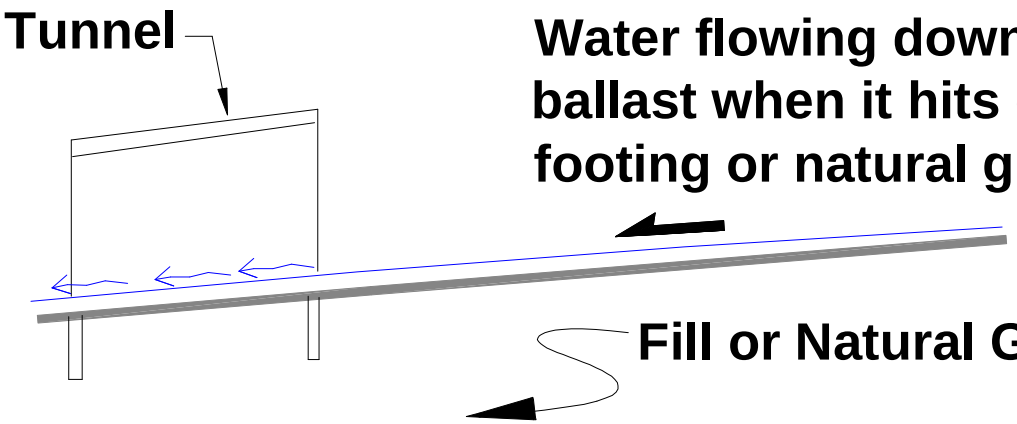


Low Rail on Superelevated Track



Superelevated track.
High loading on low rail.
Water trapped below low rail.
Track gains superelevation
with continued loading.

Upgrade of Tunnel Portals



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Where Should Trench Drains be Installed?

- Within the limits of a soft track area
- Upgrade of the affected area
- and …

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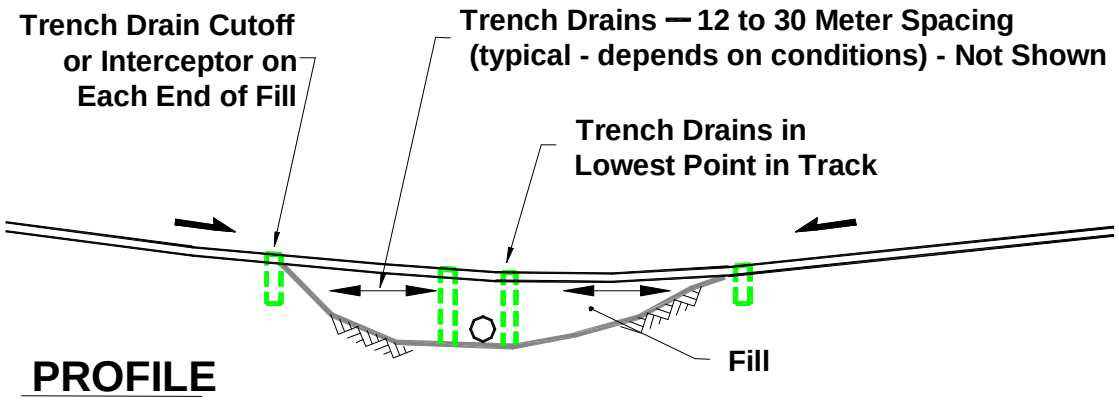
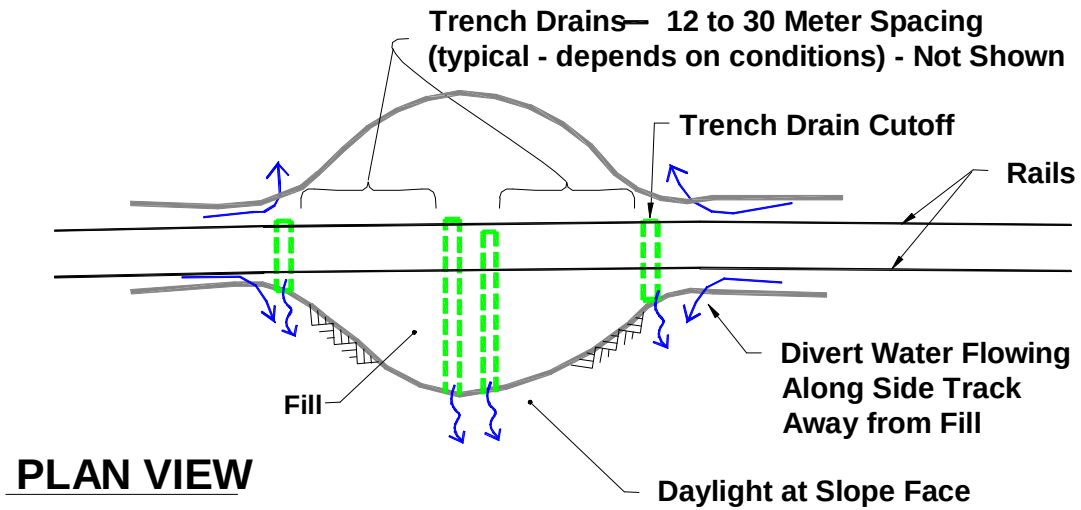
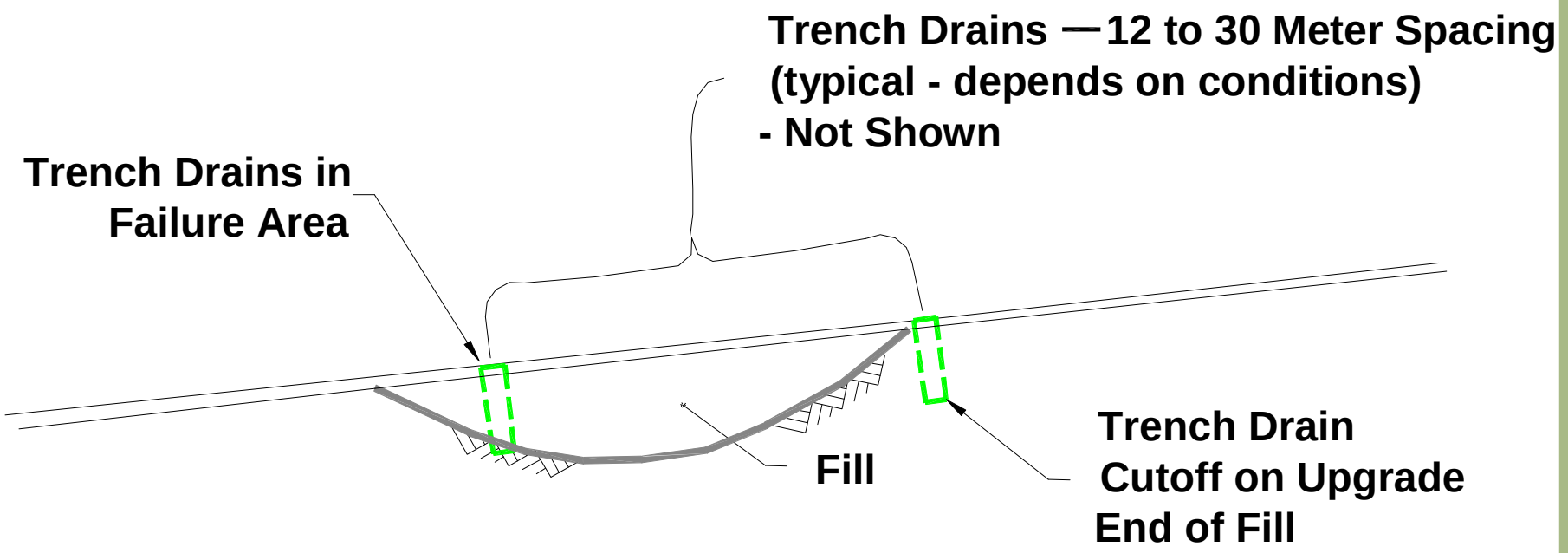
Drains in Vertical Curves

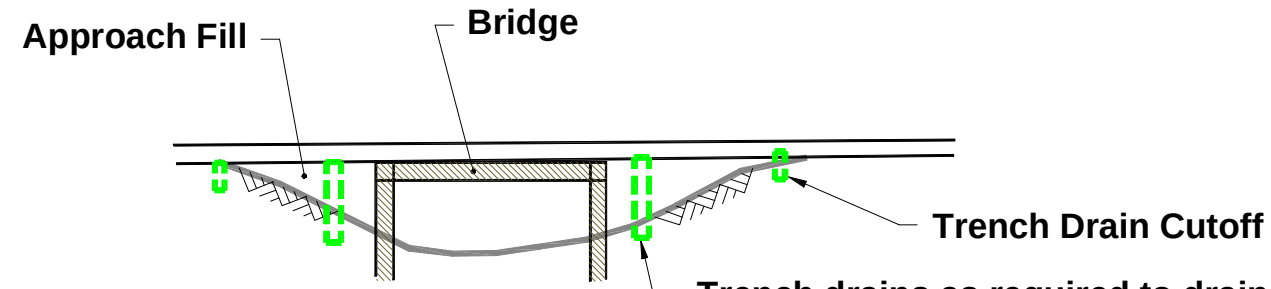




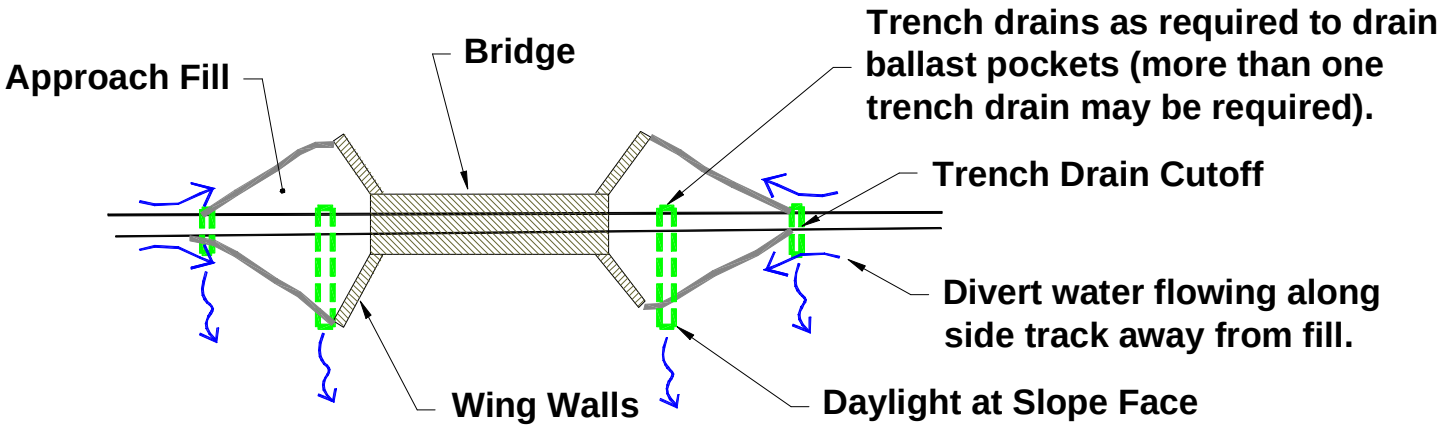
Drains in Fills



Drains at Bridge Approaches

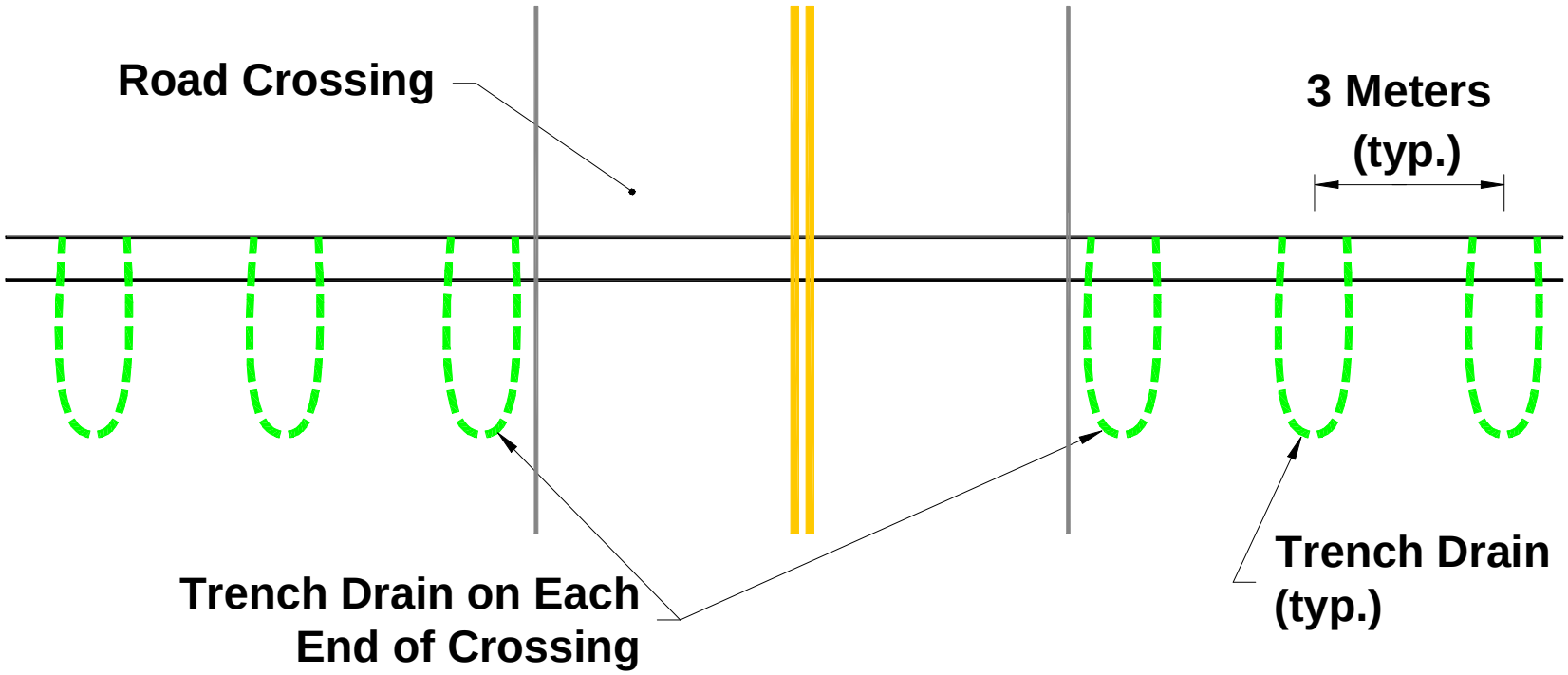


PROFILE



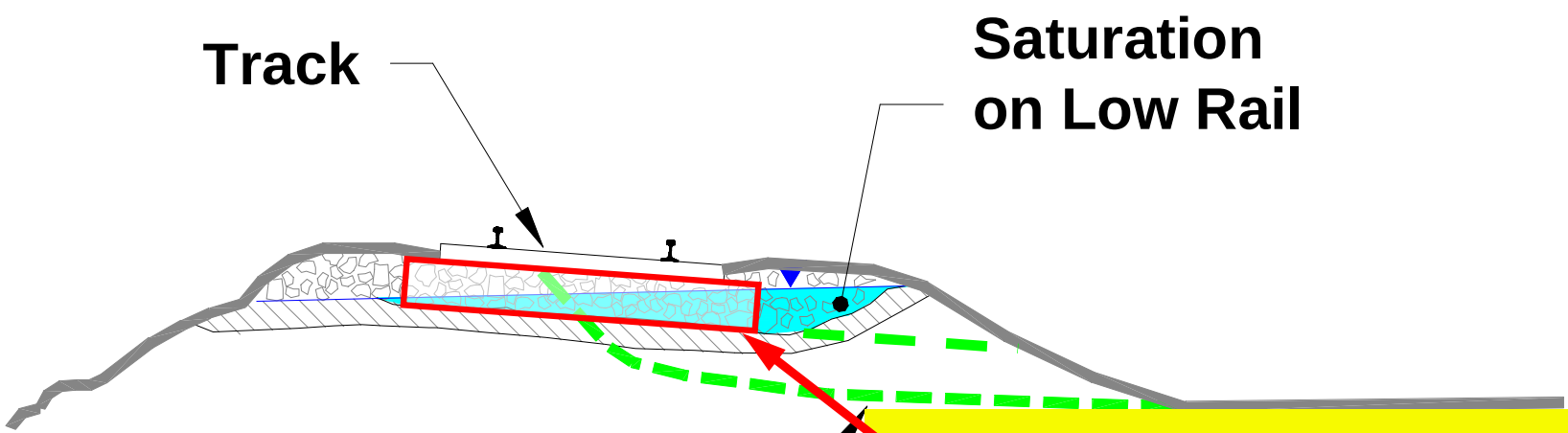
PLAN VIEW

Drains at Road Crossings



PLAN VIEW

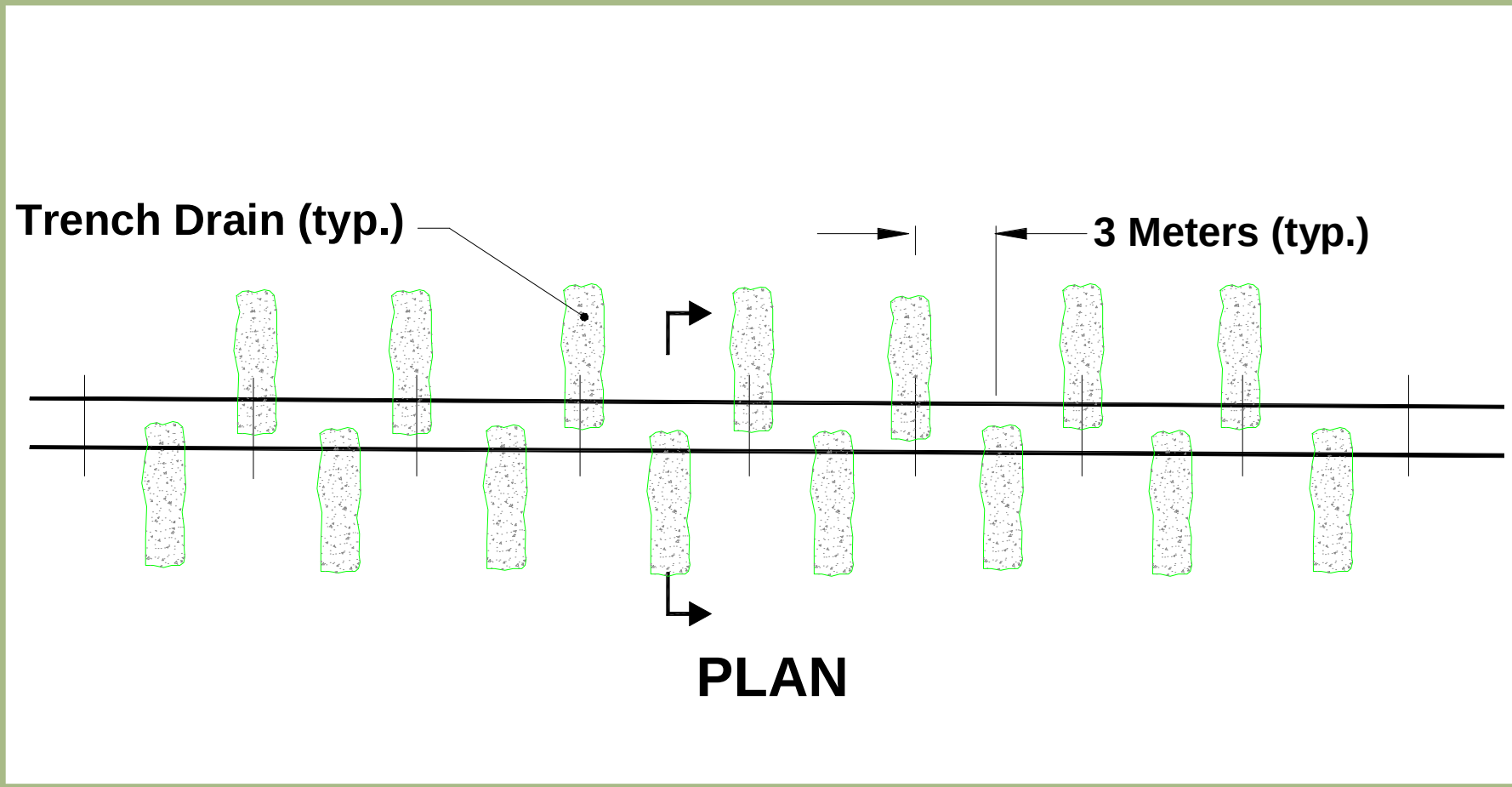
Drain in Superelevated Track



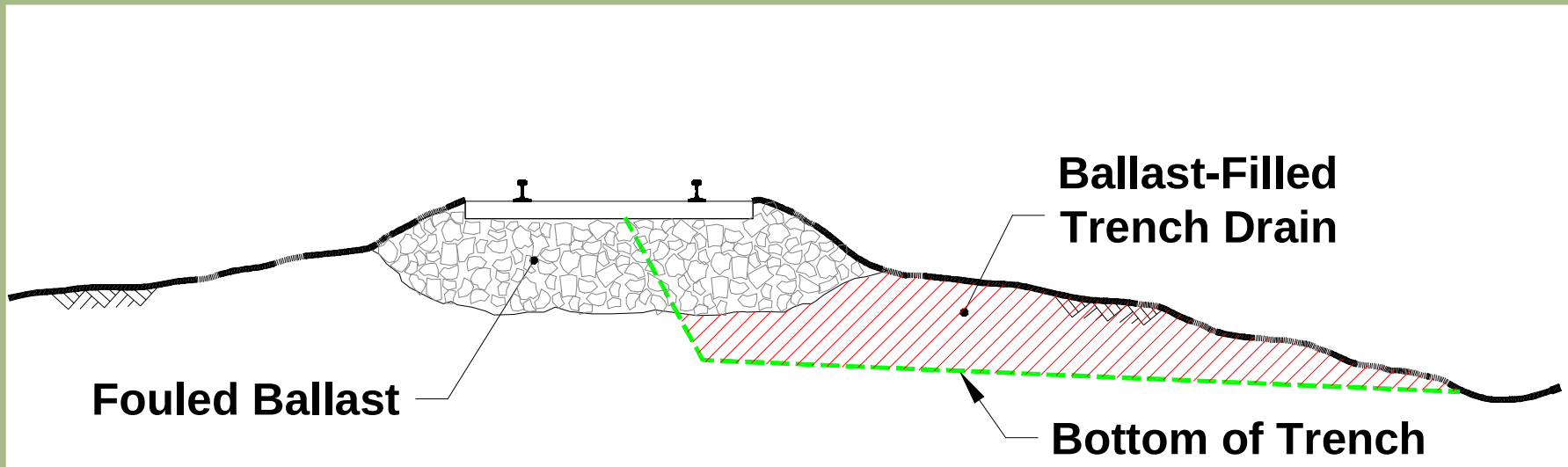
Undercutting does not solve drainage problem.

Cess should be cleaned when undercutting superelevated track

Example Trench Drain Spacing in Fouled Ballast or Low Embankment

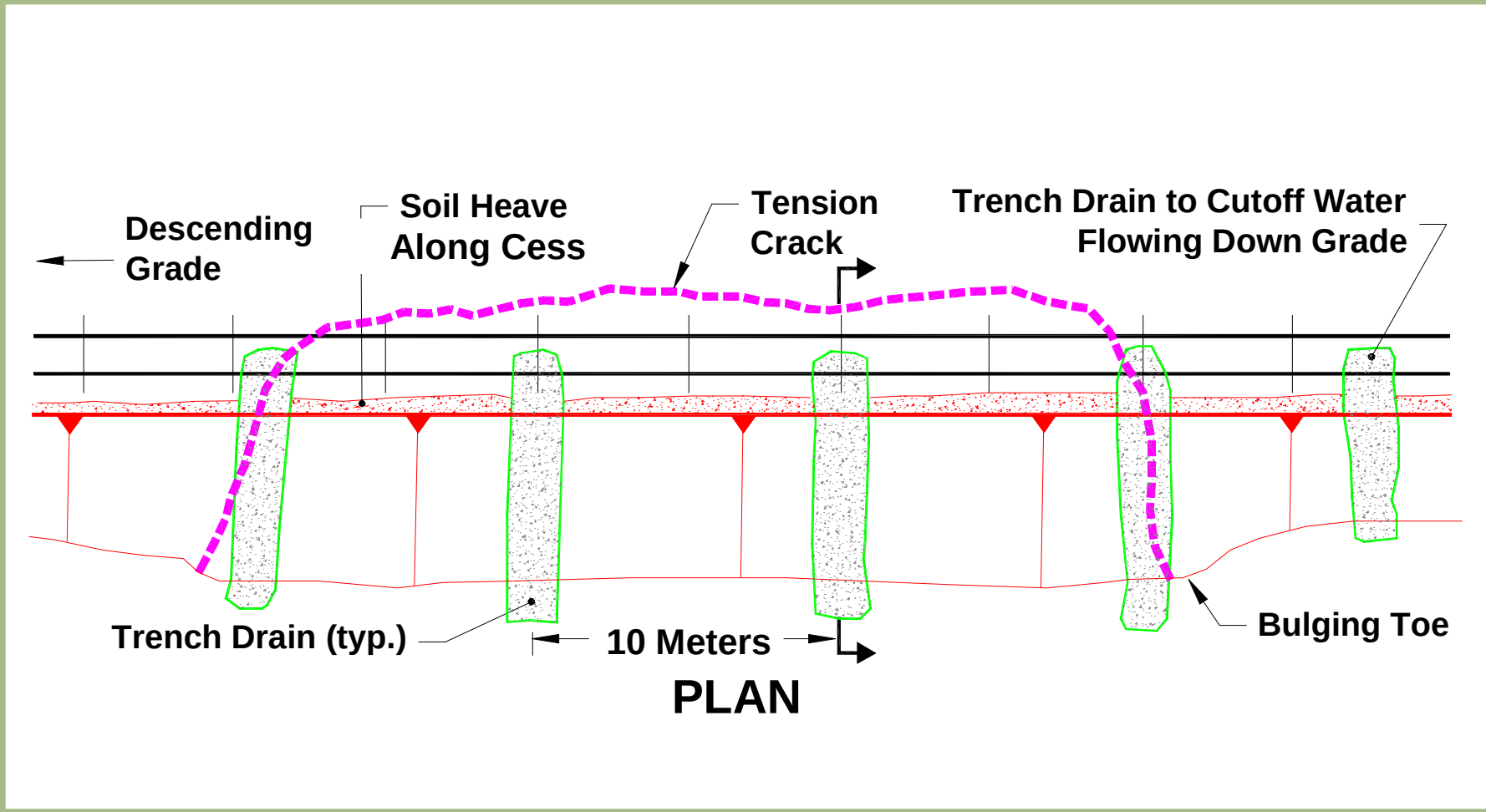


Generalized Cross Section through Trench Drain in Fouled Ballast or Low Embankment

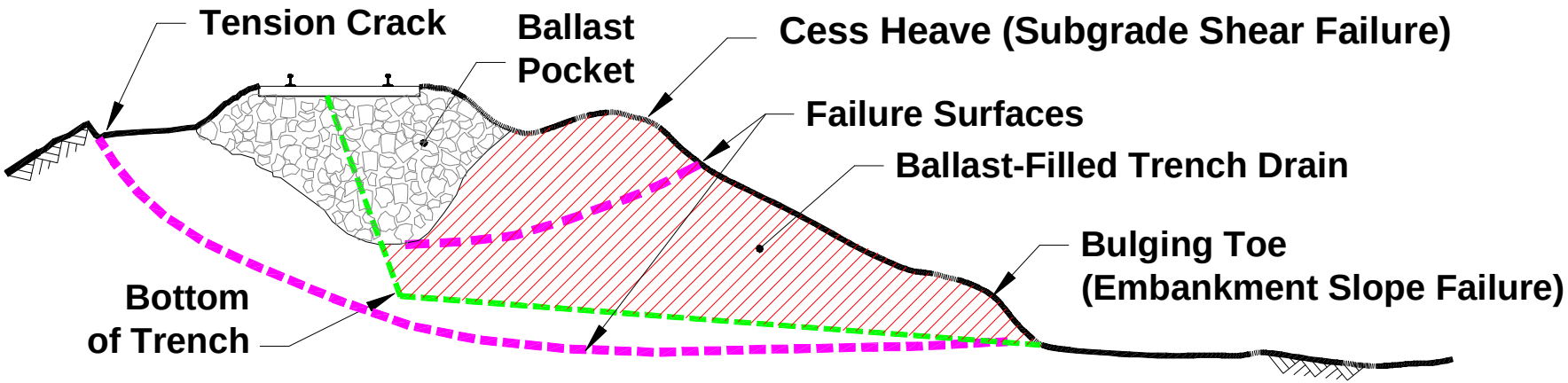


SECTION

Example Trench Drain Spacing in Higher Embankment



Generalized Cross Section of Trench Drain in Higher Embankment



SECTION

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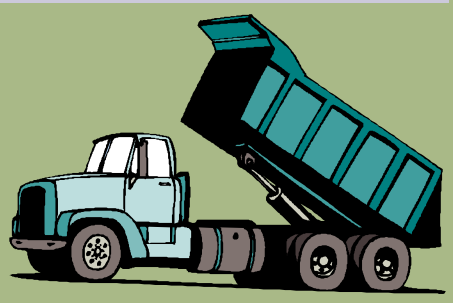
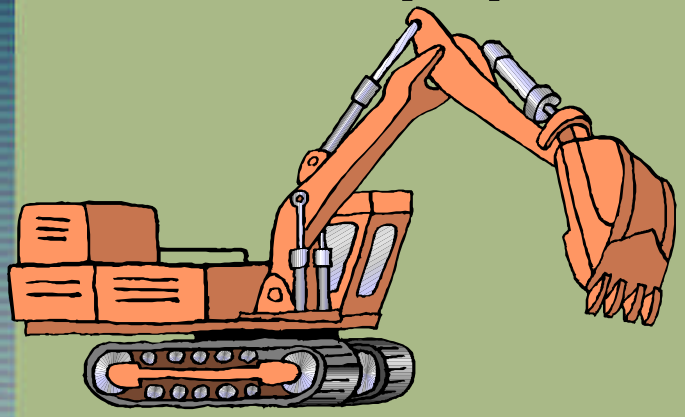
Trench Drain Construction is Simple



… it does not require special equipment or materials …



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Ballast Stockpiled on Site

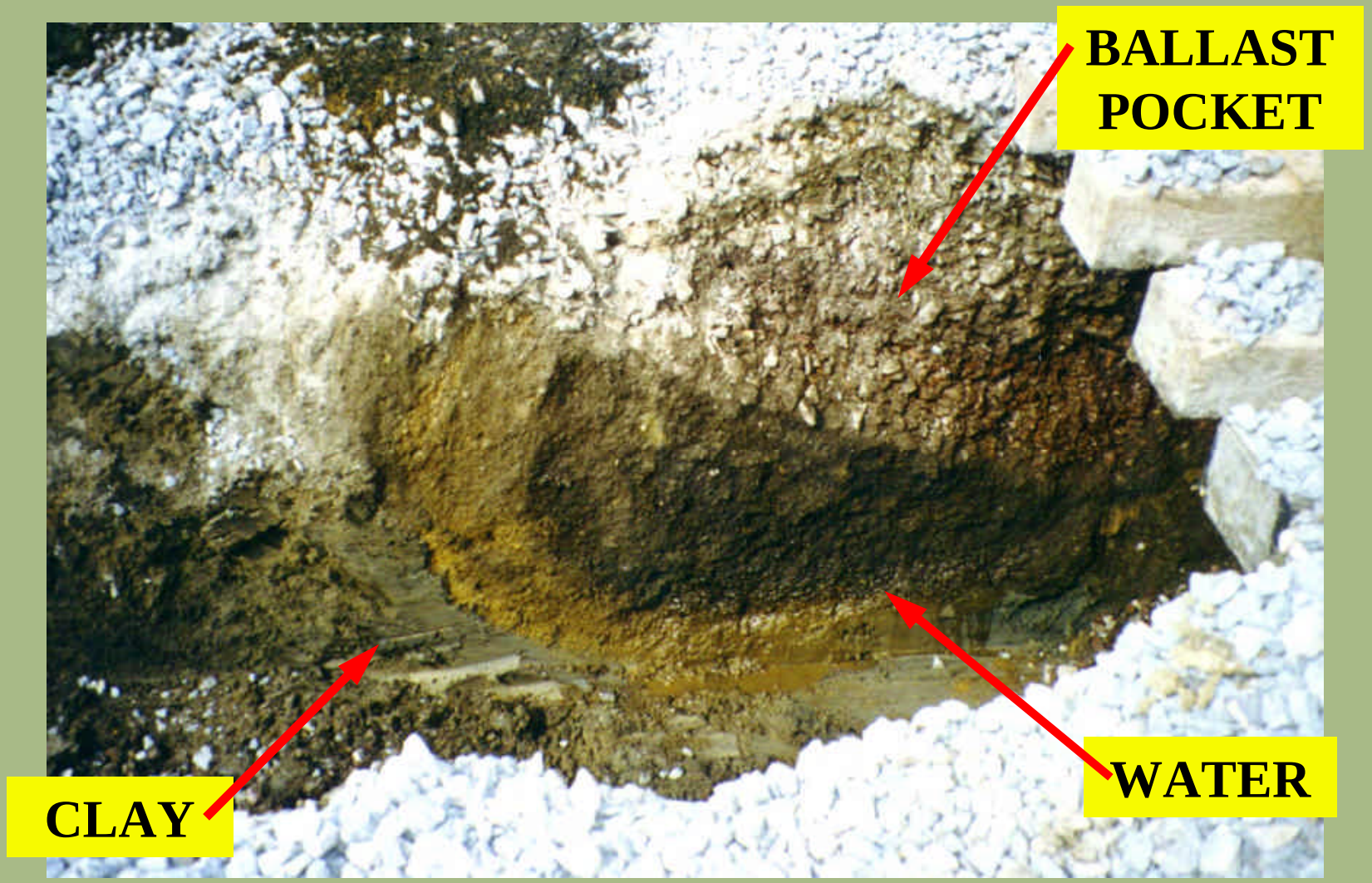
Starting Trench Drain in Low Embankment

Starting Drain in Higher Embankment

Extending Drain to Toe of Slope

Water Flowing from Ballast Pocket

Water Flowing from Ballast Pocket



Slope Drain away from Embankment

Water Flowing Down Trench

Trench Daylighted at Toe of Slope

*** PERMITS ***

Open Ditch Extended to Drain Water

Open Ditch Extended to Drain Water

Non-Perforated Drain Pipe to Carry Water Collected in the Trench Drains to a Discharge Point Away from the Track

Loader Backfilling a Trench Drain

Loader Backfilling a Trench Drain

Bulldozer Backfilling a Trench Drain

Bulldozer Backfilling a Trench Drain

Ballast Wagon used to Backfill Trench Drain

Trench Backfill Nearing Completion

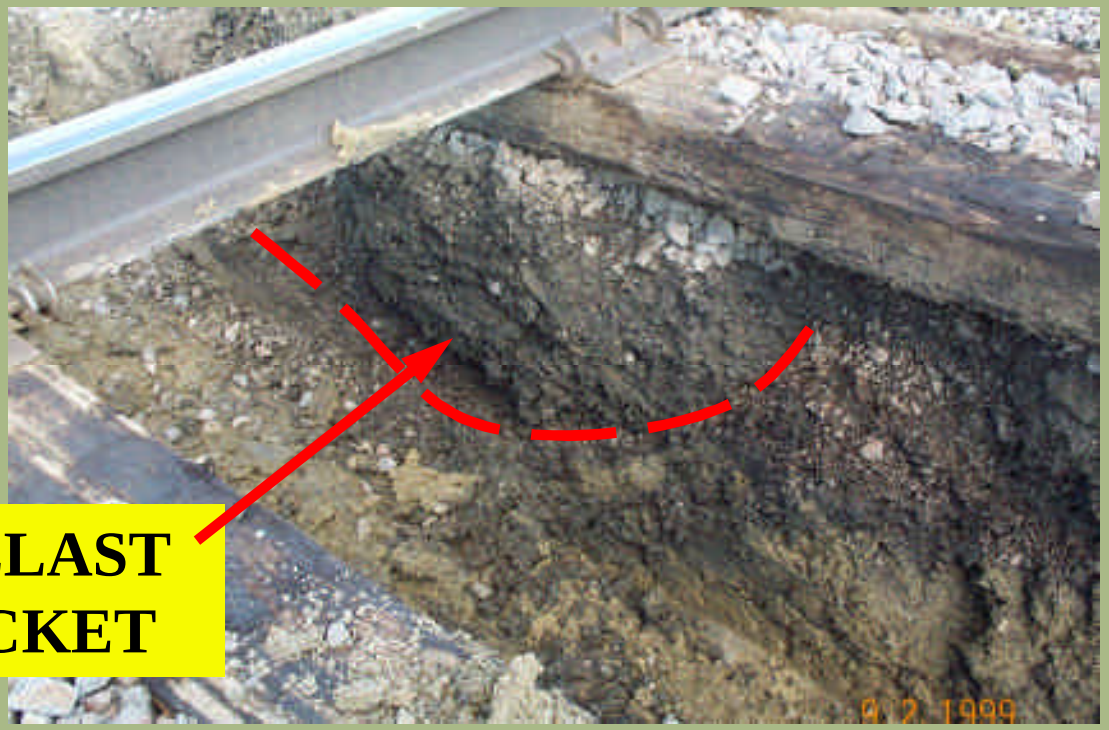
Trench Spoil Used to Flatten Slope

Trench Drains can also be used for Draining Fouled Ballast

Shallow Trench Through Fouled Ballast

Series of Closely Spaced Trench Drains

Observation of Soils Exposed in Trenches Can Provide Clues about the Failure Mode and the Required Depth and Spacing for Trench Drains



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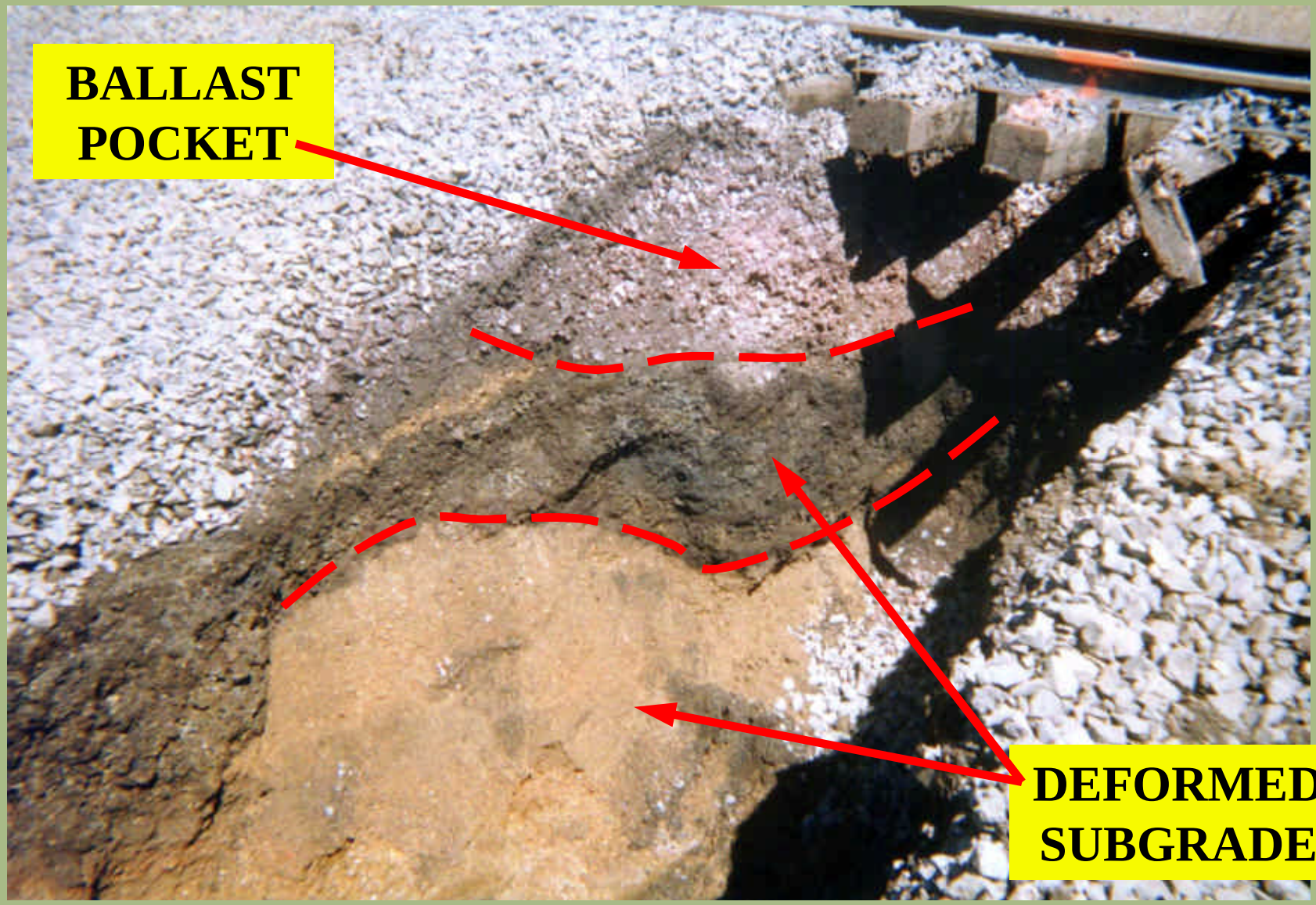
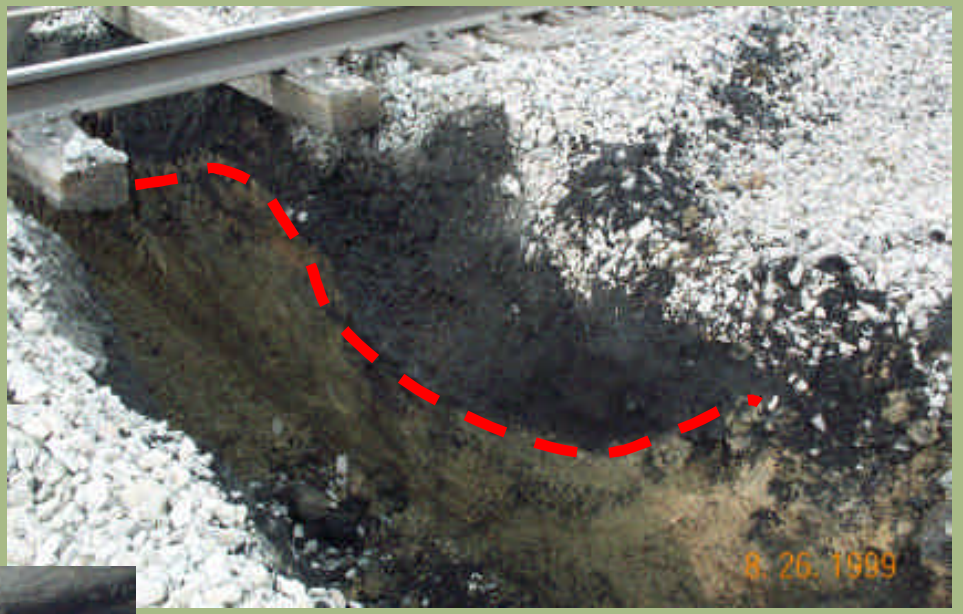
Typical Subgrade Condition



Ballast Pocket Under Each Rail

More Examples …



A sampling of Cross Sections through Actual Embankments in which Trench Drains were Installed

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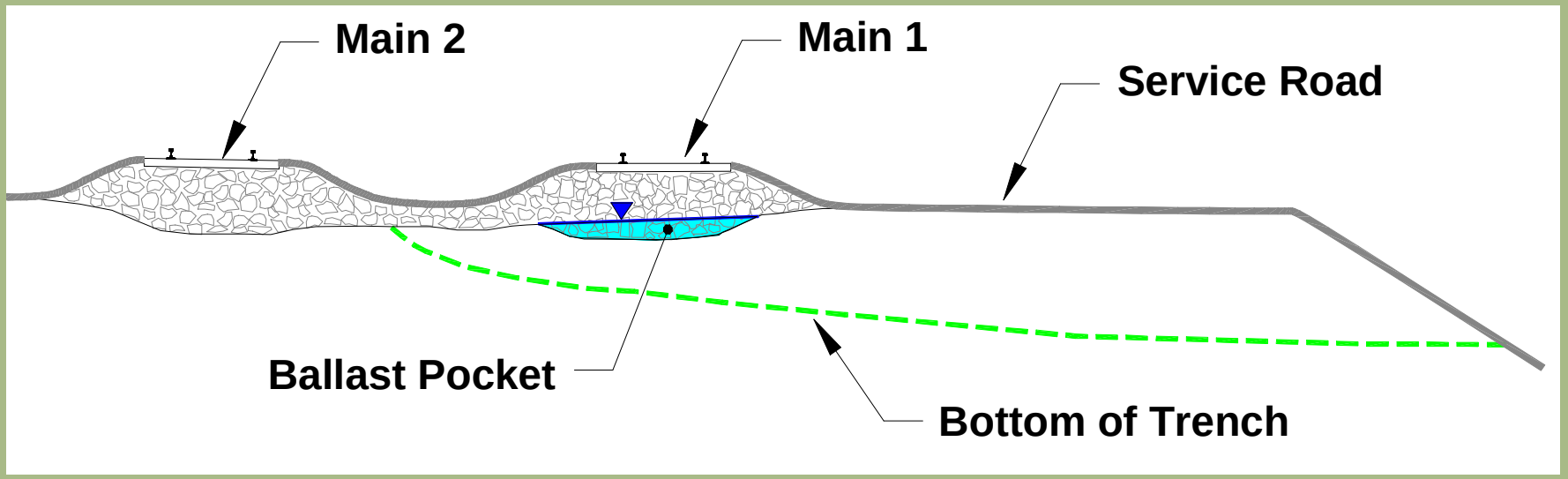
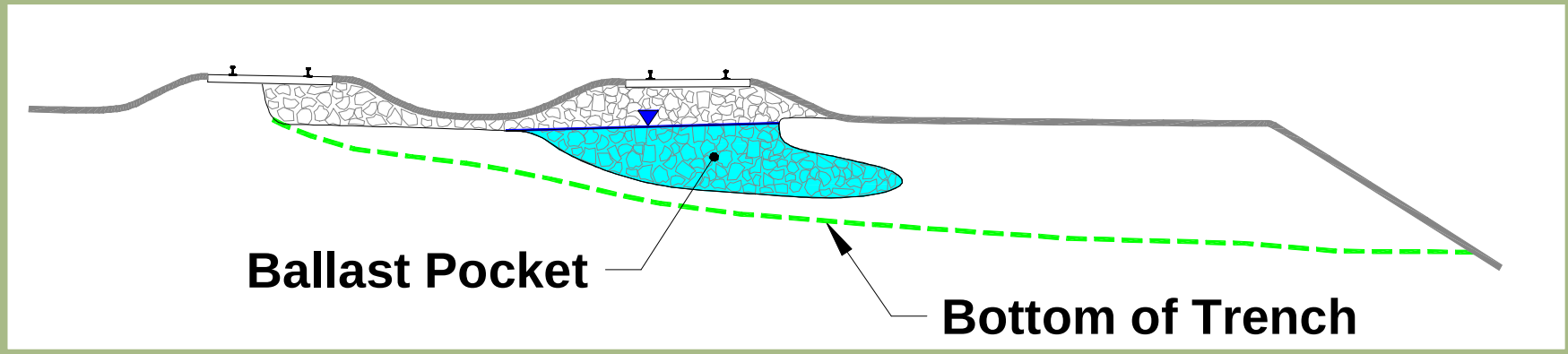
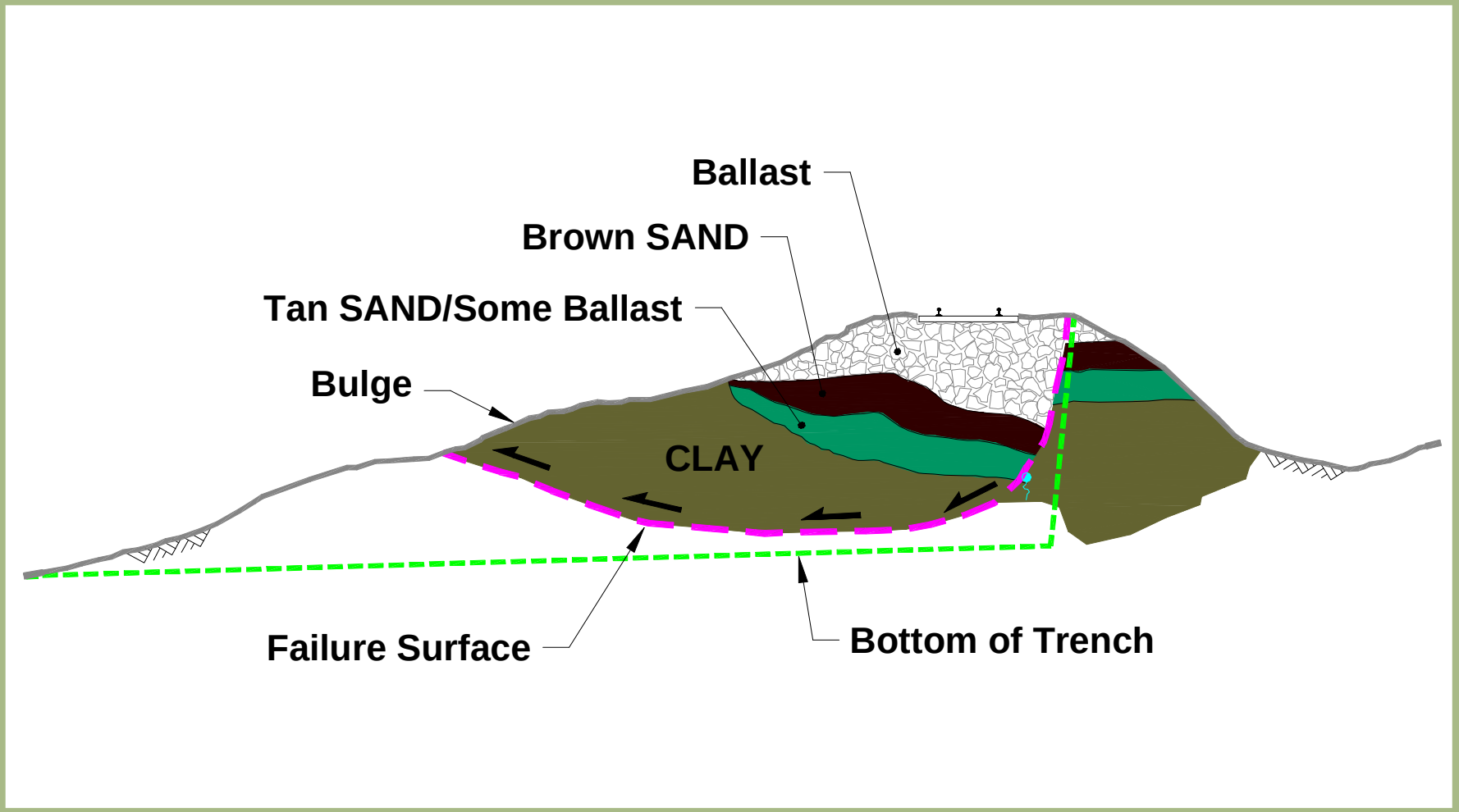
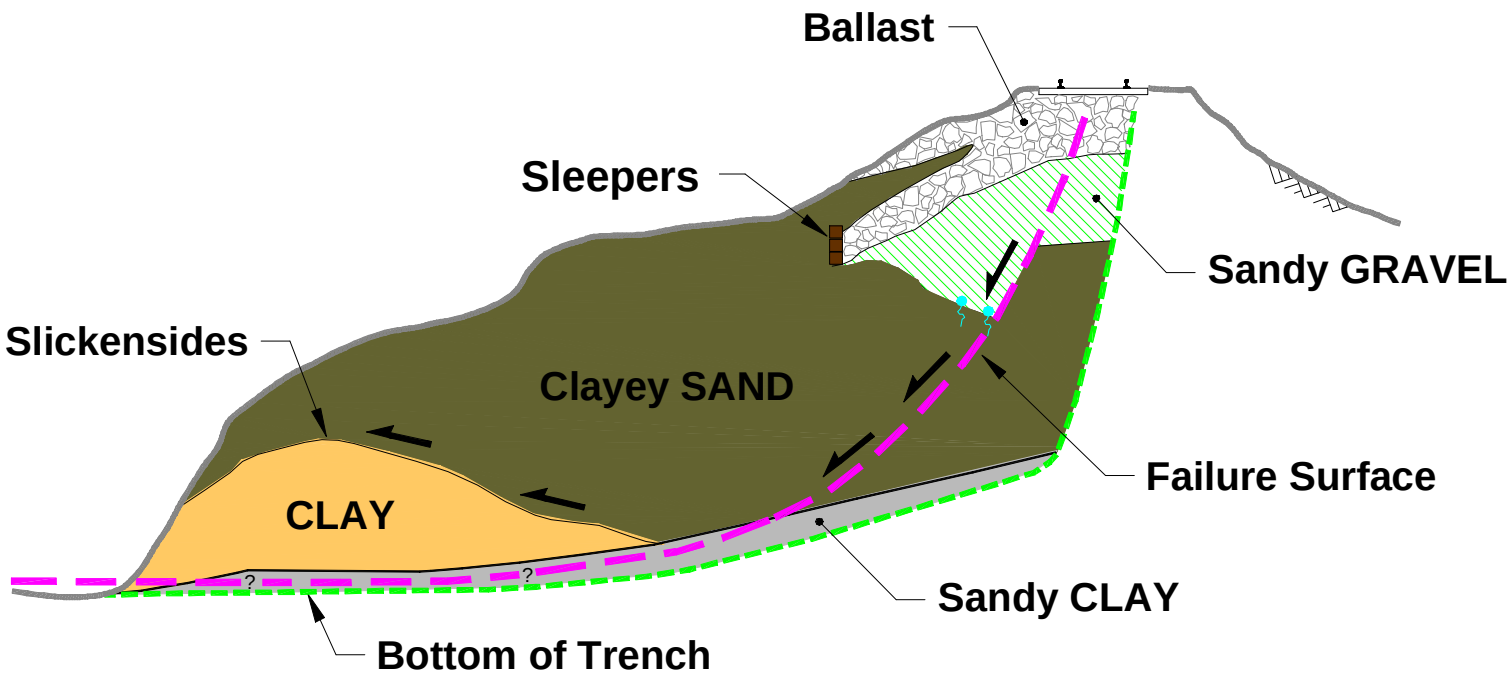


Ballast pocket in area that has experienced little ground movement

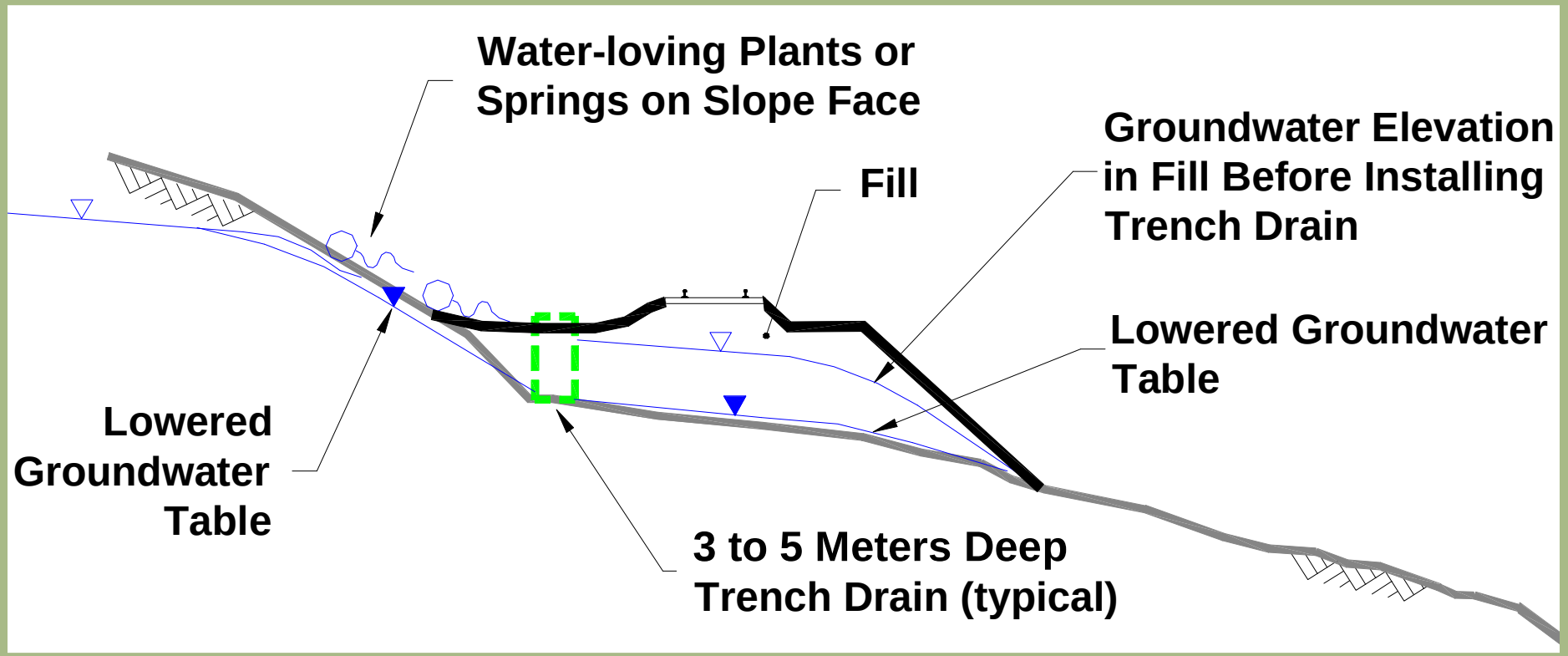


… and in area that has experienced significant ground movement

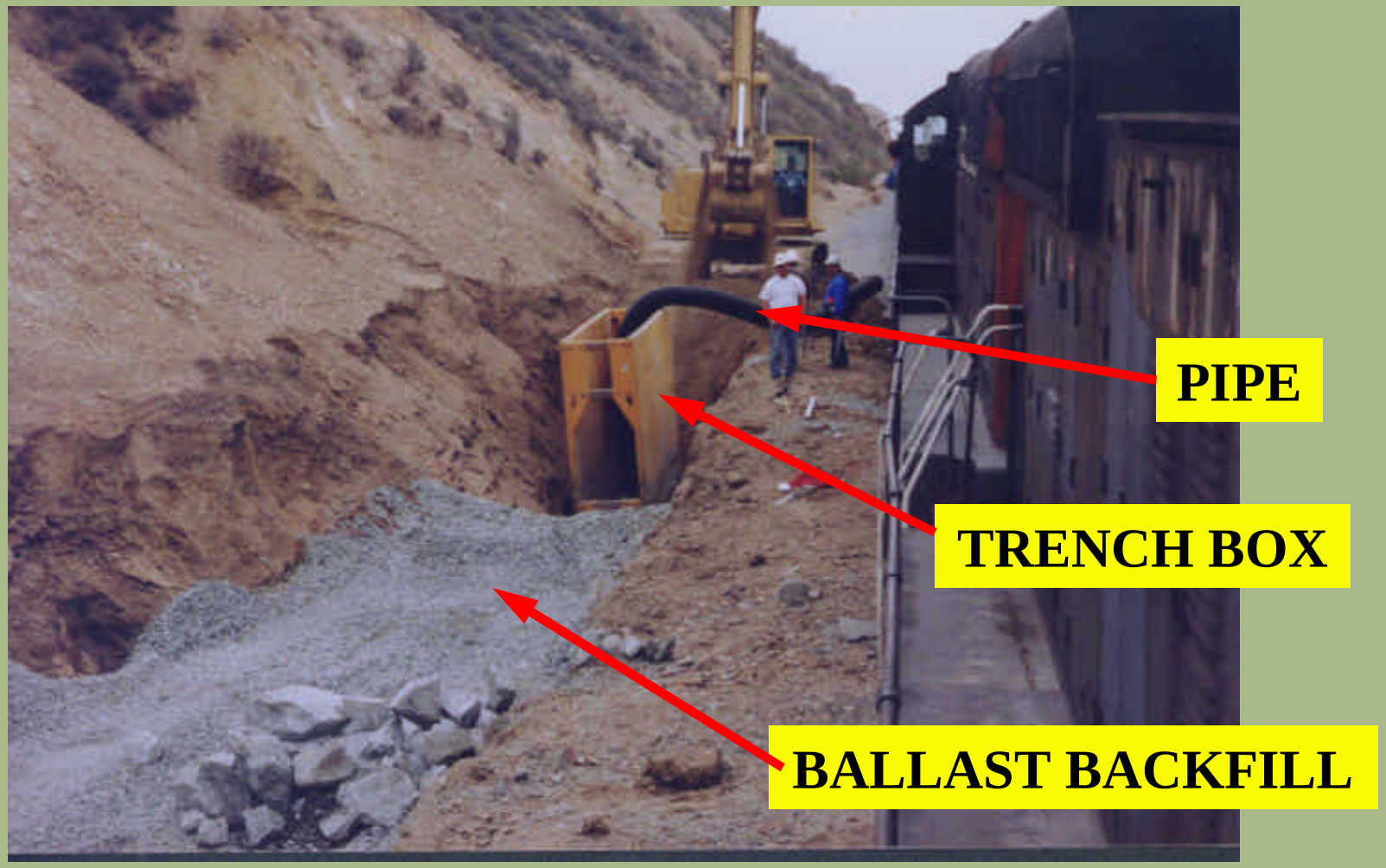

Ballast
Brown SAND
Tan SAND/Some Ballast
Bulge
CLAY
Failure Surface
Bottom of Trench


Ballast
Sleepers
Sandy GRAVEL
Slickensides
Clayey SAND
Failure Surface
CLAY
Sandy CLAY
Bottom of Trench

Trench Drains may also be Constructed Outside the Track Limits to Intercept Groundwater Flowing toward the Track



Trench Drain to Intercept Groundwater Flowing Toward Track



Pipes Daylight to Existing Ditch

MP 478.8 Marion, Arkansas
May 1995

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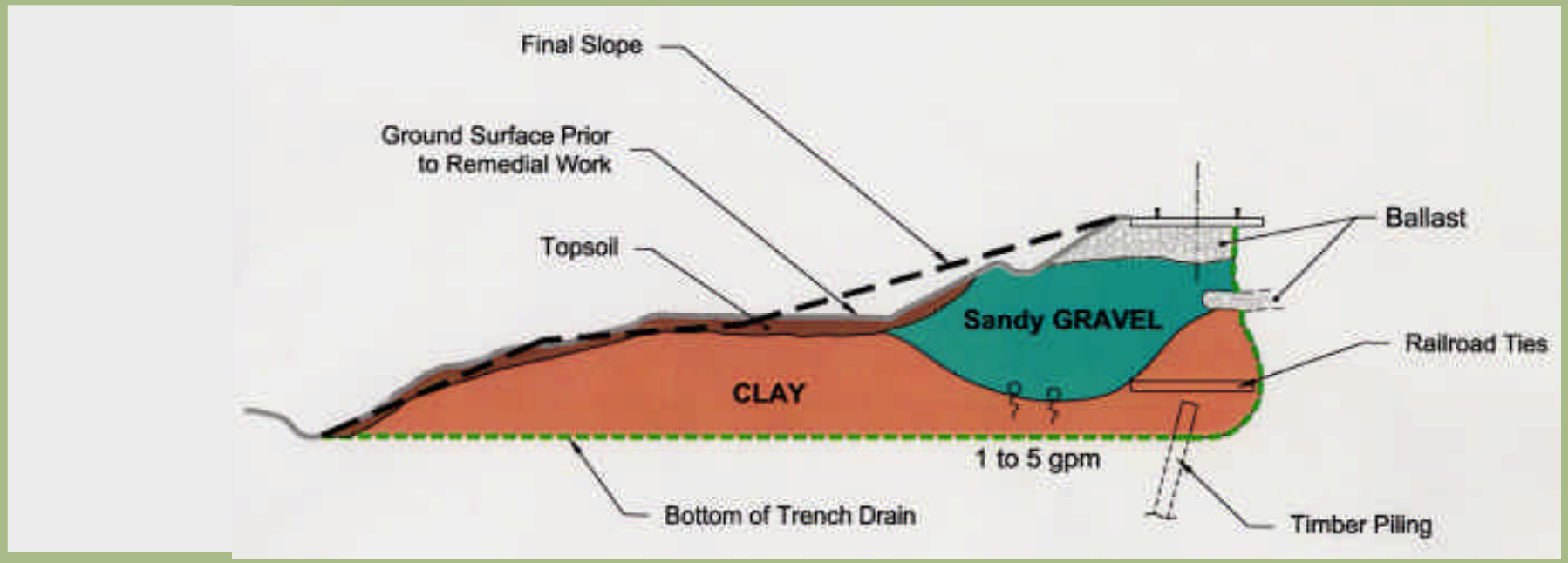
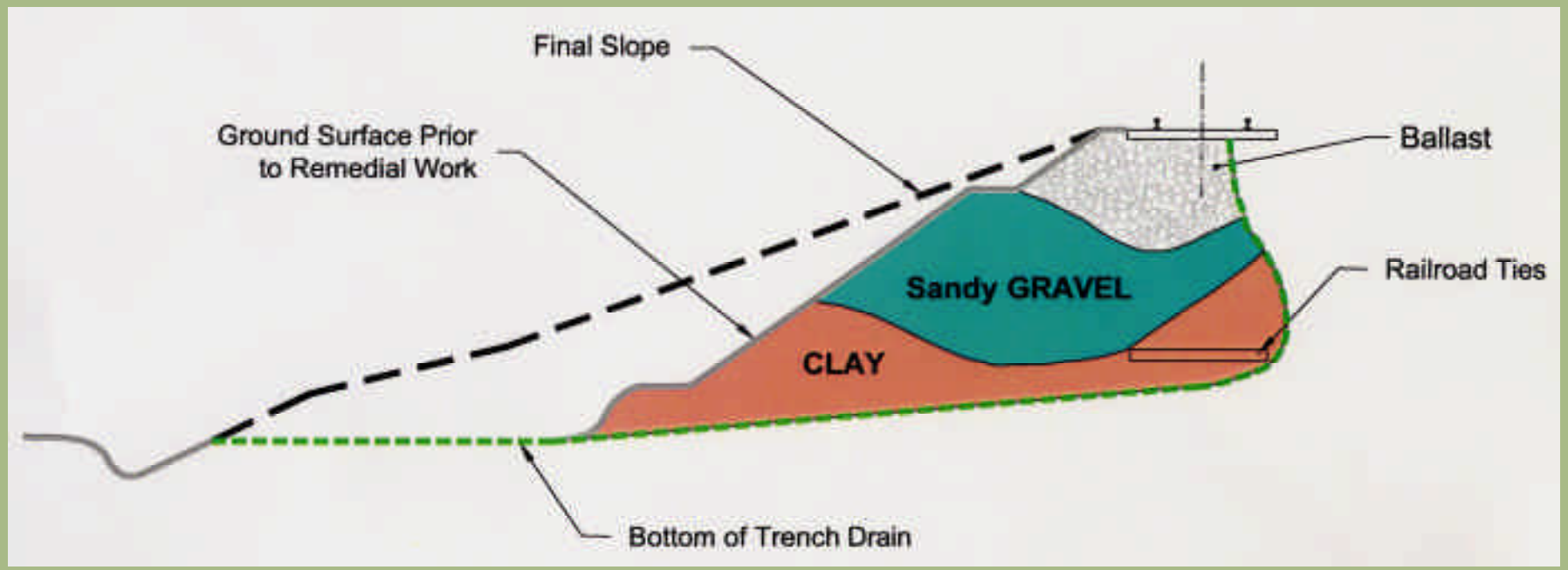

Final Slope
Ground Surface Prior
to Remedial Work
Topsoil
Ballast
Sandy GRAVEL
Railroad Ties
CLAY
1 to 5 gpm
Bottom of Trench Drain
Timber Piling


Final Slope
Ground Surface Prior
to Remedial Work
Ballast
Sandy GRAVEL
Railroad Ties
CLAY
Bottom of Trench Drain

Trench drain excavated


Water drained
from ballast
pocket and fill

Trench drain backfilled with ballast

Slope flattened

Trench Drain Construction Tips

- Orient drains perpendicular to the track (for drains beneath the track)
- Bottom 300 to 450 millimeters below the bottom of the ballast pocket
- Bottom sloped to drain
- Daylight trench at the toe of slope
- Extend trench beneath both rails
- Space trenches based on site conditions

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Preparation

- Stockpile Ballast on Site in Advance
- Have Extra Material Available
- Arrange for Track Time
- Be Prepared to Modify Program during Construction

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Cess Heave

… a common occurrence in low embankments …

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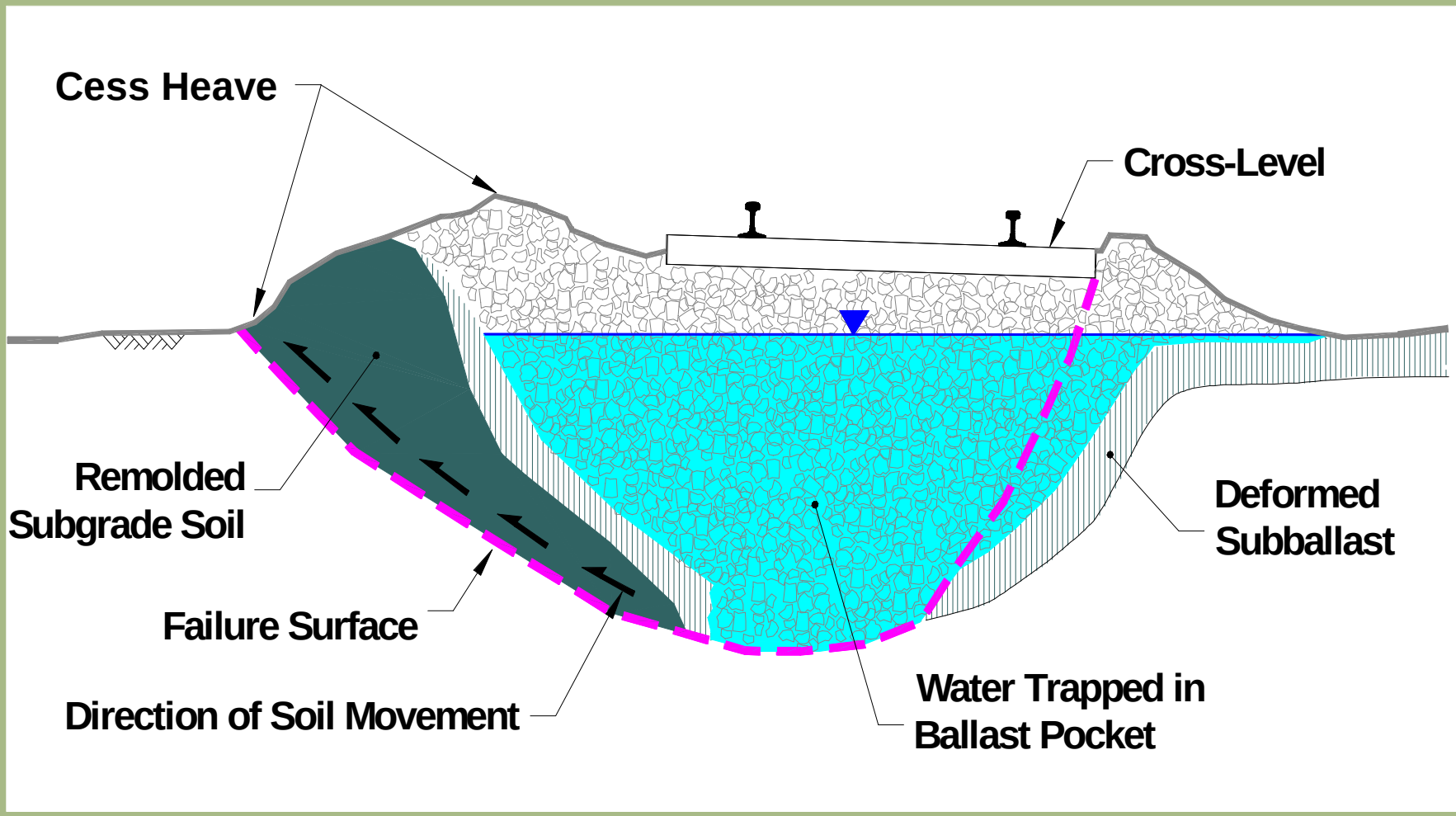
Example of Track with Heaved Cess

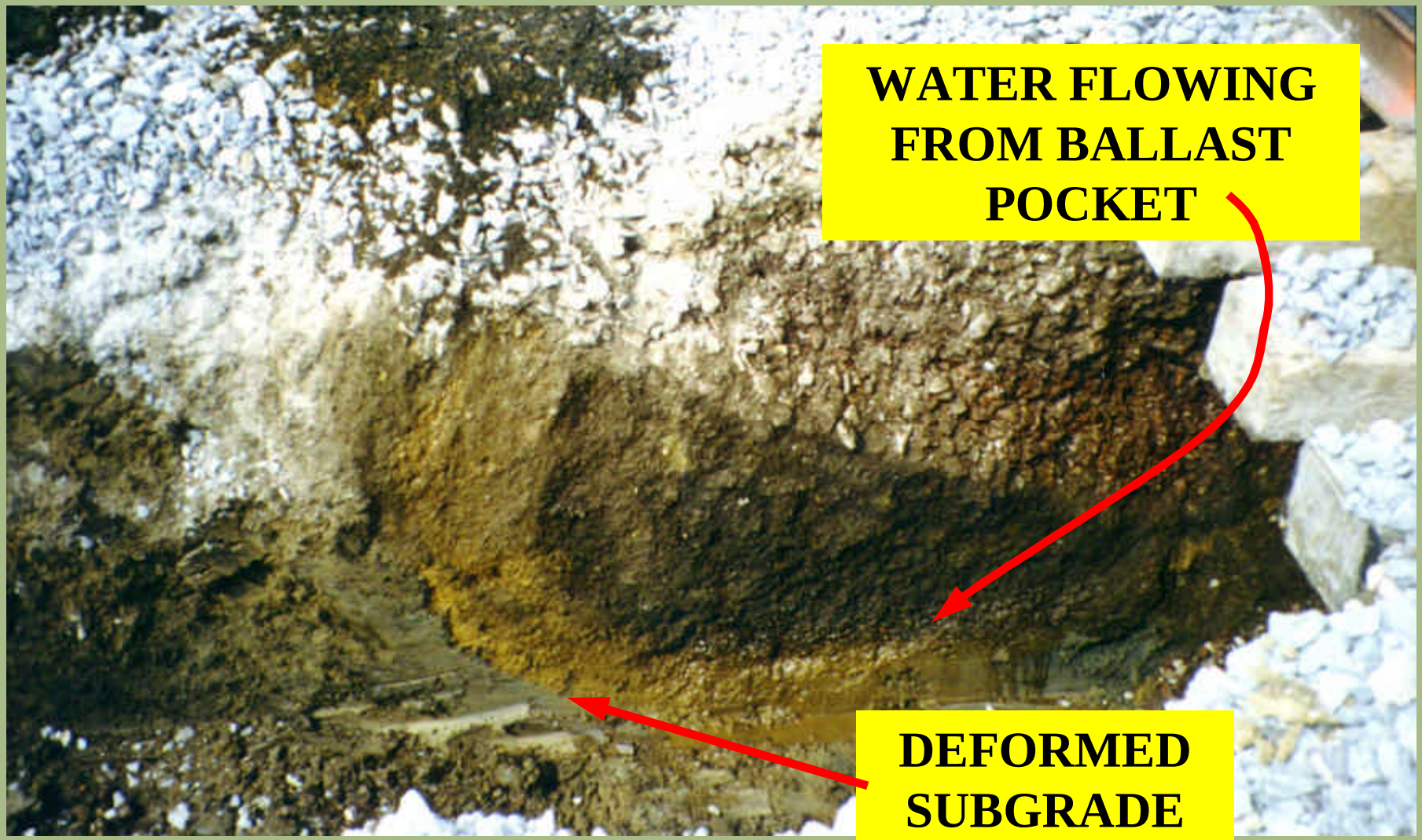
Cracks in Heaved Cess

Heaved Cess

Typical Cross Section through Embankment with Heaved Cess



Trench through Heaved Cess



Trench through Heaved Cess

Cess Heave Repair

- Install closely spaced trench drains
- Construct shear keys
- Replace subgrade soils
- Make sure water will drain from shear key backfill

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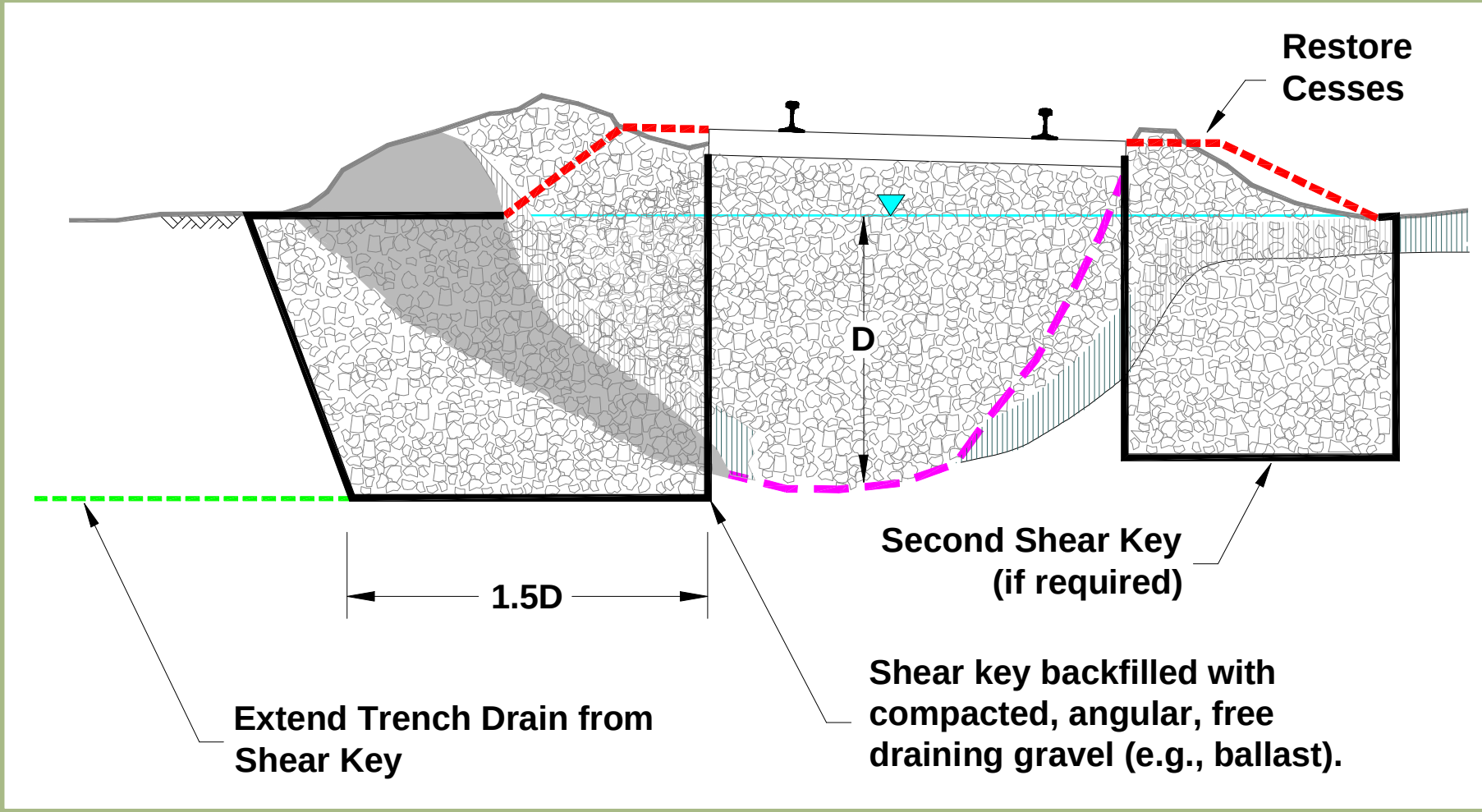
Cross Section Through Shear Key
Repair of Heaved Cess



Cutting Shear Key with Loader

Trench Cut for Shear Key

Backfilling Shear Key with Ballast

Constructing a shear key on one side of the track may create a new failure toward the other side of the track.

Summary

- Water within the embankment and within ballast pockets contributes to soft track conditions
- Trench drains are an inexpensive and effective means for draining this water and improving track performance

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Summary - Trench Drains

- DO install drains as soon as practical
- DO excavate drain bottoms 300 to 450 millimeters below the ballast pocket
- DO extend drains beneath both rails
- DO install drains within and upgrade of soft track areas

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Summary
(continued)

- DO vary drain spacing and depth based on site conditions
- DO daylight drains at the toe of slope, or use surface ditches or pipes
- DO keep a record of where the drains are installed
- DO NOT enter trenches

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Summary - Shear Keys

Shear keys may be appropriate for treating cess heave

- **DO install drains to remove water from shear key backfill**
- **DO get assistance**
- **DO NOT undercut the embankment**

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WATER

… is the problem …

DRAINAGE

DRAINAGE

DRAINAGE

… is the solution …

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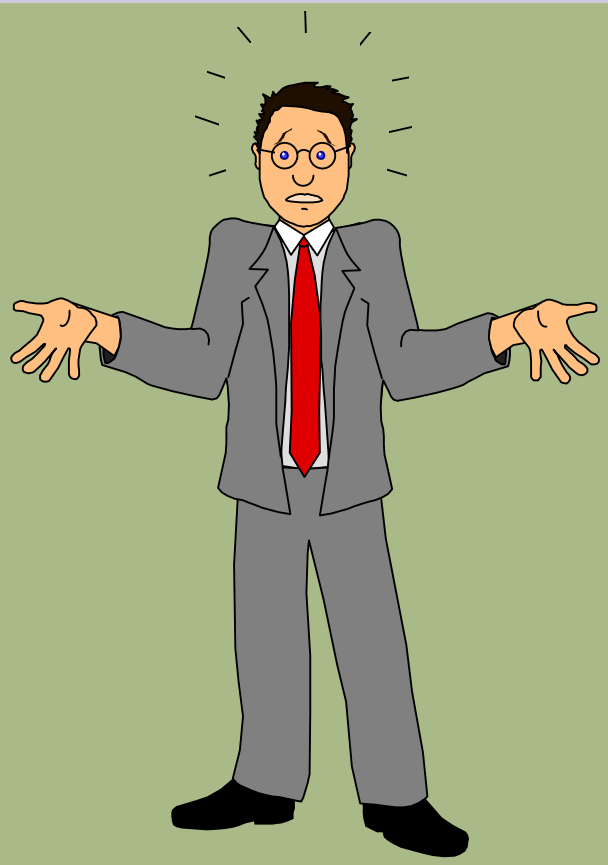
Get the Help of a Geotechnical Engineer When Appropriate



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