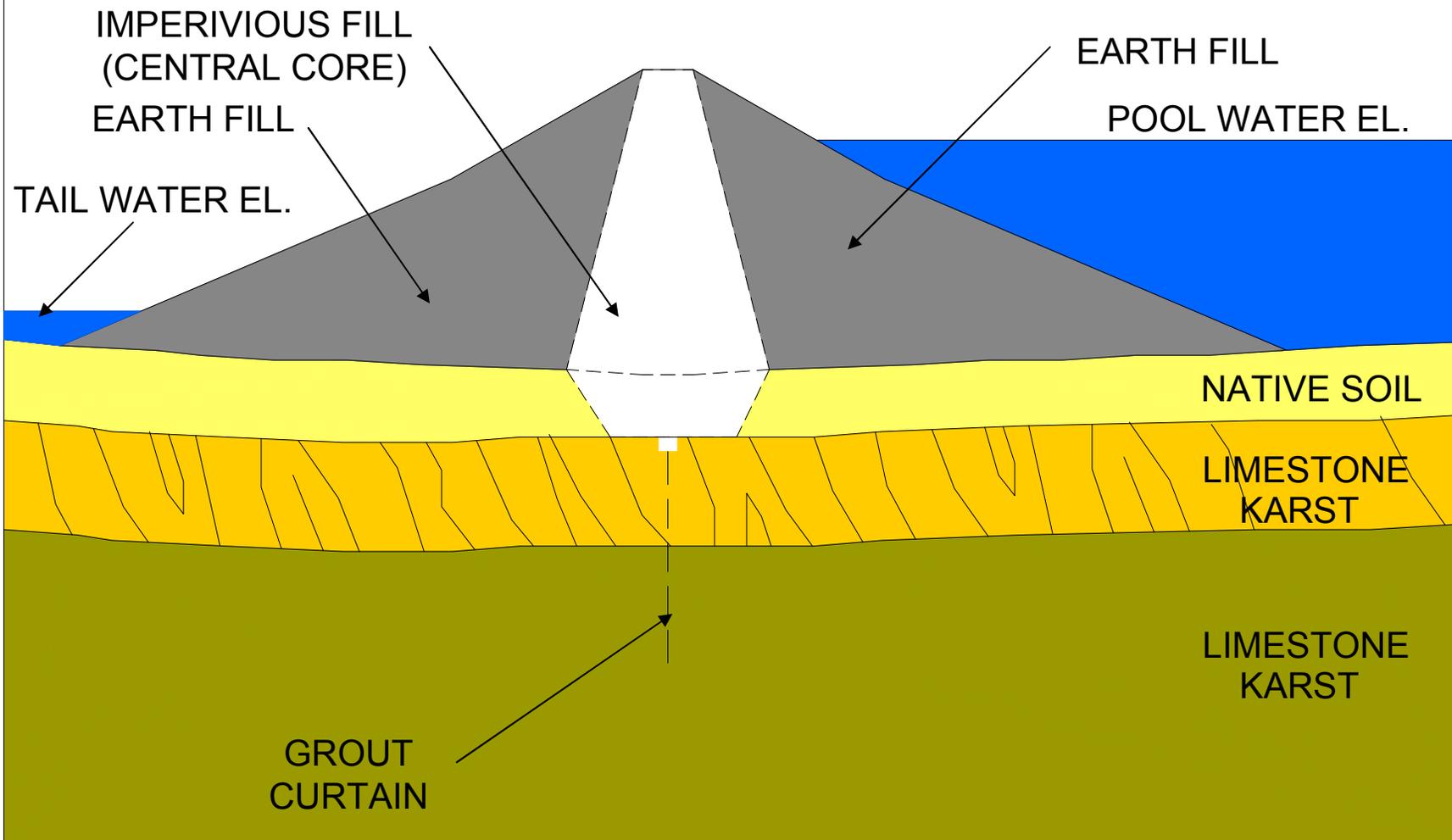


SPECIALTY DRILLING, TESTING, AND GROUTING TECHNIQUES FOR REMEDIATION OF EMBANKMENT DAMS

**Presented By: Douglas M. Heenan, P.Eng
Advanced Construction Techniques, Ltd.**



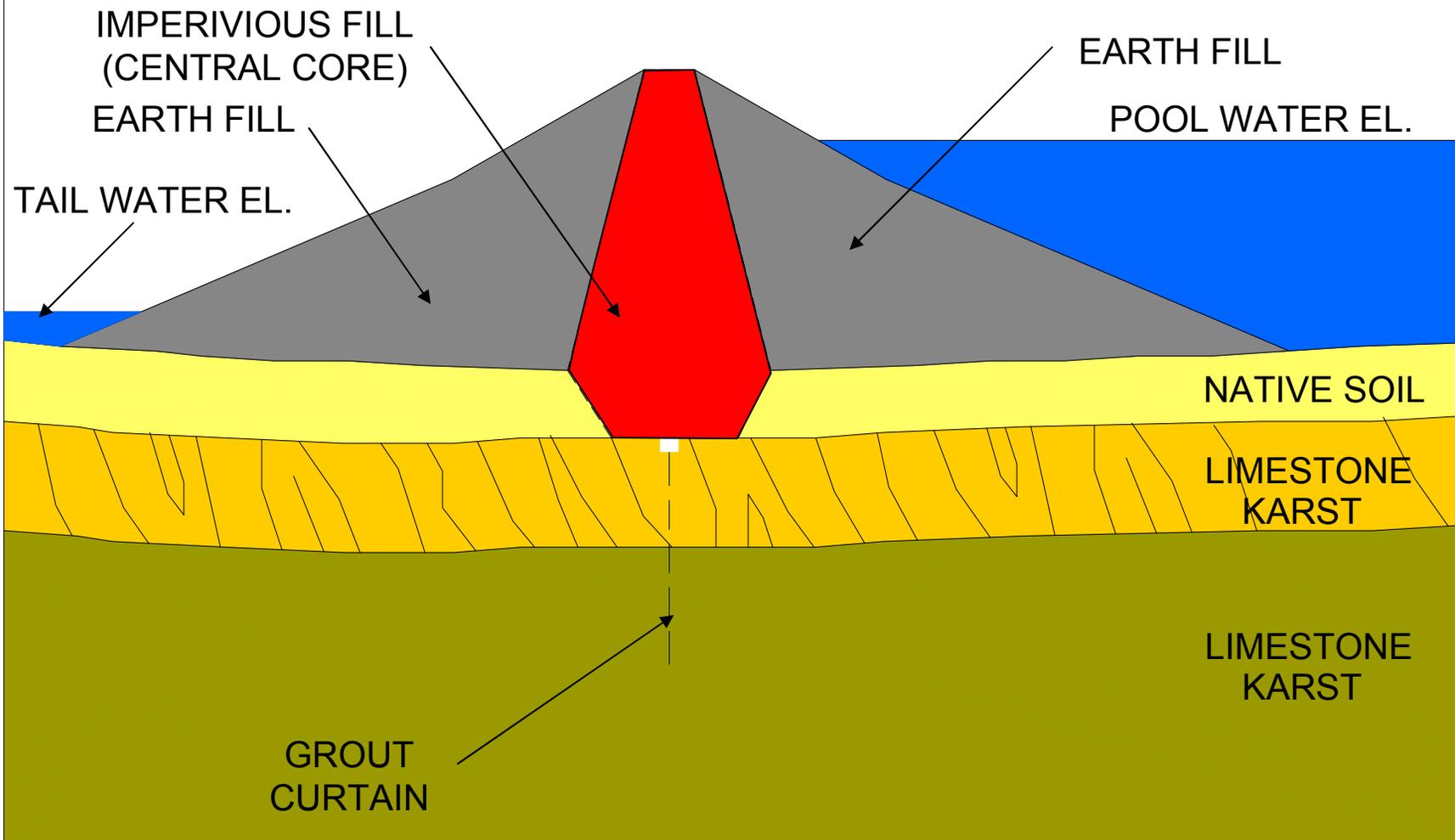
Typical Cross Section of Embankment Dams



Key Elements of Dam Remediation

- Central Core

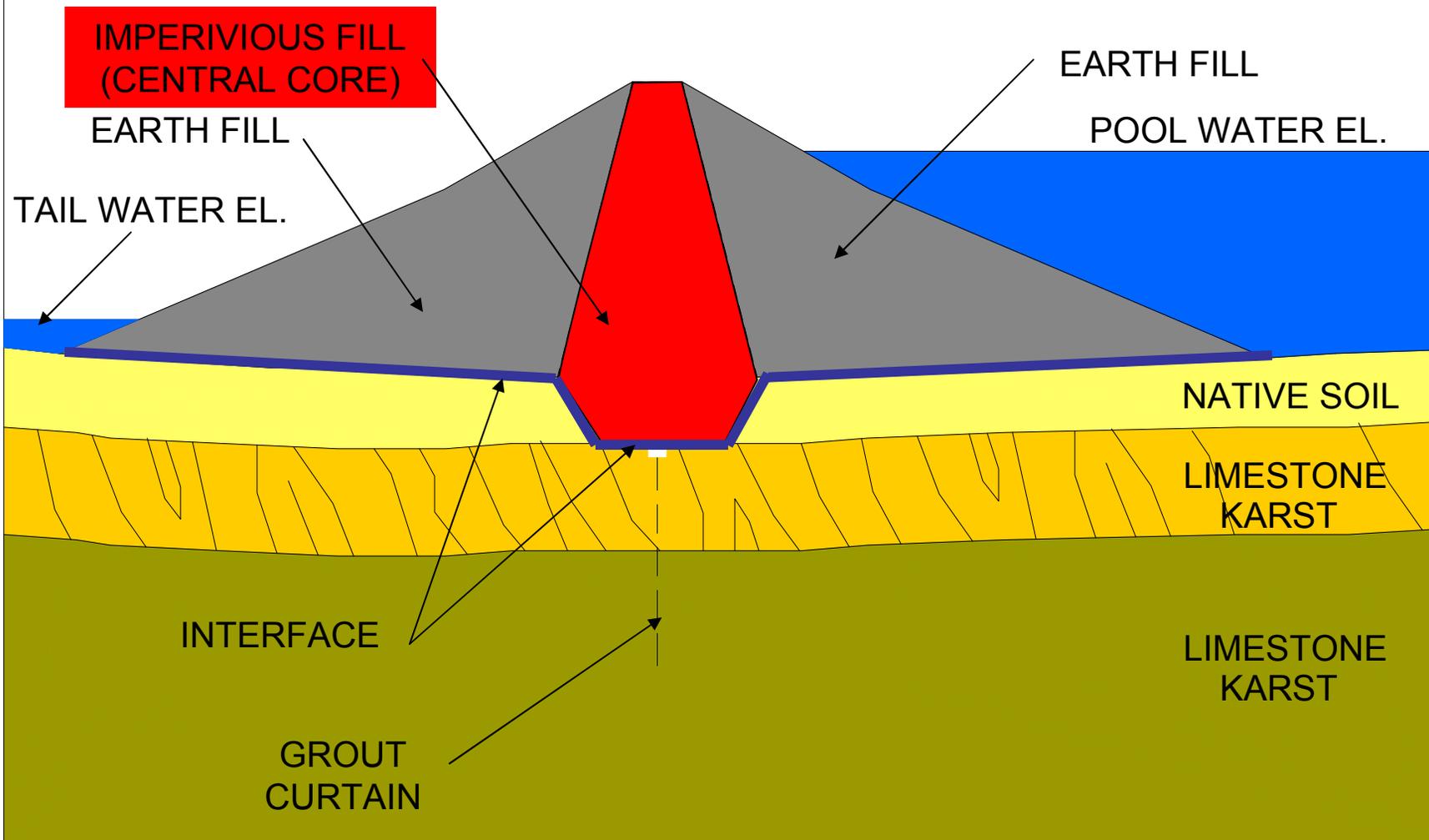
Typical Cross Section of Embankment Dams



Key Elements of Dam Remediation

- Central Core
- Interface

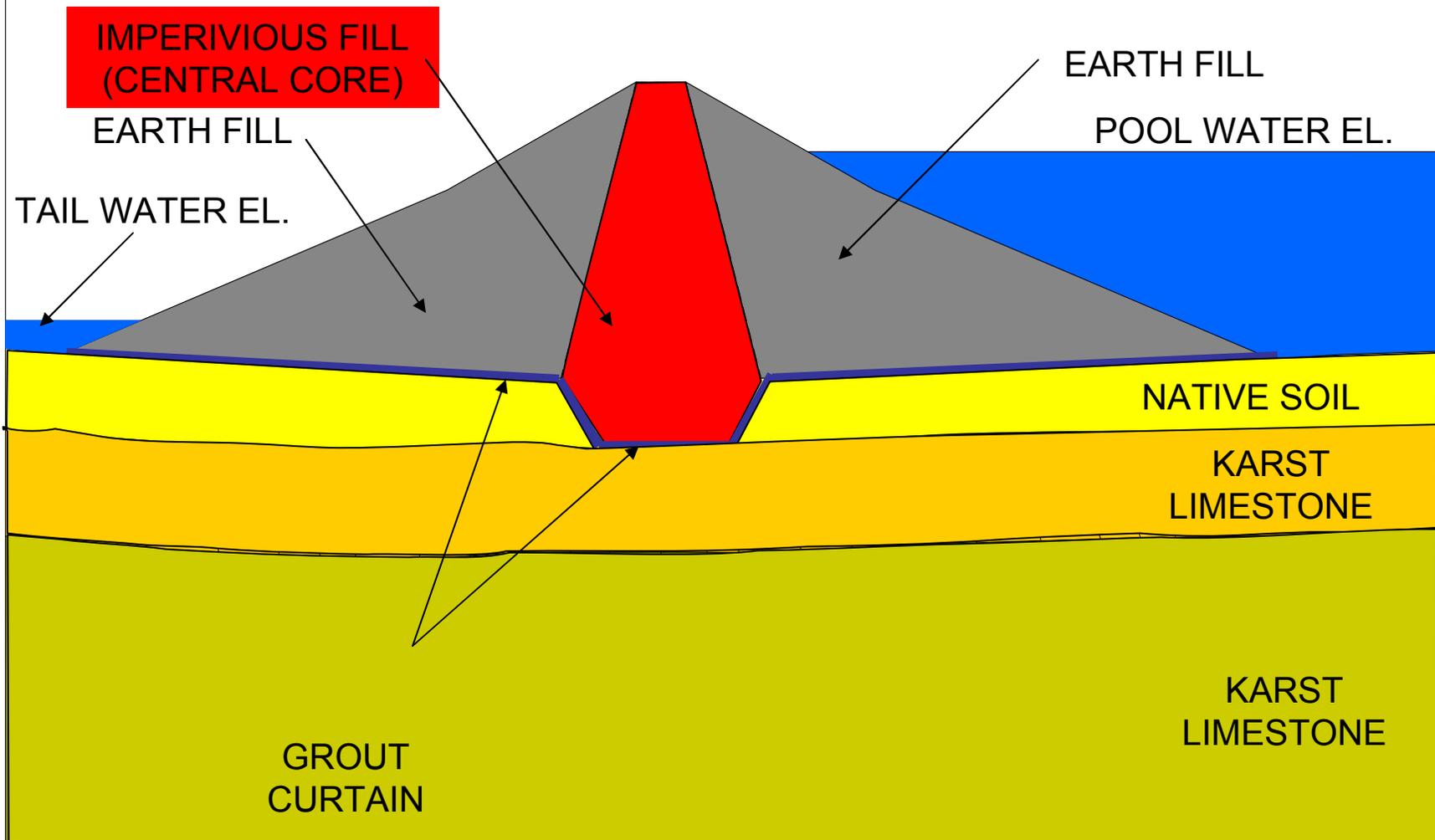
Typical Cross Section of Embankment Dams



Key Elements of Dam Remediation

- Central Core
- Interface
- Foundation

Typical Cross Section of Embankment Dams



Reason

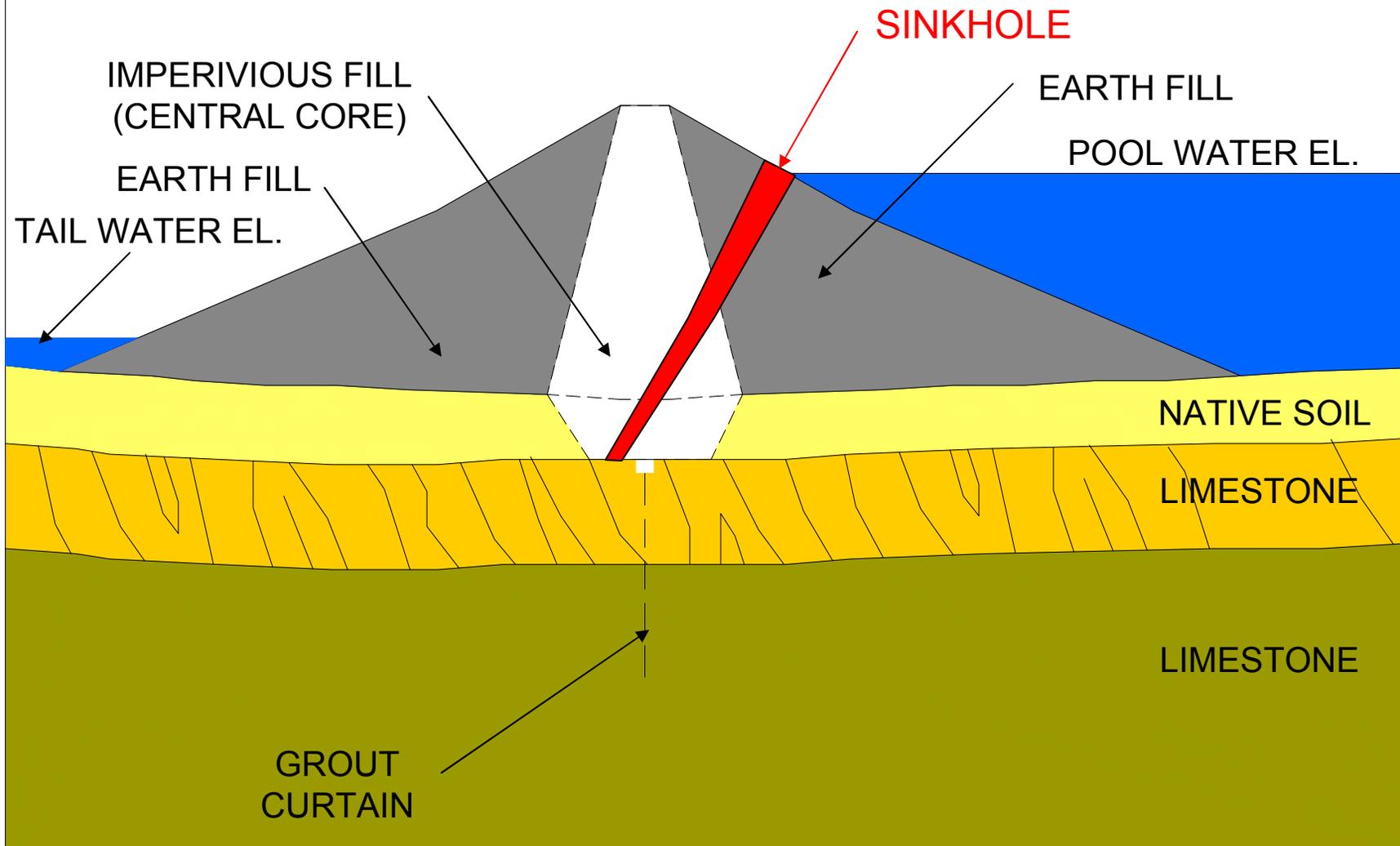
Why Drilling & Grouting Is Used For Remediation of Embankment Dams

- Repair Defects

Typical Defects of Embankment Dams

- Sinkholes

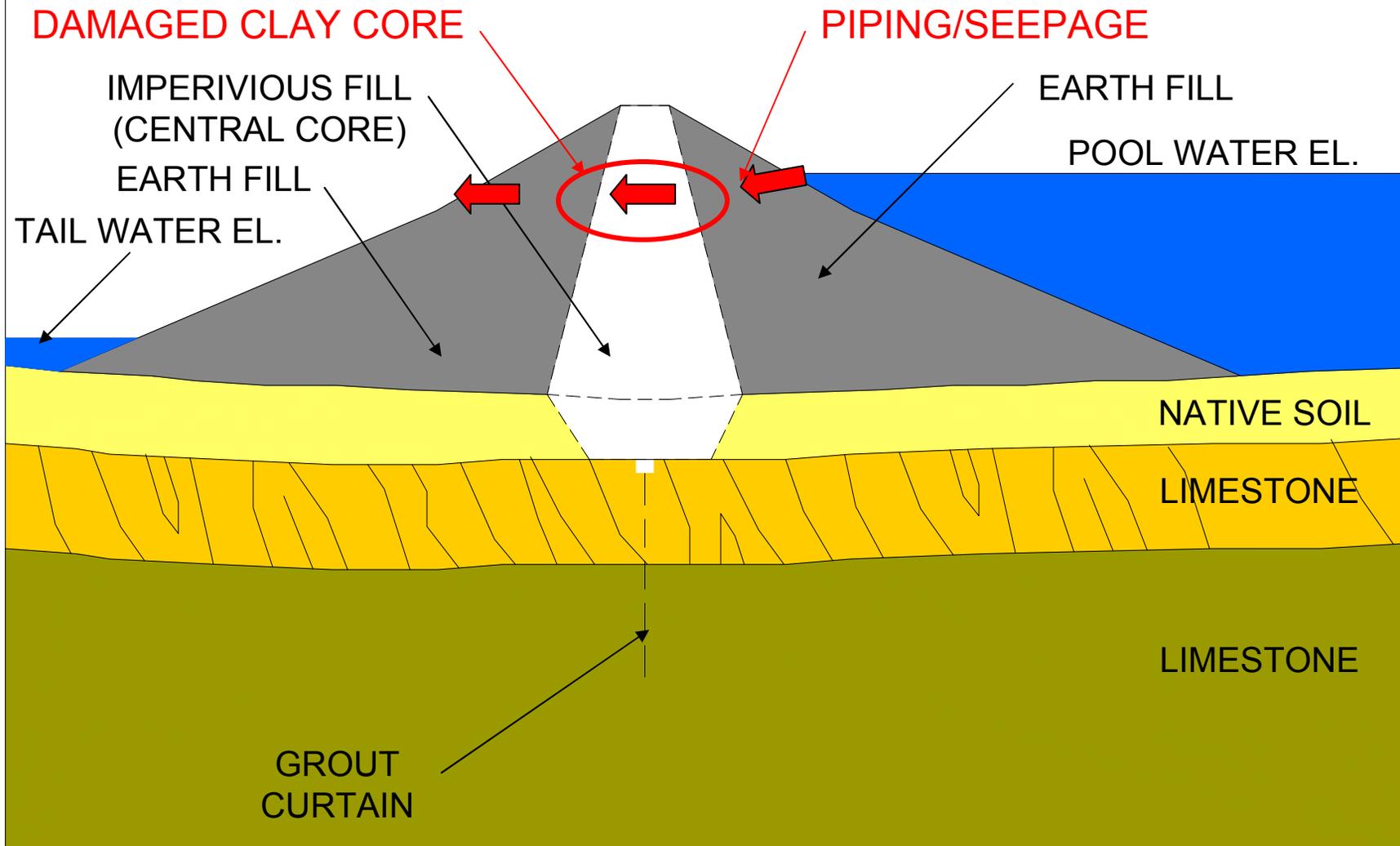
Typical Defects of Embankment Dams



Typical Defects of Embankment Dams

- SINKHOLES
- PIPING / SEEPAGE
- DAMAGED CLAY CORE

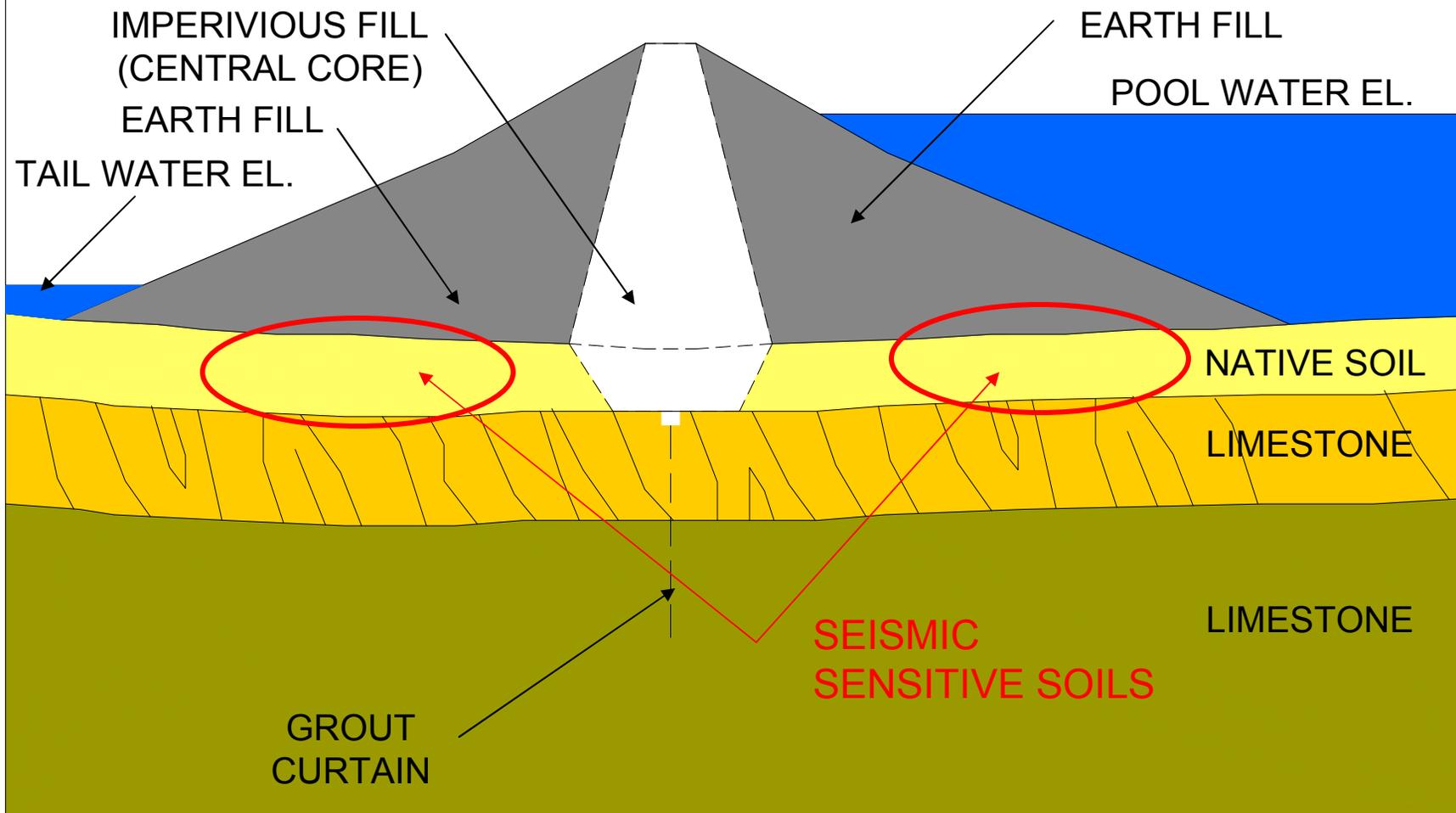
Typical Defects of Embankment Dams



Typical Defects of Embankment Dams

- SINKHOLES
- PIPING / SEEPAGE
- DAMAGED CLAY CORE
- SEISMIC SENSITIVE SOILS

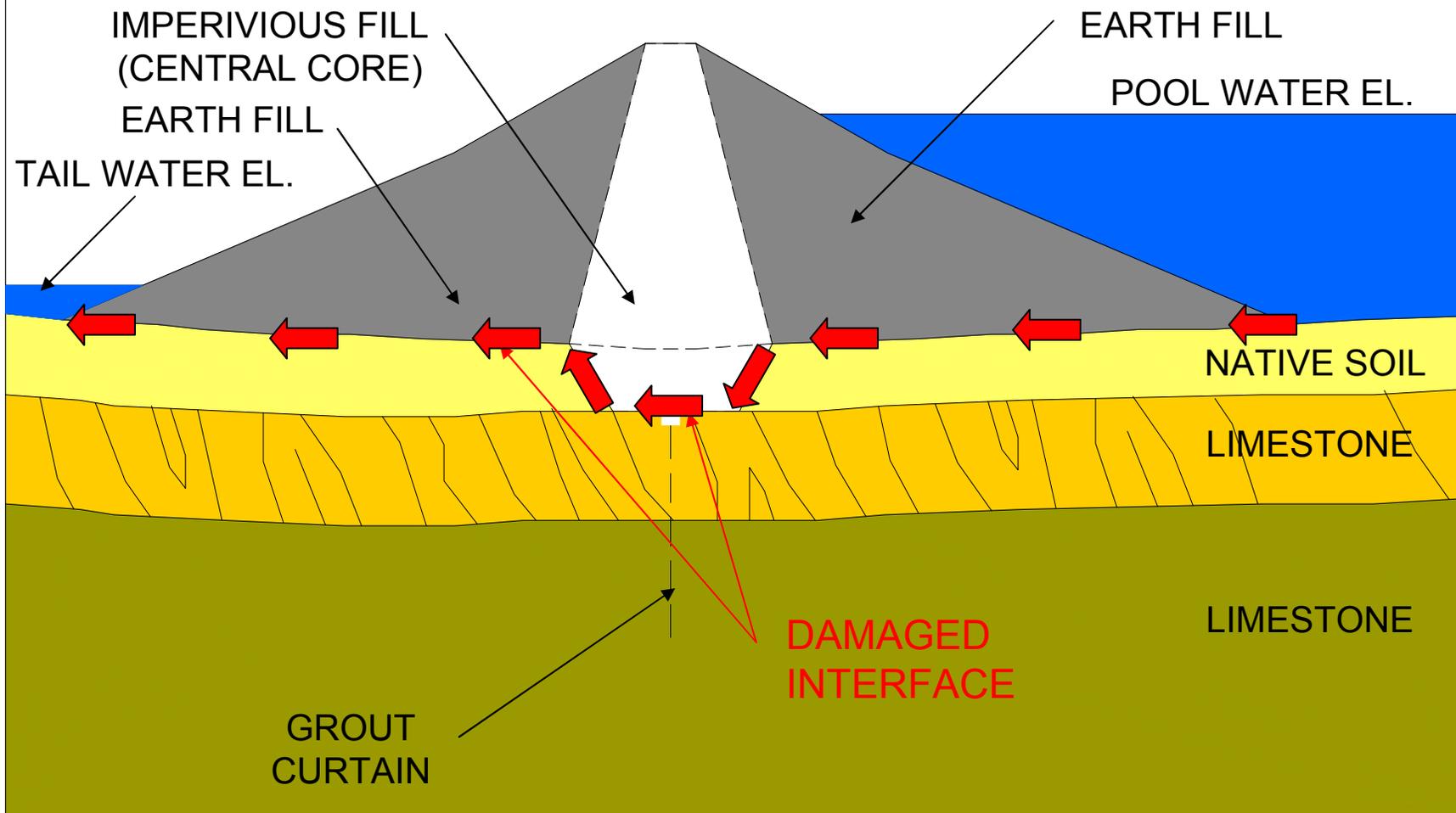
Typical Defects of Embankment Dams



Typical Defects of Embankment Dams

- SINKHOLES
- PIPING / SEEPAGE
- DAMAGED CLAY CORE
- SEISMIC SENSITIVE SOILS
- **DAMAGED INTERFACE**

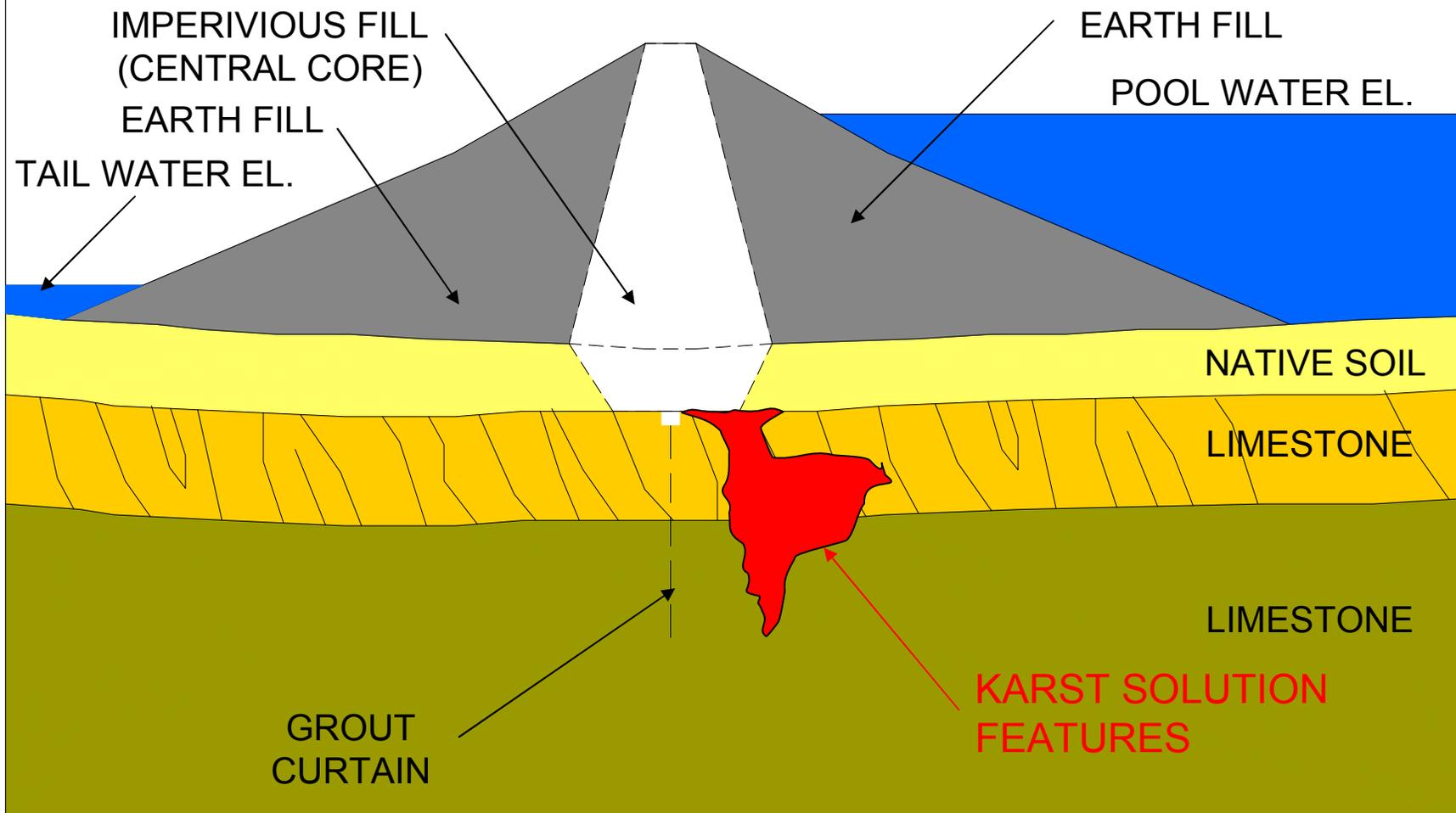
Typical Defects of Embankment Dams



Typical Defects of Embankment Dams

- SINKHOLES
- PIPING / SEEPAGE
- DAMAGED CLAY CORE
- SEISMIC SENSITIVE SOILS
- DAMAGED INTERFACE
- KARST SOLUTION FEATURES

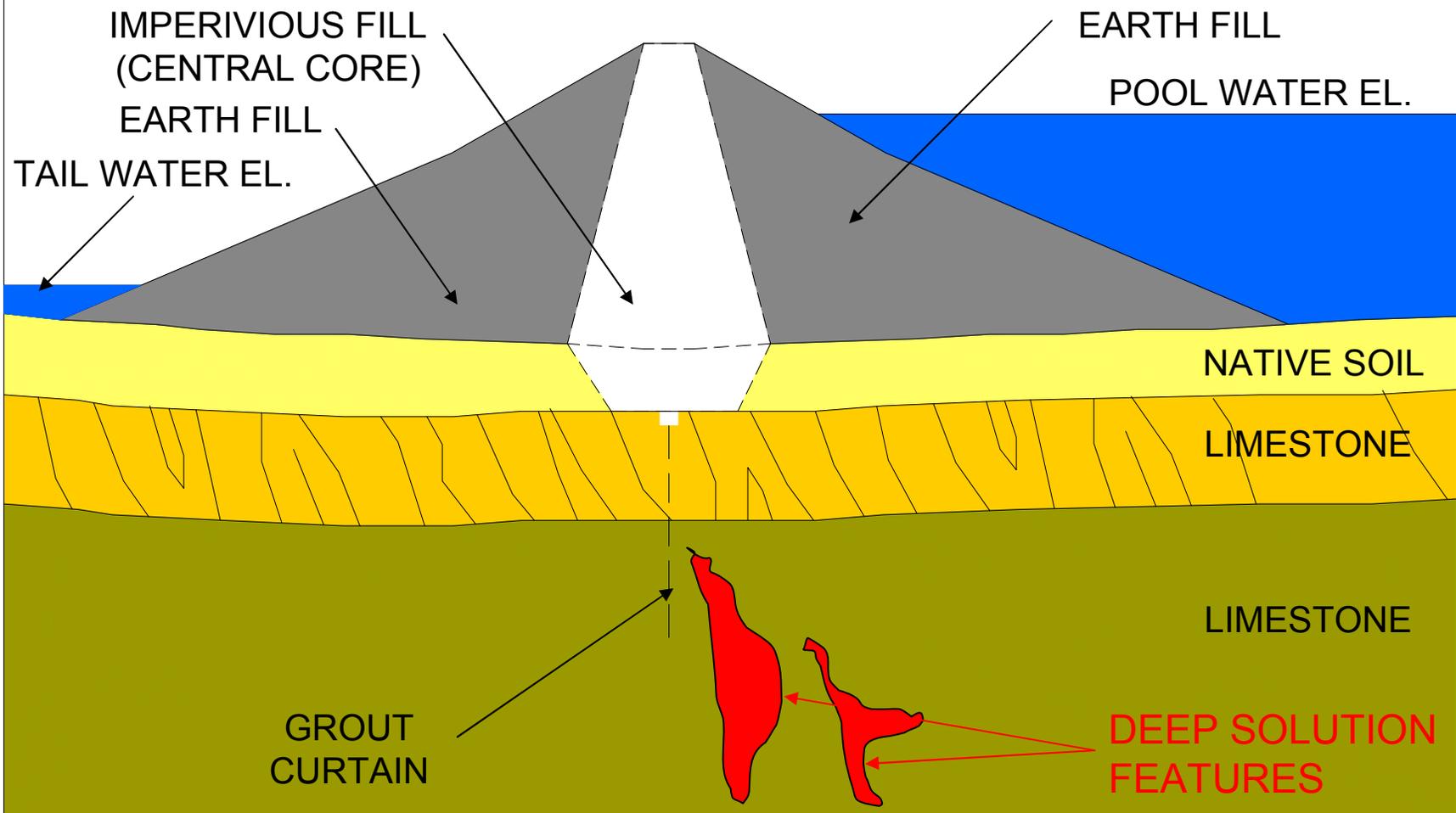
Typical Defects of Embankment Dams



Typical Defects of Embankment Dams

- SINKHOLES
- PIPING / SEEPAGE
- DAMAGED CLAY CORE
- SEISMIC SENSITIVE SOILS
- DAMAGED INTERFACE
- KARST SOLUTION FEATURES
- DEEP SOLUTION FEATURES

Typical Defects of Embankment Dams



USACE Operational Manuals That Govern Drilling and Grouting Operation

- Procedures for Drilling in Earth Embankments
ER 110-1-1807
- Grouting Technology
EM 1110-2-3506
- Geotechnical Investigation
EM 1110-1-1804
- Soil Sampling
EM 1110-1-1906

Types of Embankment Drilling

- Sonic Drilling
- Rotary Drilling with Drilling Fluid
- Cased Auger

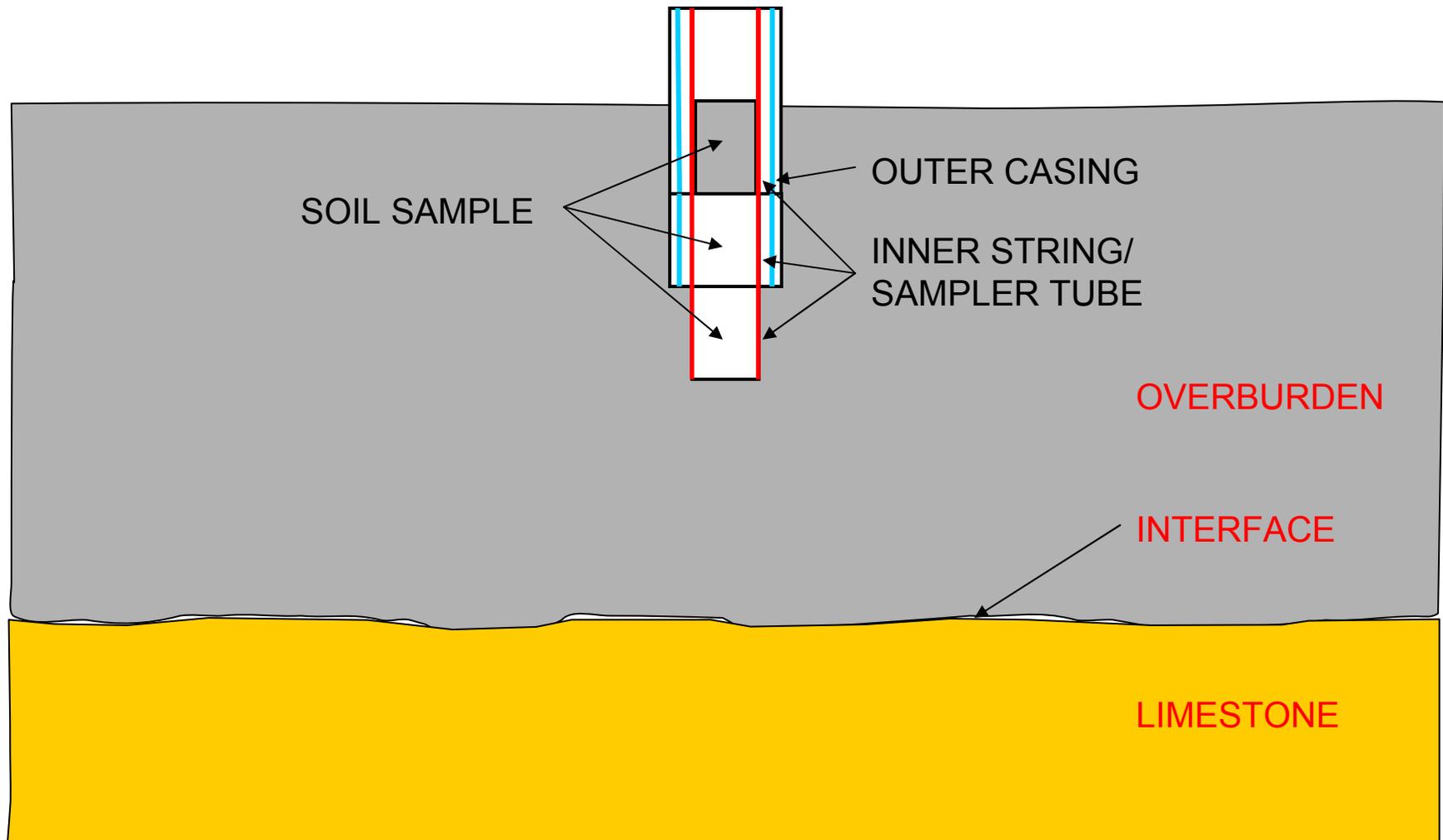


INTEROCK AN160

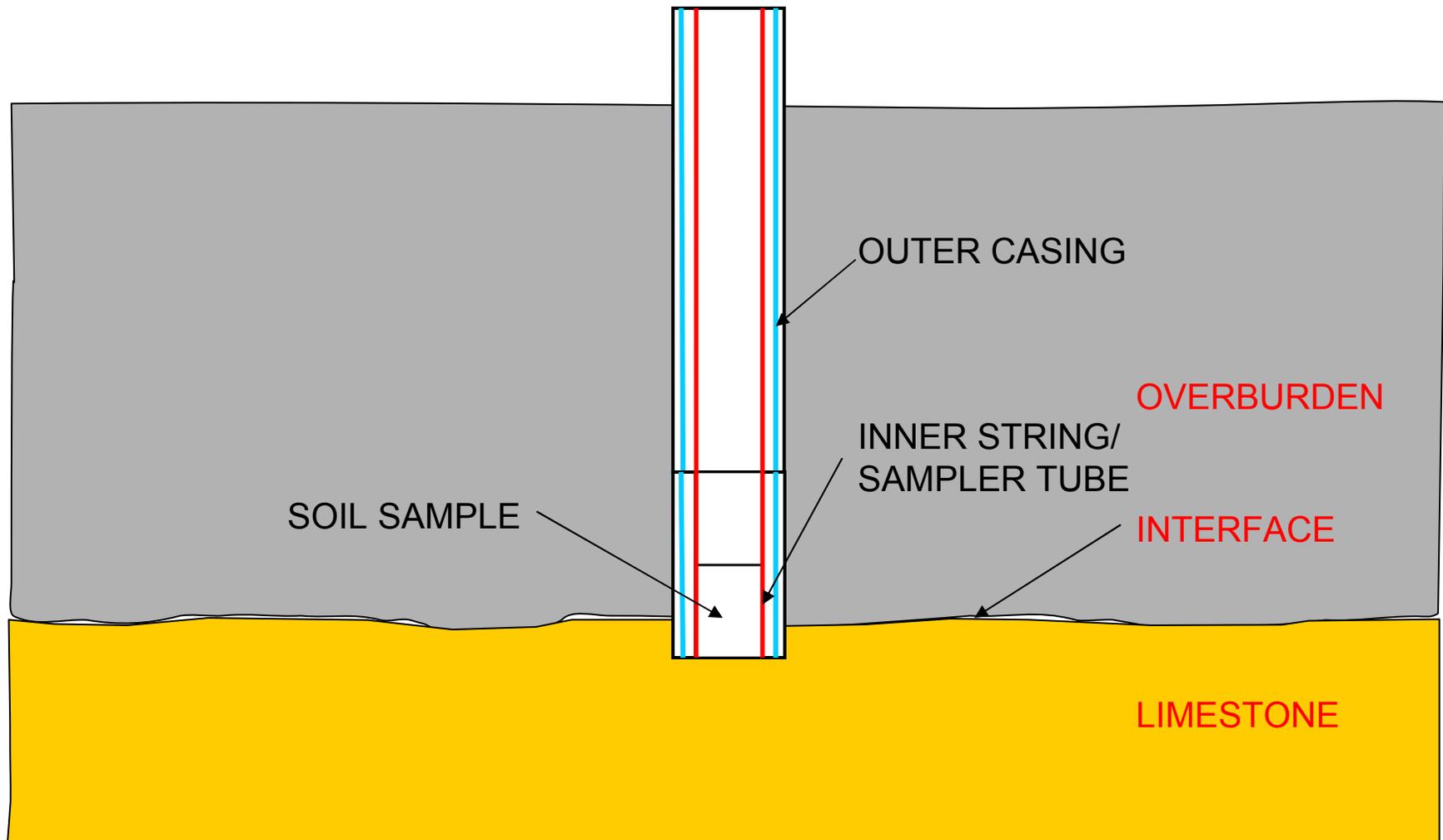
SONIC DRILL



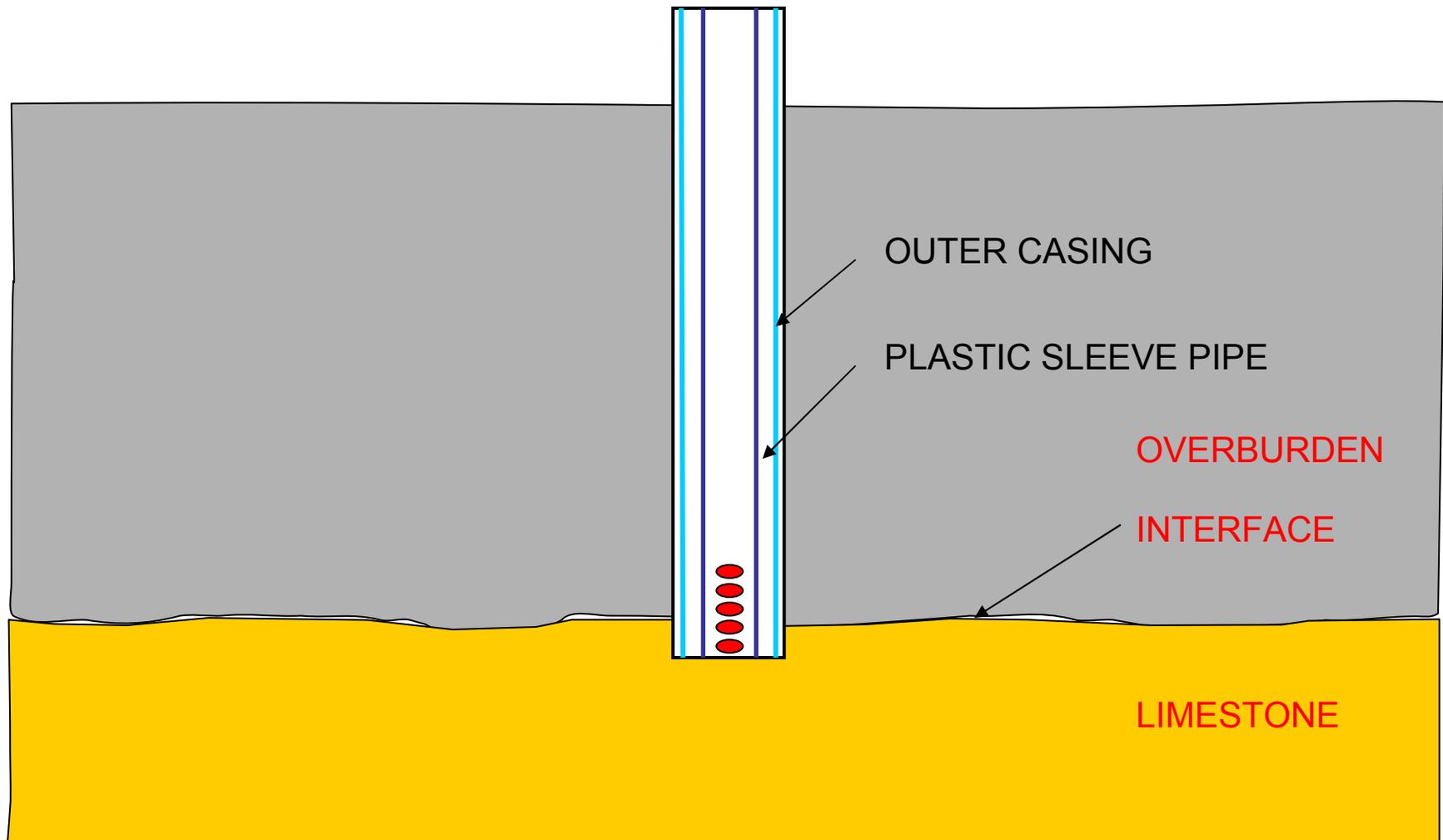
Sonic Drilling



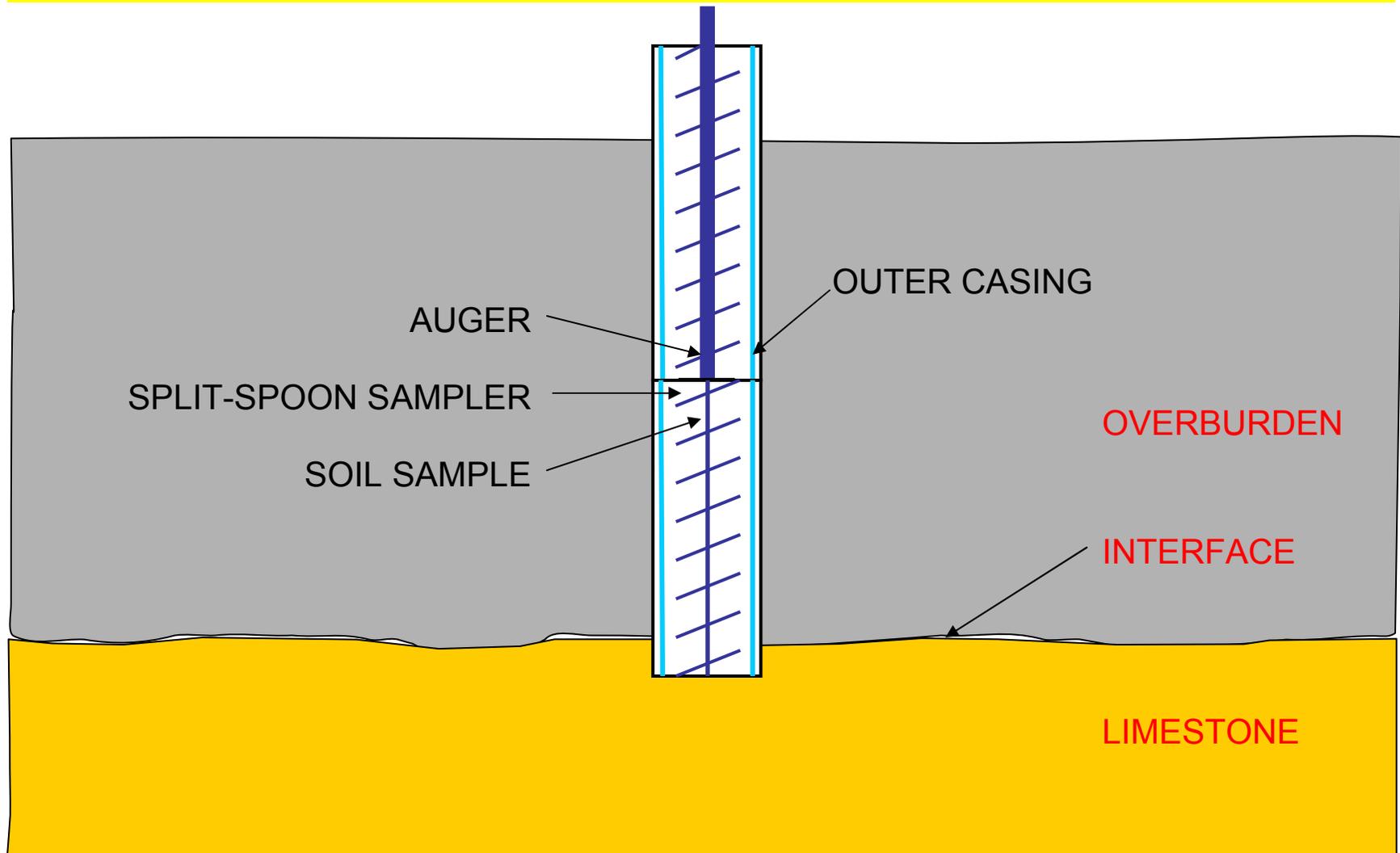
Sonic Drilling



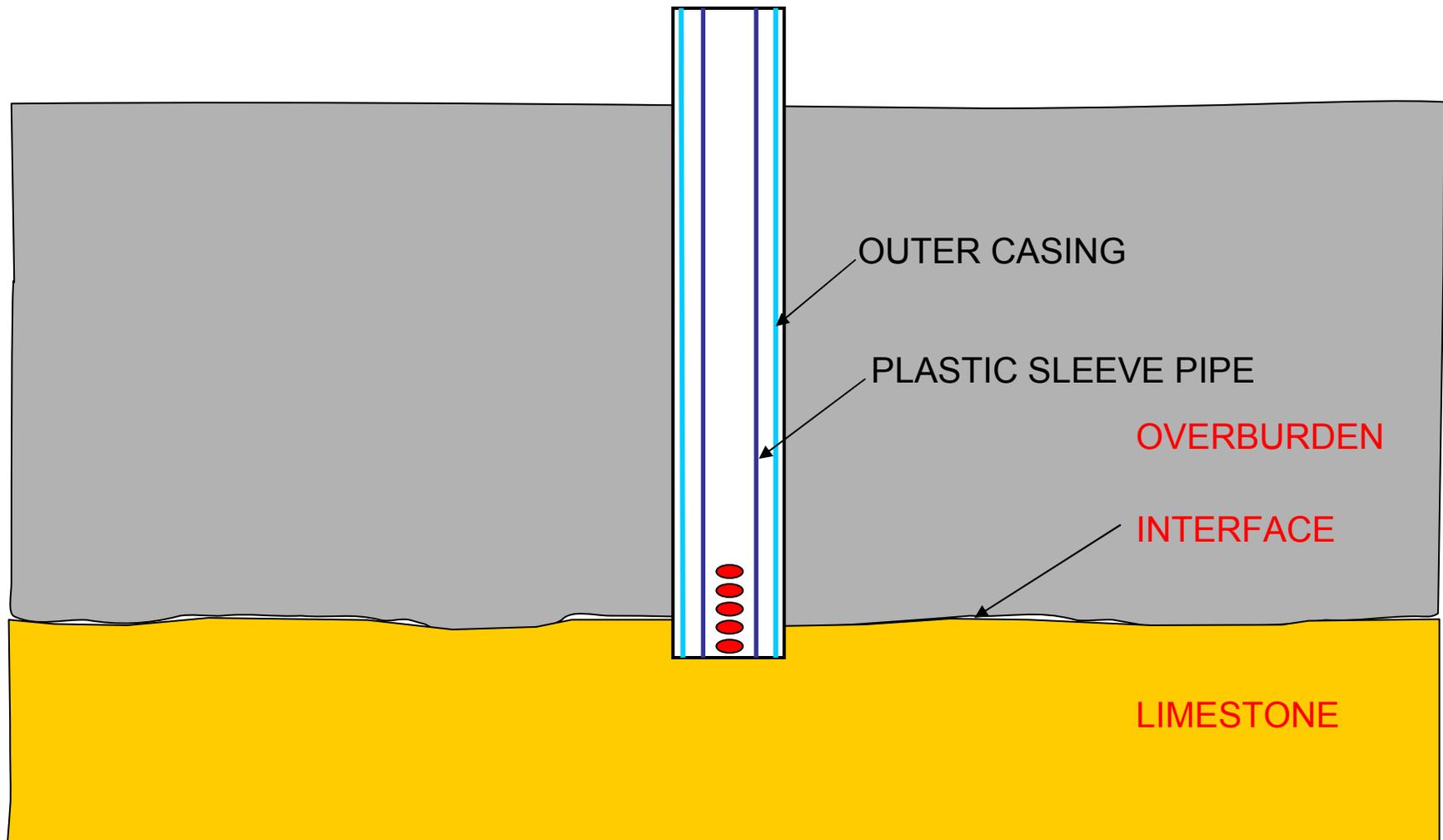
Sonic Drilling



Cased Auger Drilling



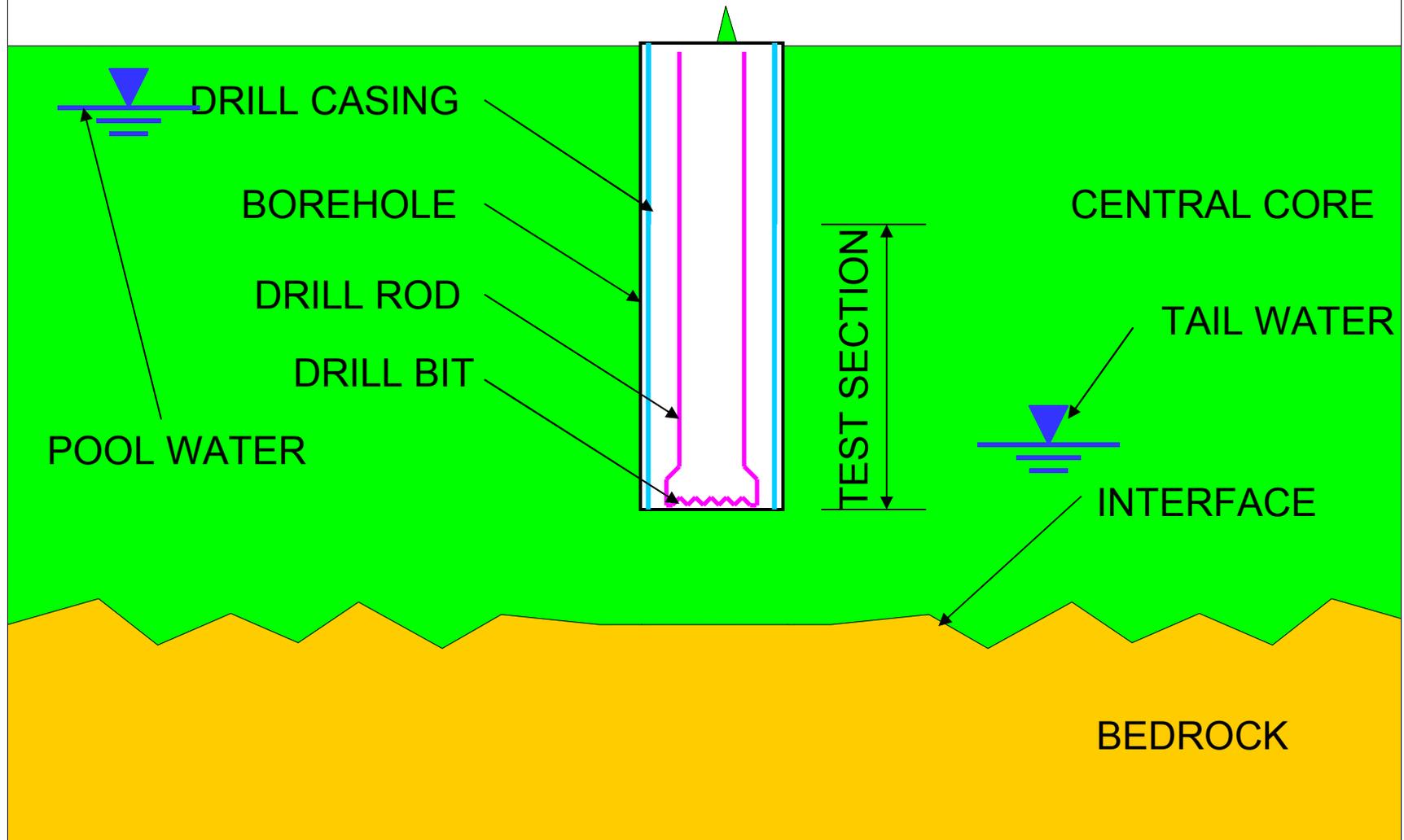
Cased Auger Drilling



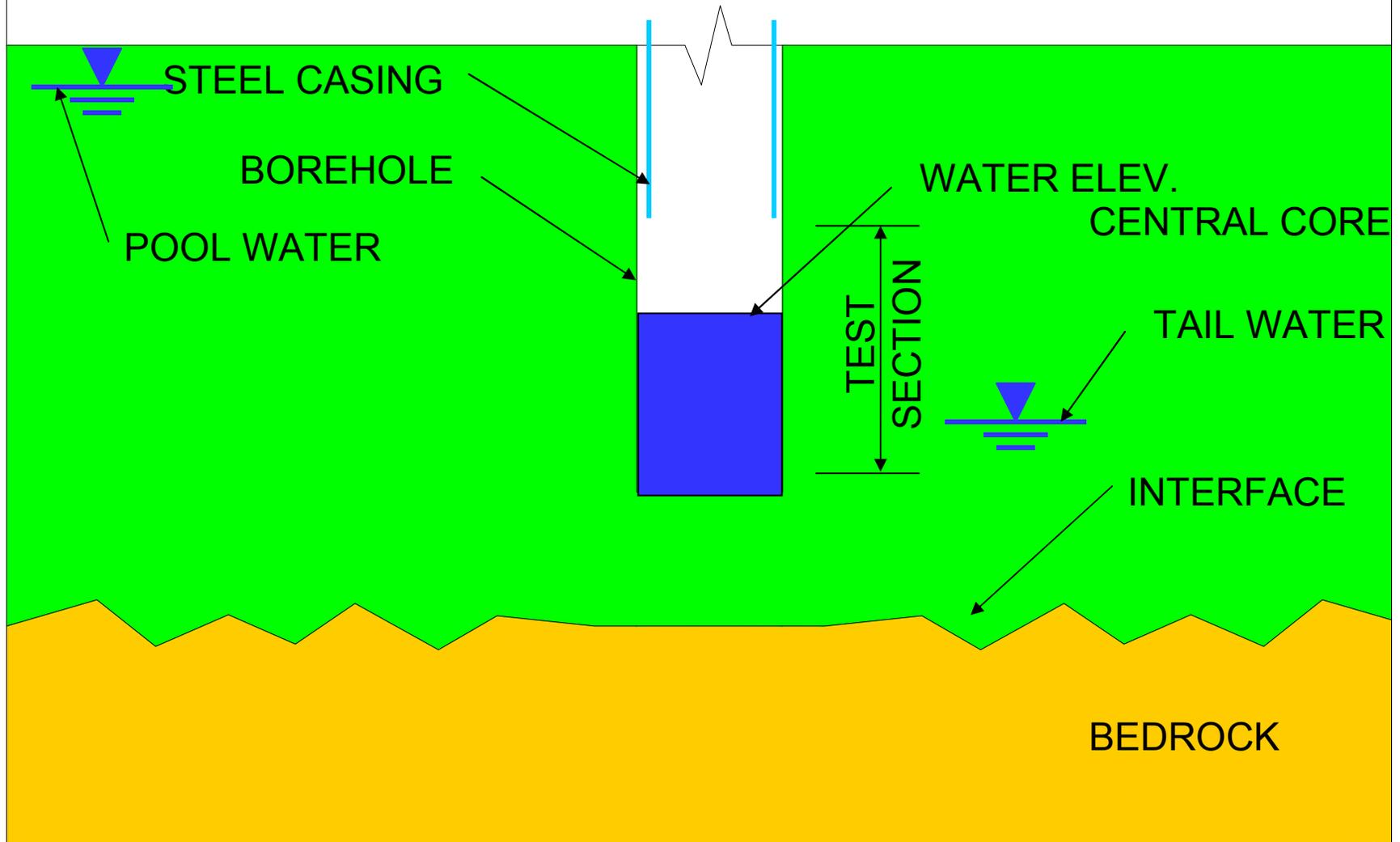
Specific Tests of Embankment Dams

- Core Integrity Test (C.I.T.)
- Interface Integrity Test (I.I.T.)
- Foundation Integrity Test (F.I.T.)

Core Integrity Test (C.I.T.)



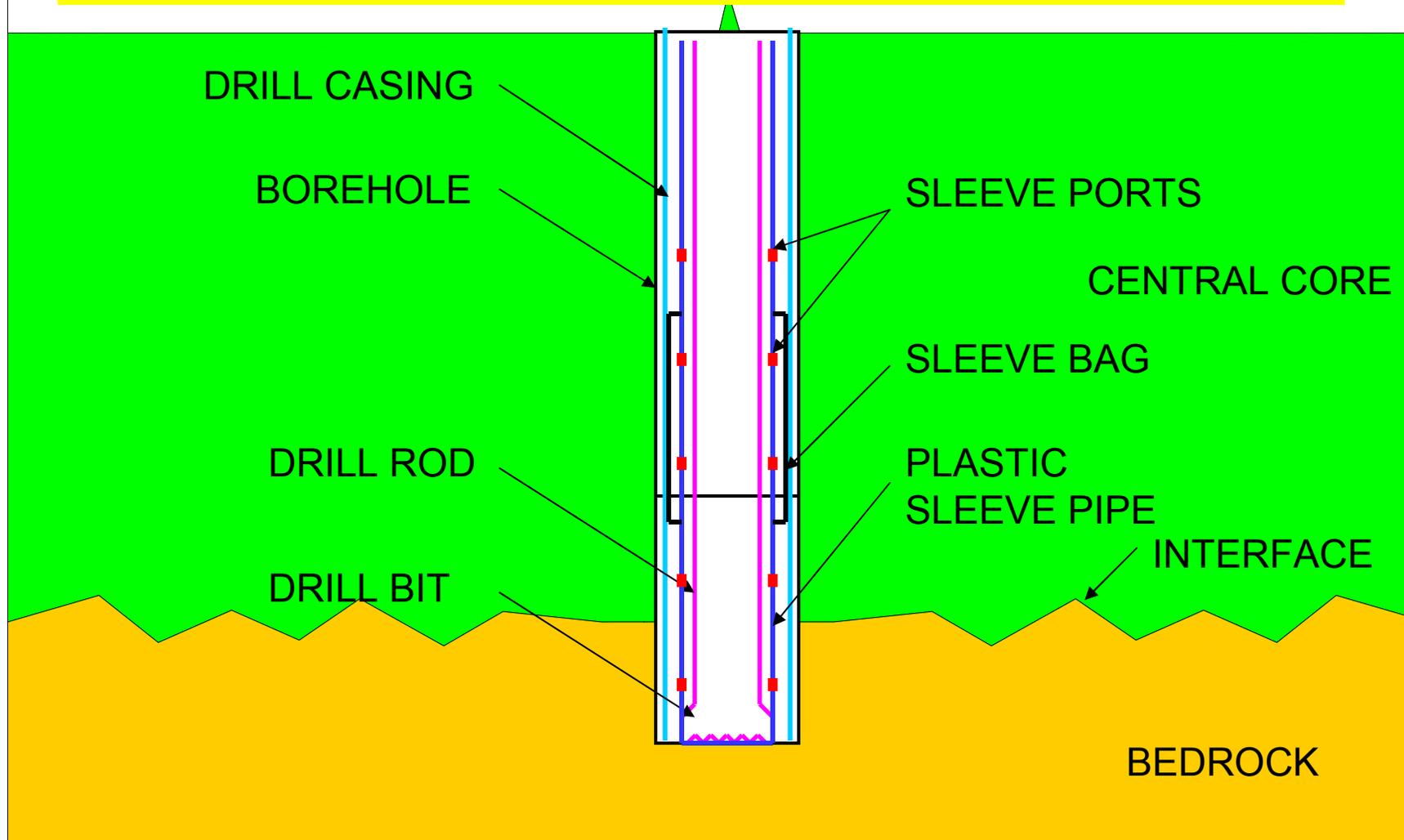
Core Integrity Test (C.I.T.)



Core Condition Chart

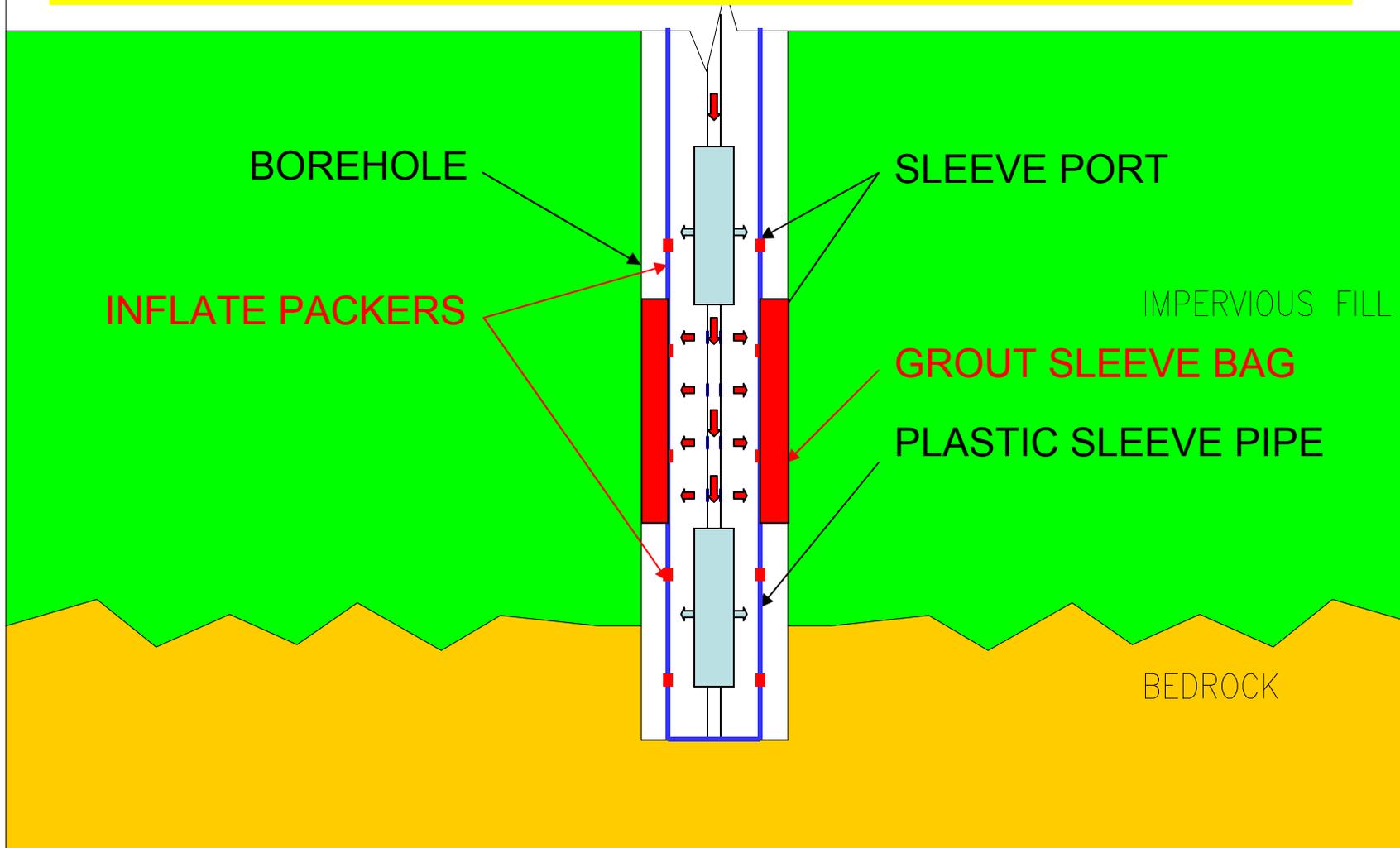
WATER ELEVATION	CORE CONDITION	COMMENTS
NO WATER RISE	EXCELLENT	GOOD LONG TREM PERFORMANCE
RISE TO TAIL WATER ELEV.	POOR	CONNECTED TO DOWNSTREAM
RISE TO POOL WATER ELEV.	POOR	CONNECTED TO UPSTREAM
RISE BETWEEN HW & TW	POOR	GENERAL CONNECTION

Interface Integrity Test (I.I.T.) Casing Installation



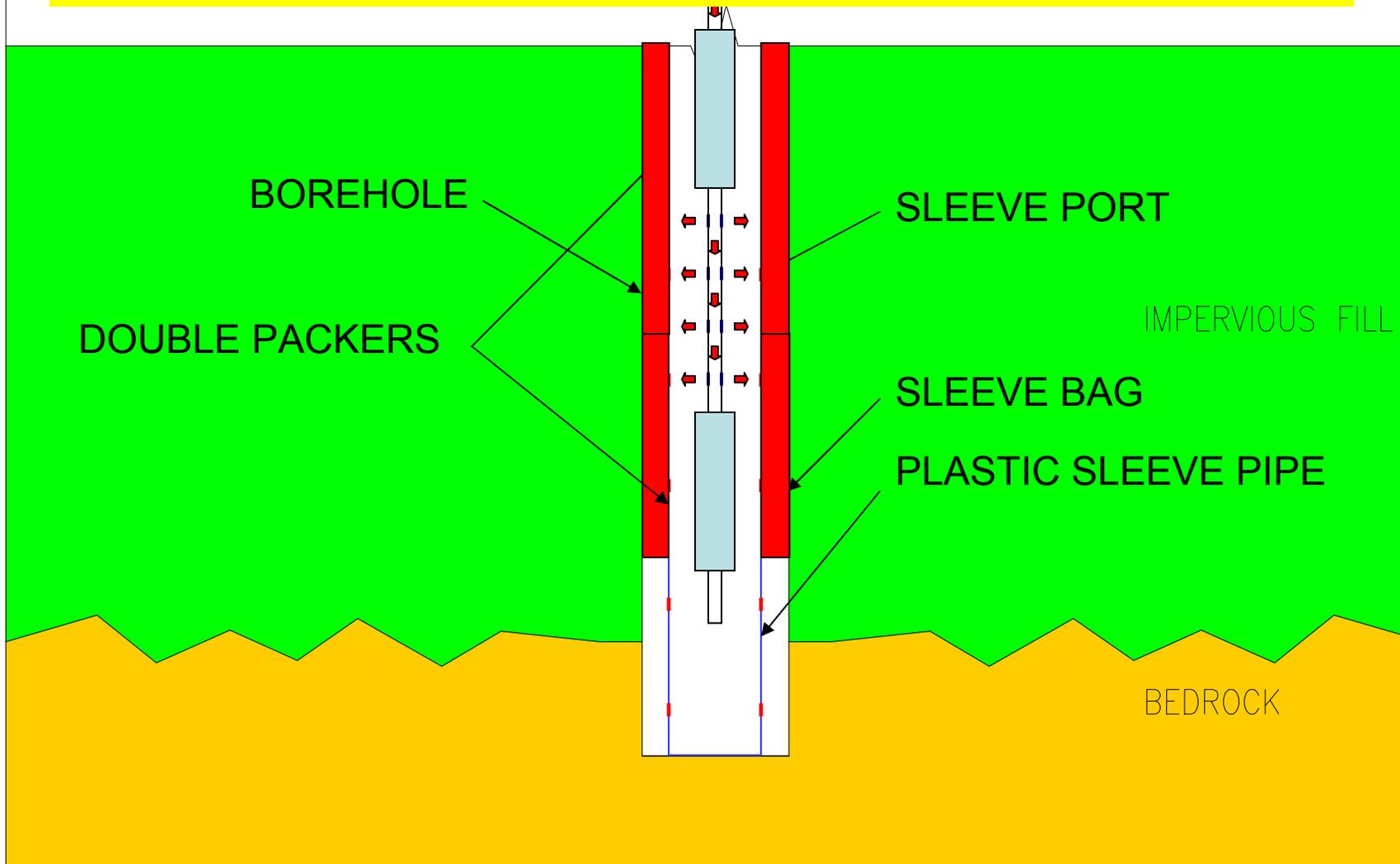
Interface Integrity Test (I.I.T.)

Interface Insulation



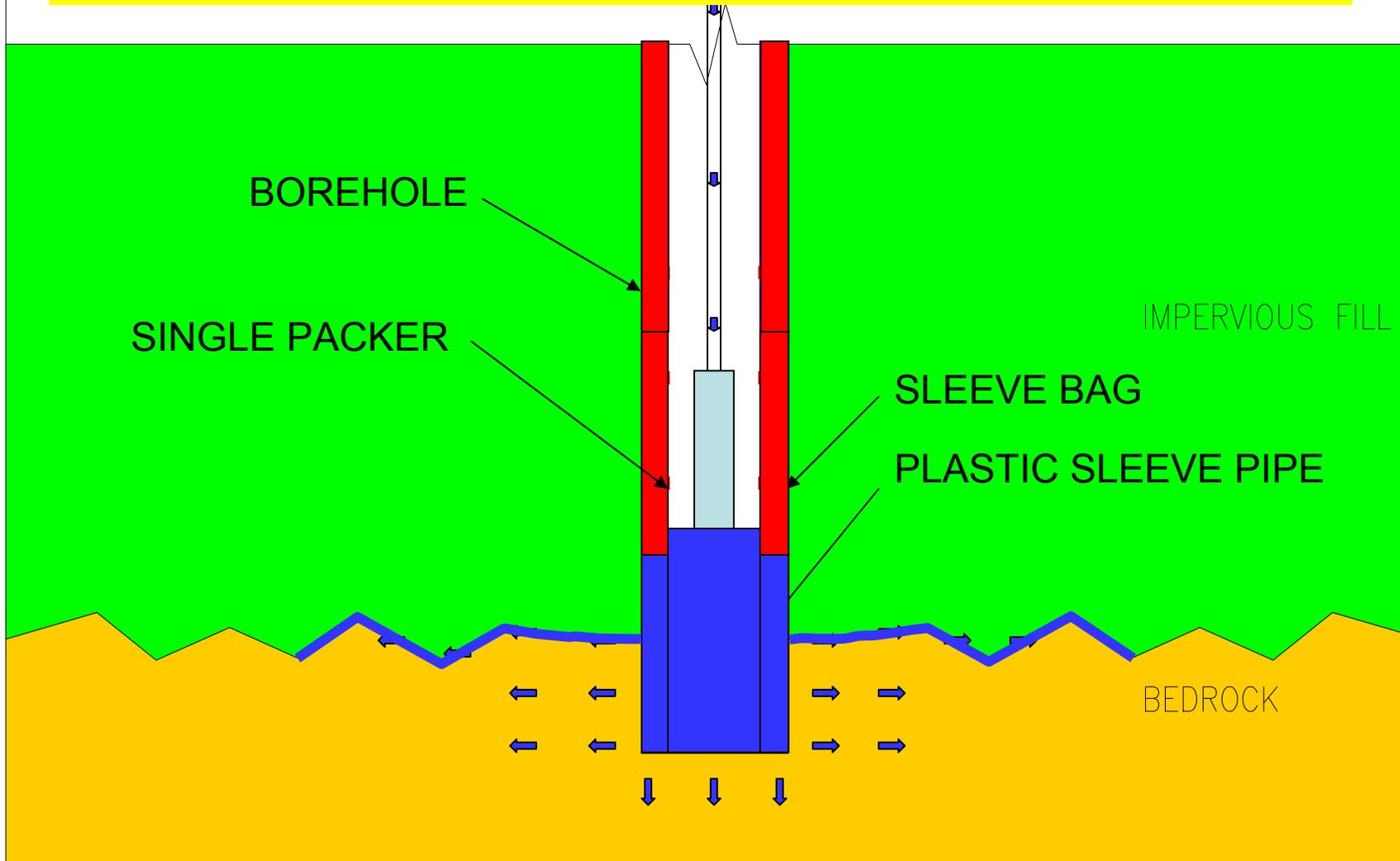
Interface Integrity Test (I.I.T.)

Overburden Casing Grouting



Interface Integrity Test (I.I.T.)

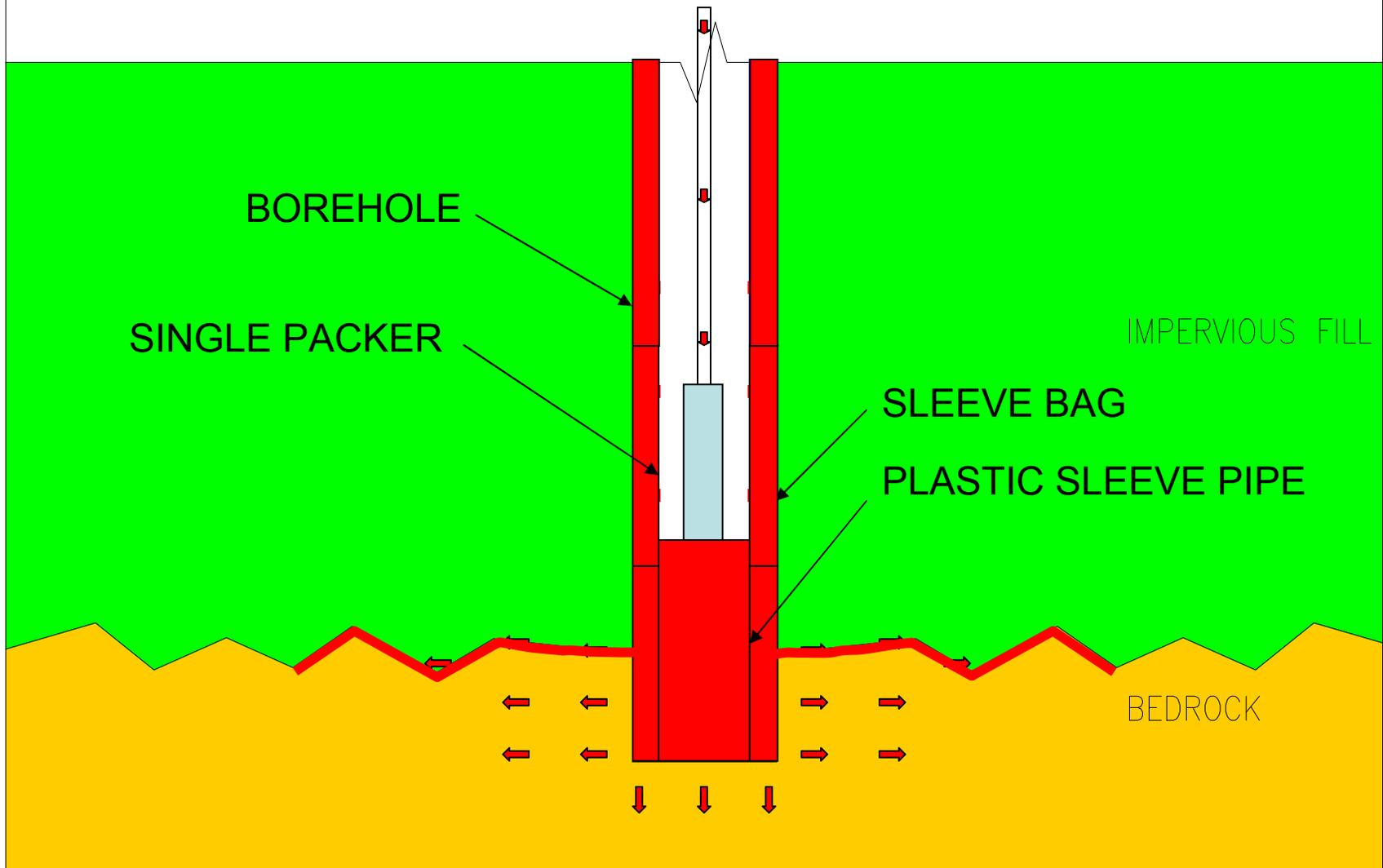
Interface Integrity Test



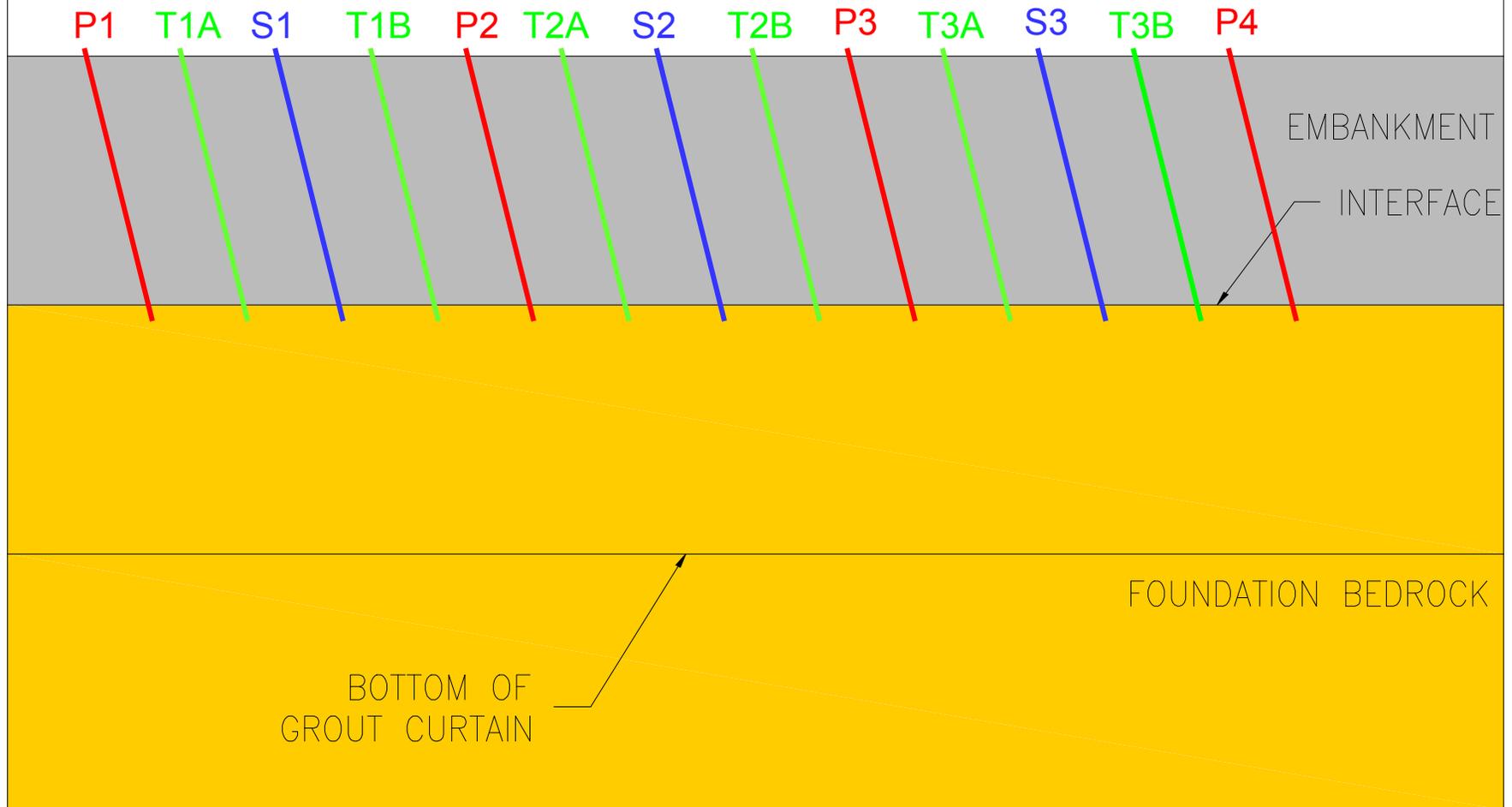
Interface Condition Chart

LUGEON VALUE	CONDITION OF INTERFACE	COMMENT
0 - 1	EXCELLENT	INTACT / NO ACTION REQUIRED
1 - 5	GOOD	INTACT / LONG TERM MONITORING REQUIRED
5 - 10	POOR	SUSPECTION CONDITION / MONITORING REQUIRED
> 10	UNSATISFACTORY	POSSIBLE PIPING / REMEDIATION REQUIRED

Interface Grouting



Overburden Casing Installation



Exploratory Drilling

100 – 200 FT

P1 T1A S1 T1B P2 T2A S2 T2B P3 T3A S3 T3B P4

EMBANKMENT

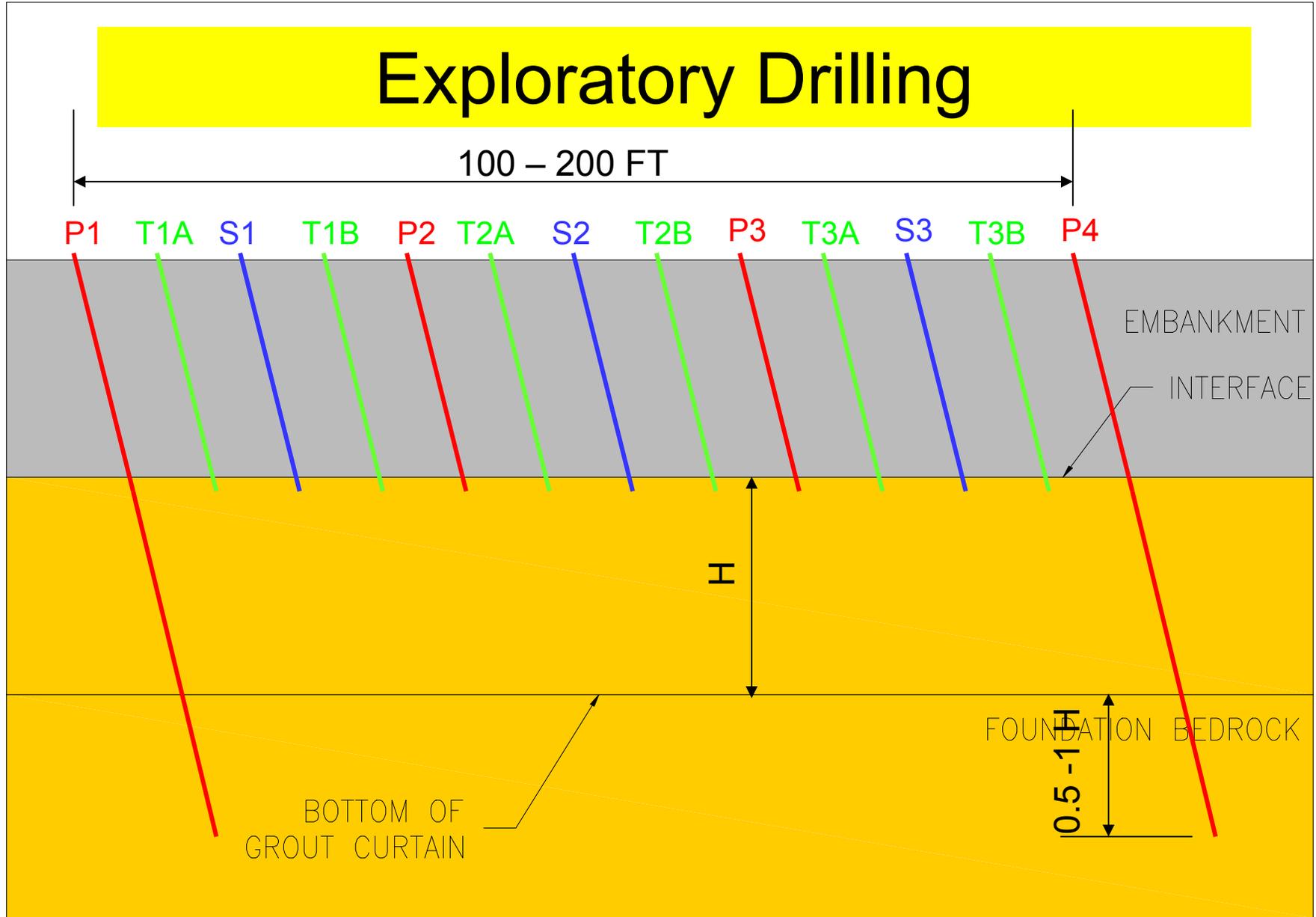
INTERFACE

H

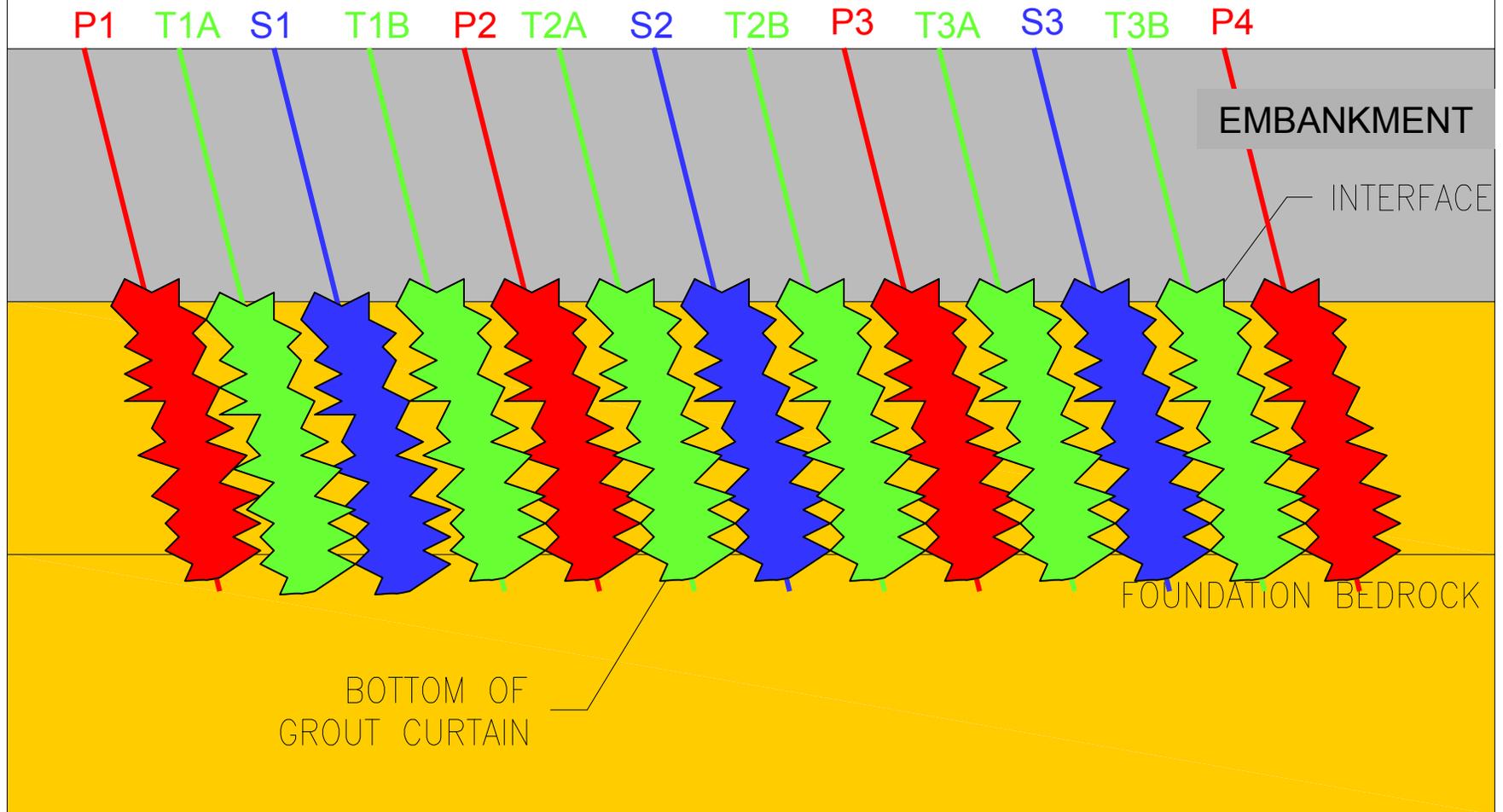
FOUNDATION BEDROCK

0.5 - 1H

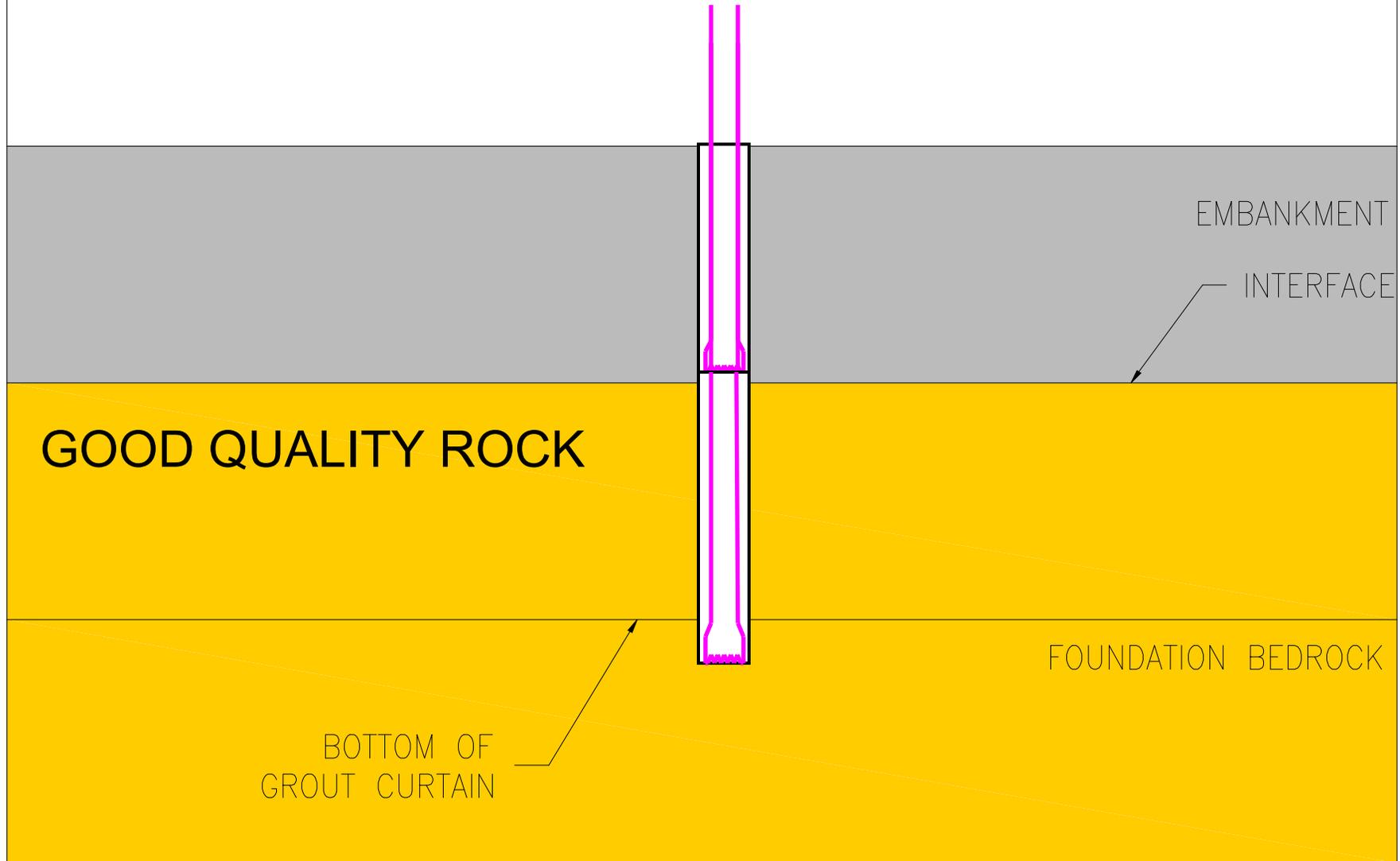
BOTTOM OF GROUT CURTAIN



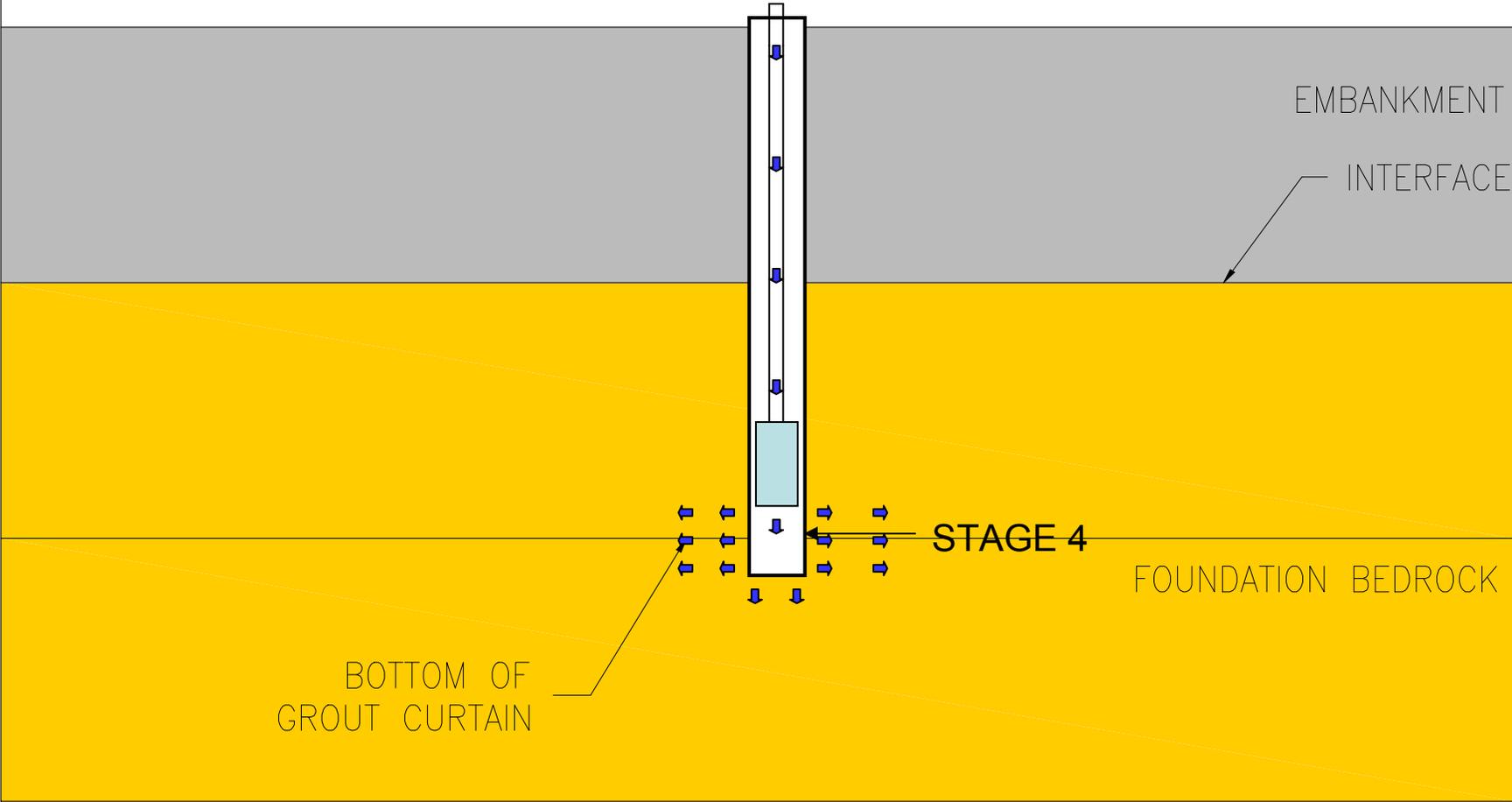
Sequences of Drilling, Water Testing & Grouting



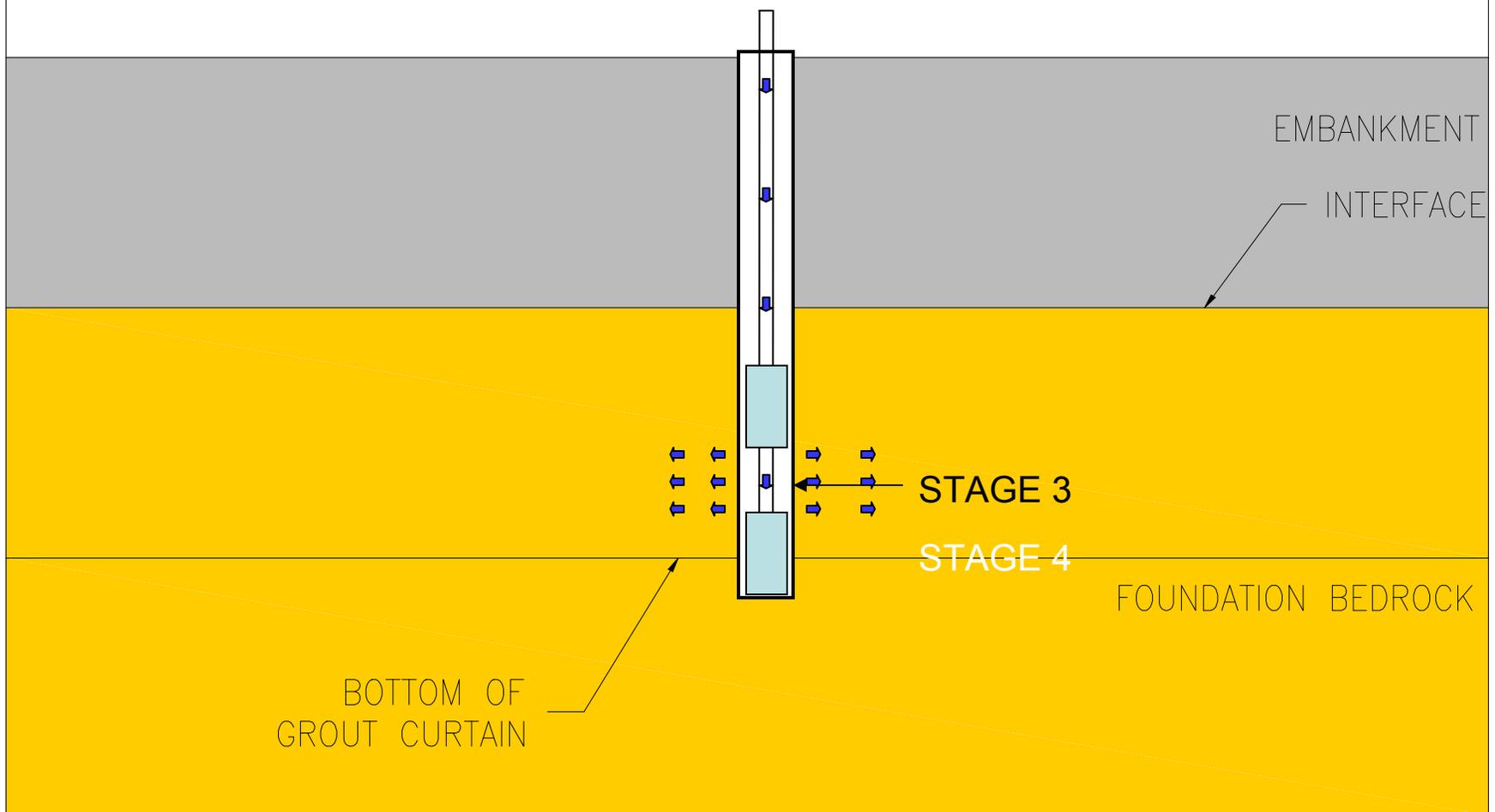
Upstage Grouting



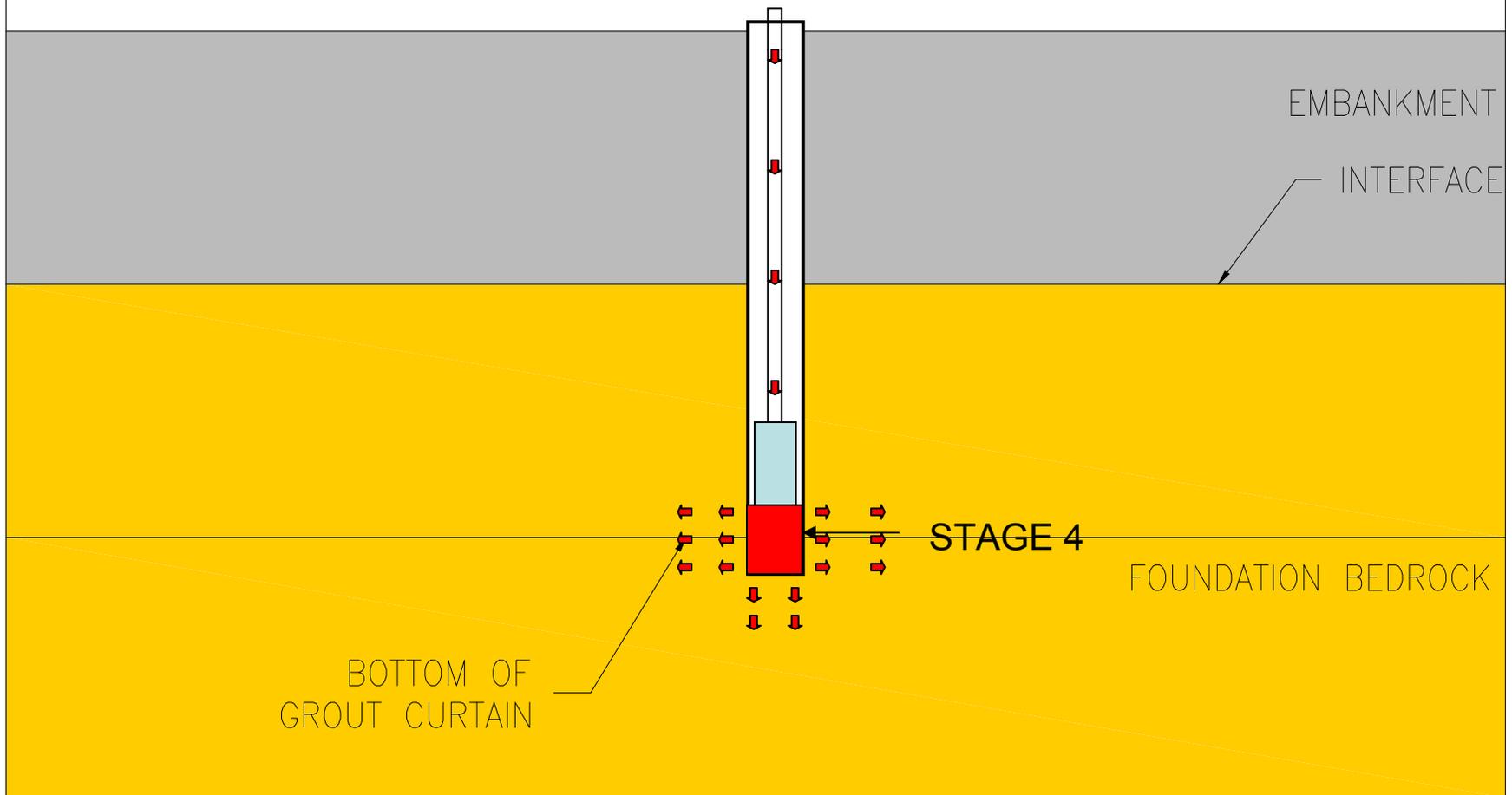
Single Packer Water Testing



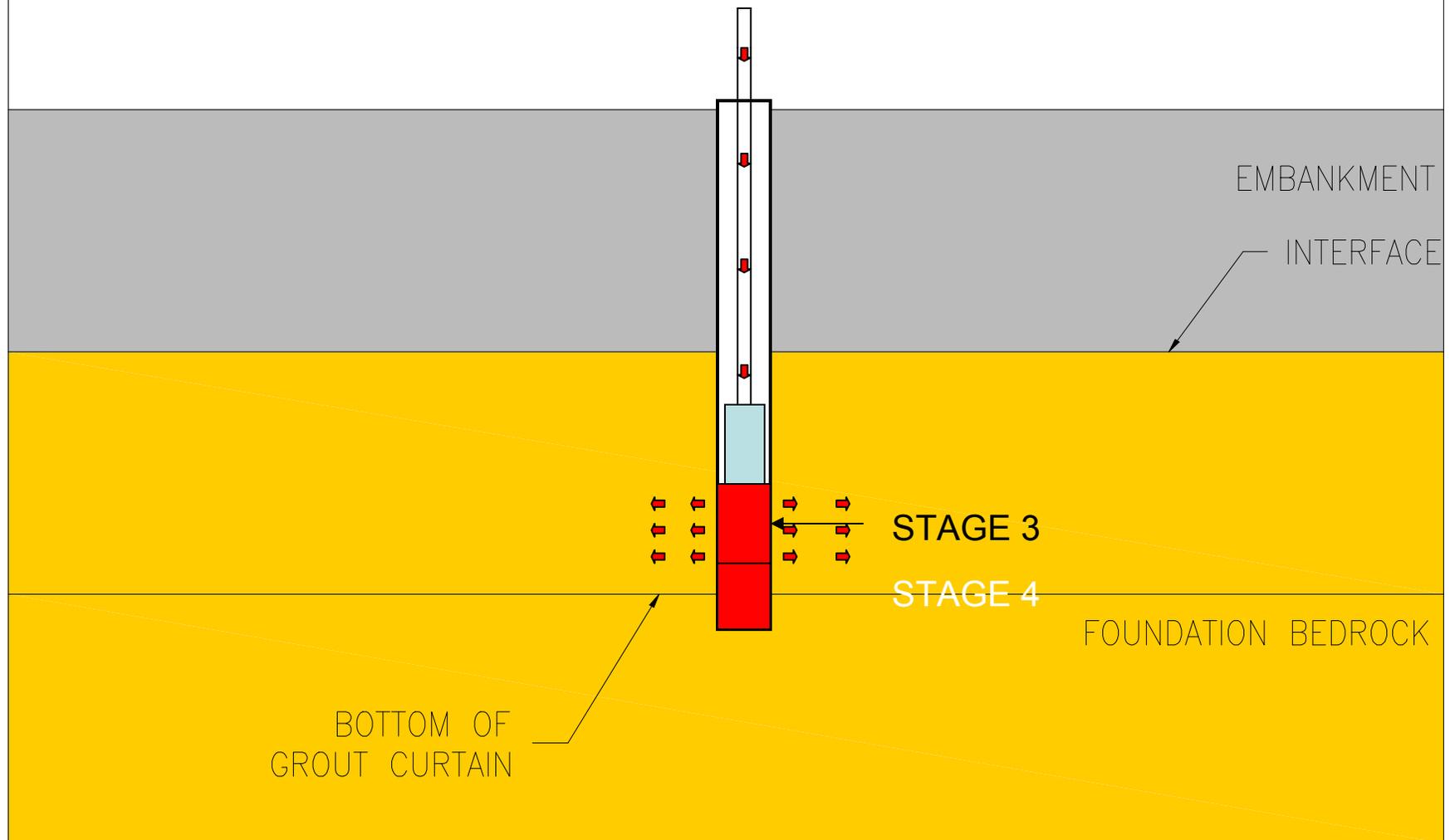
Double Packer Upstage Water Testing



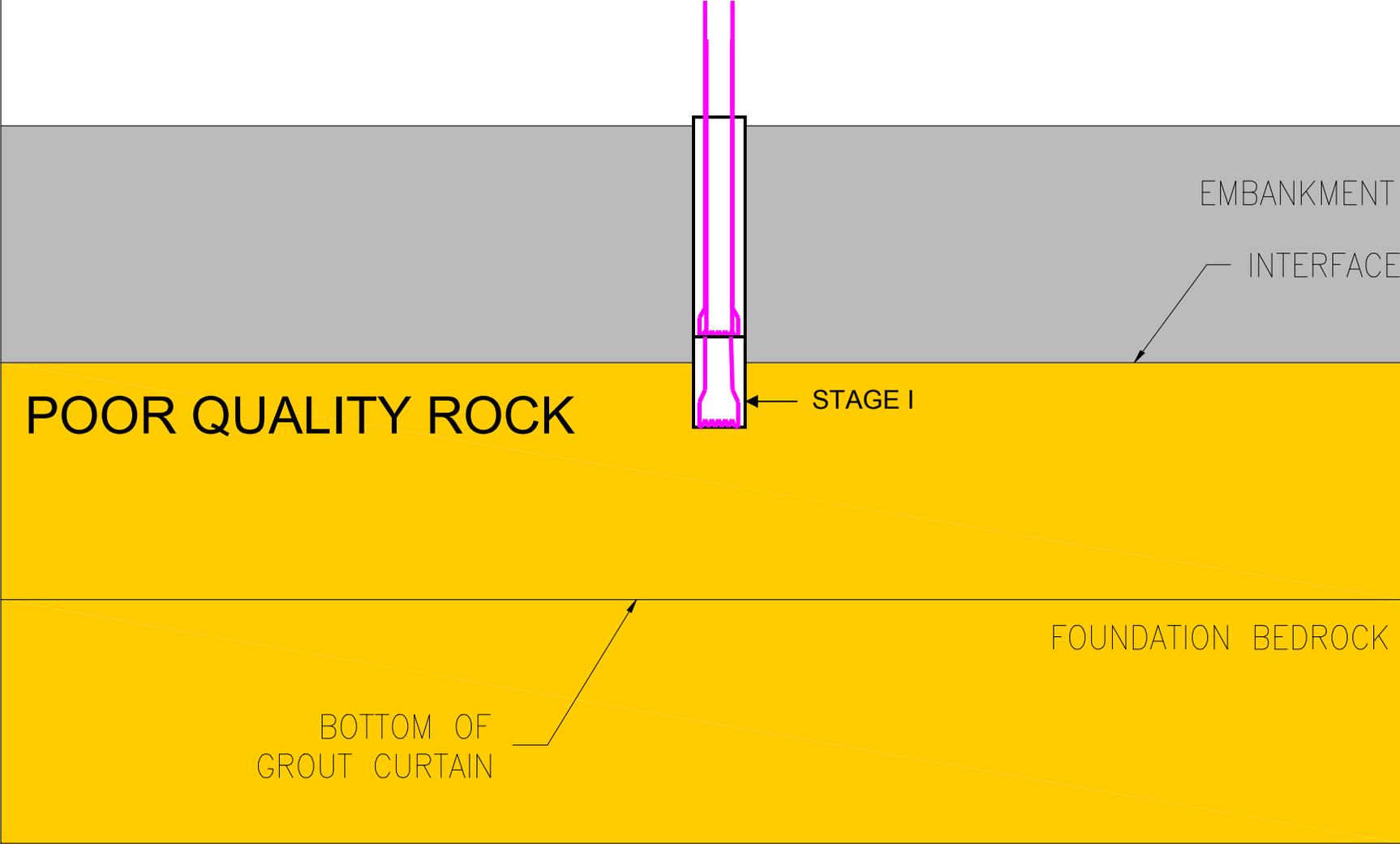
Single Packer Upstage Grouting



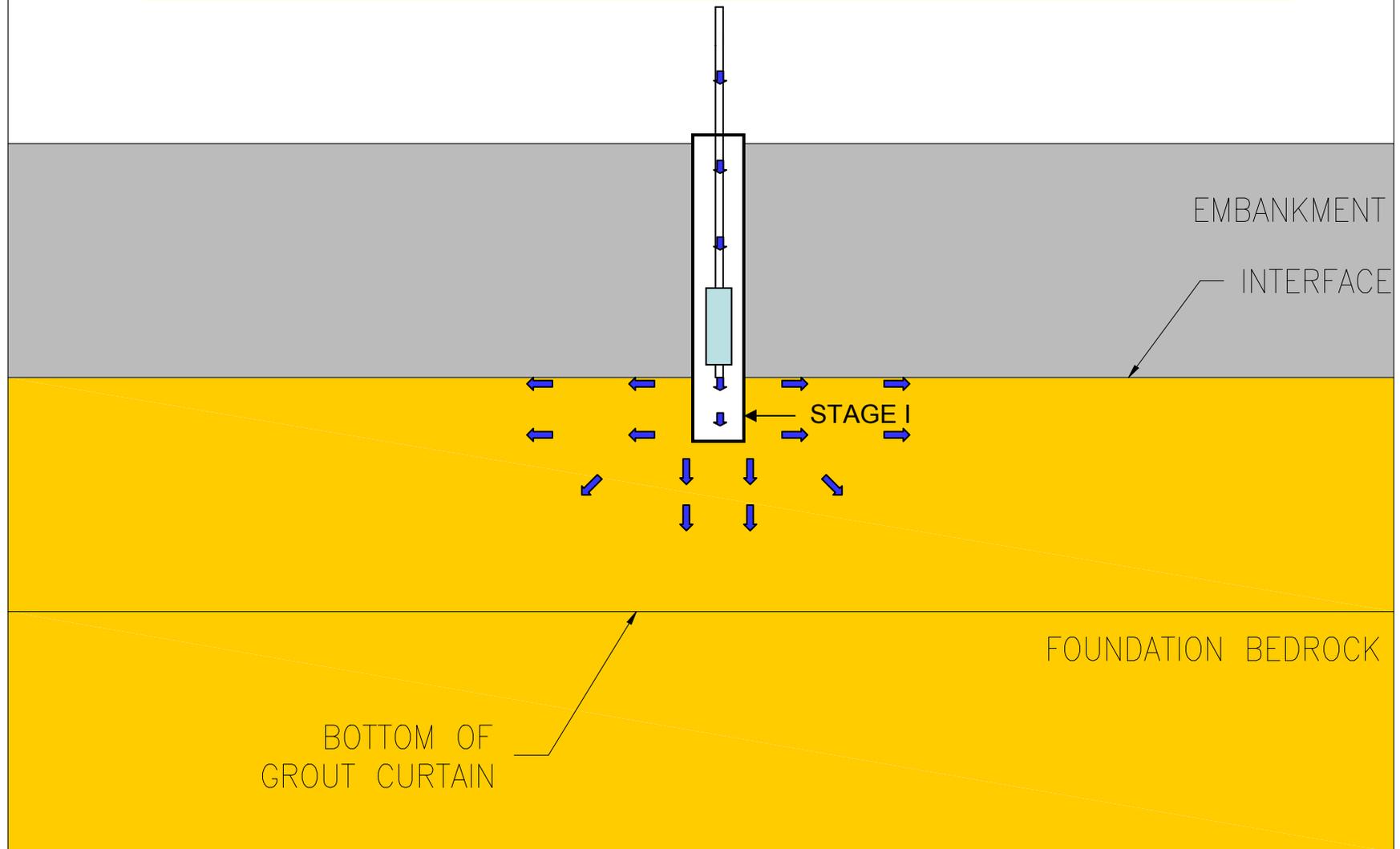
Single Packer Upstage Grouting



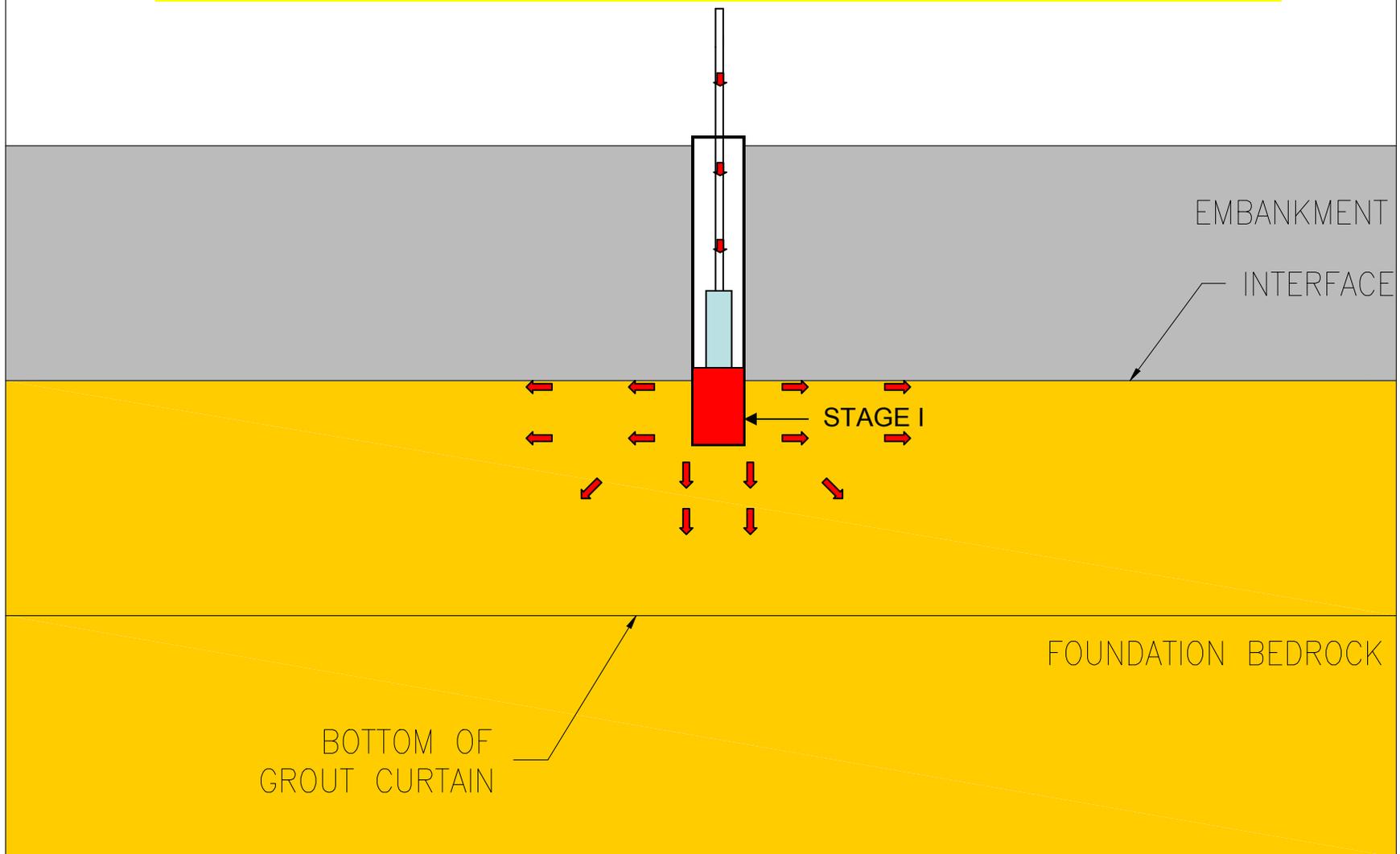
Downstage Drilling



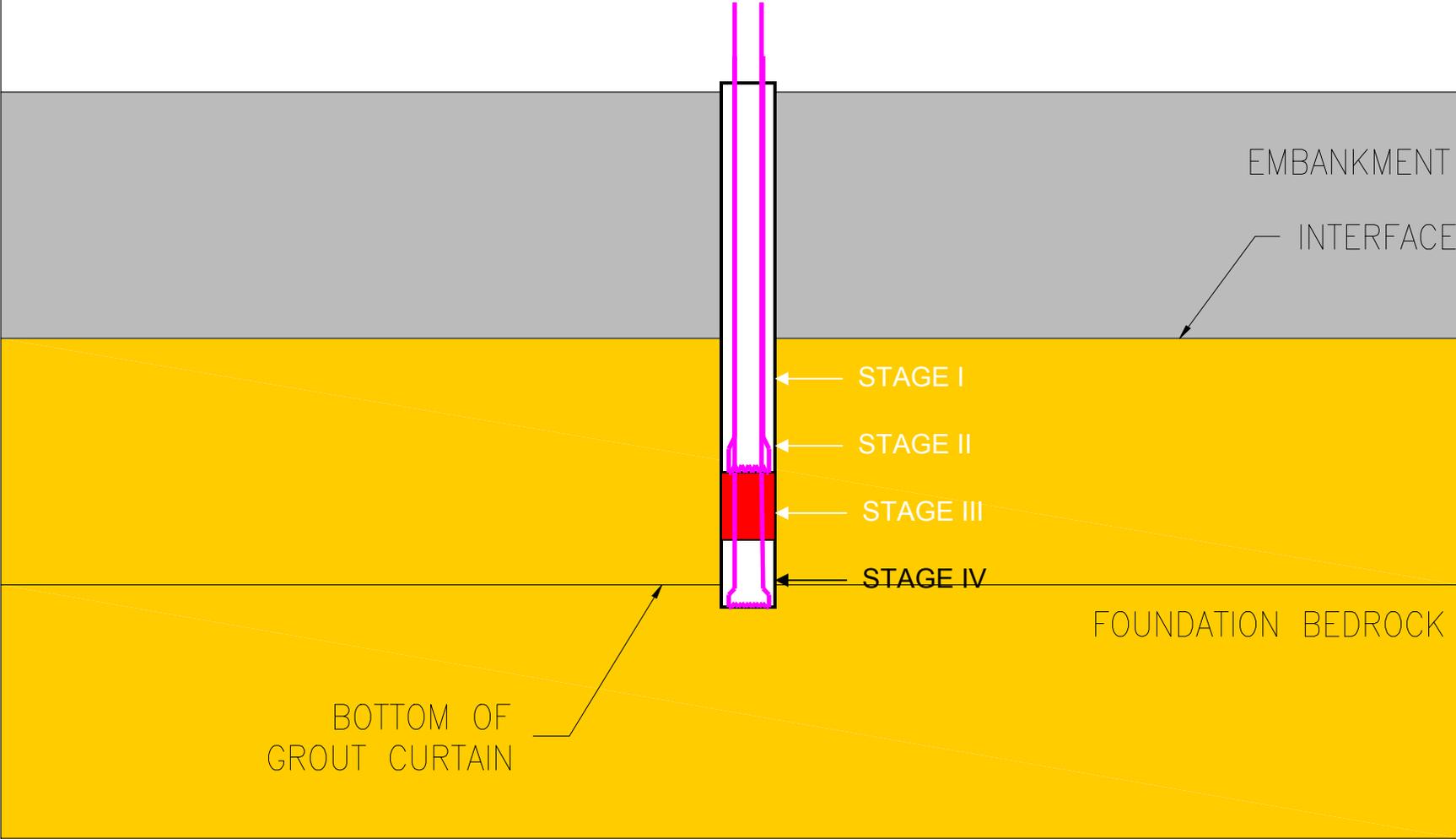
Downstage Water Testing



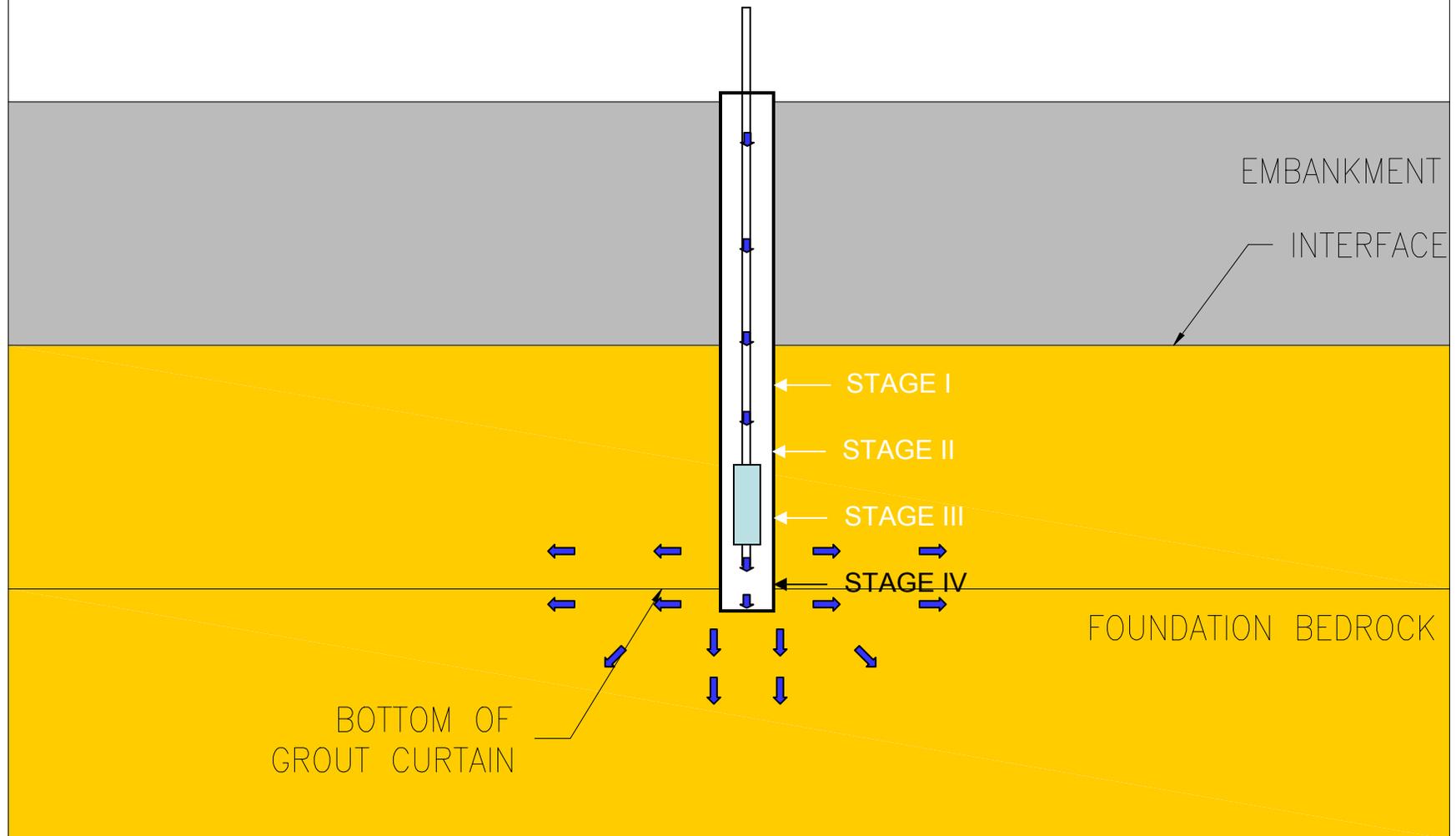
Downstage Grouting



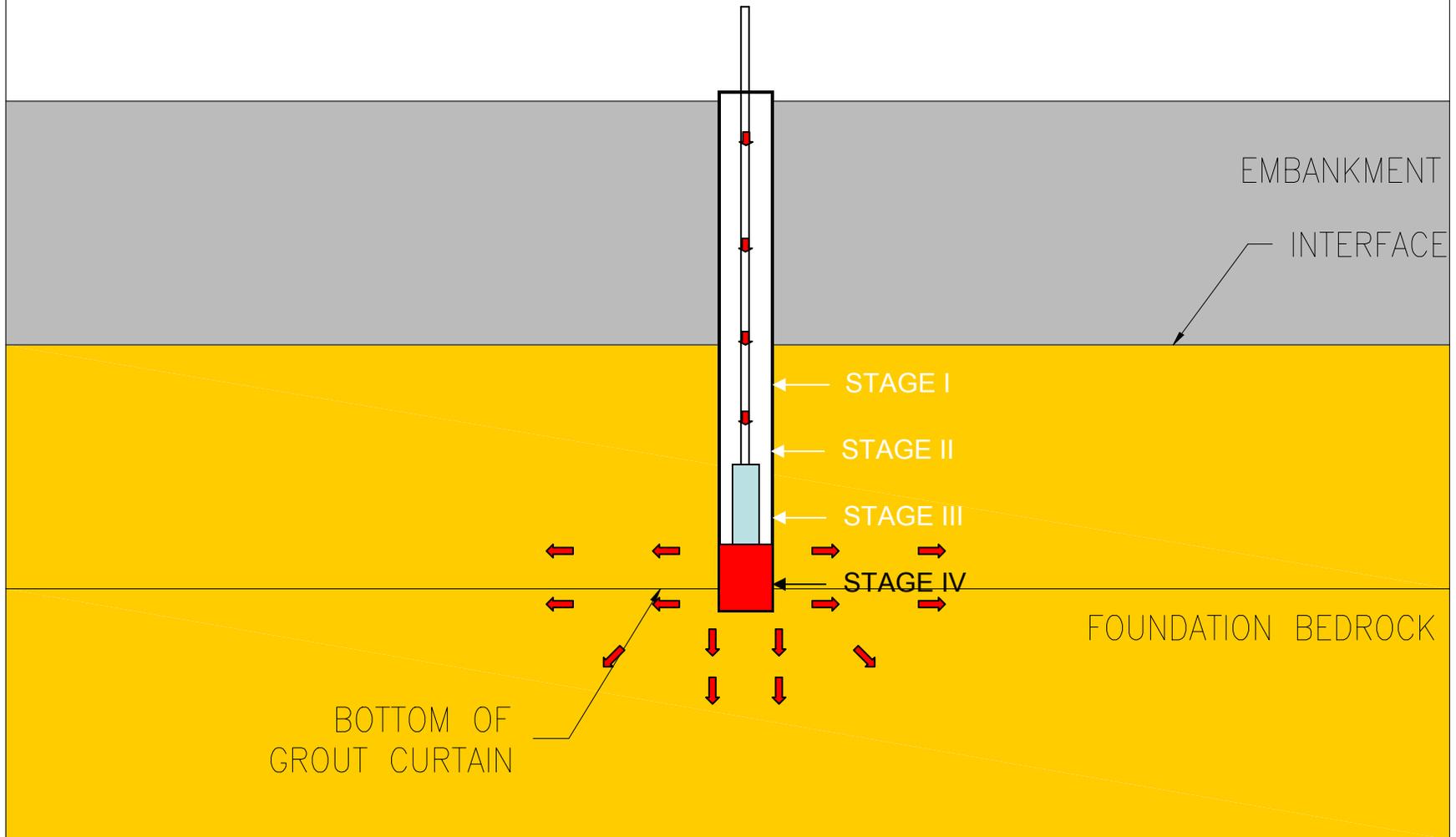
Downstage Drilling



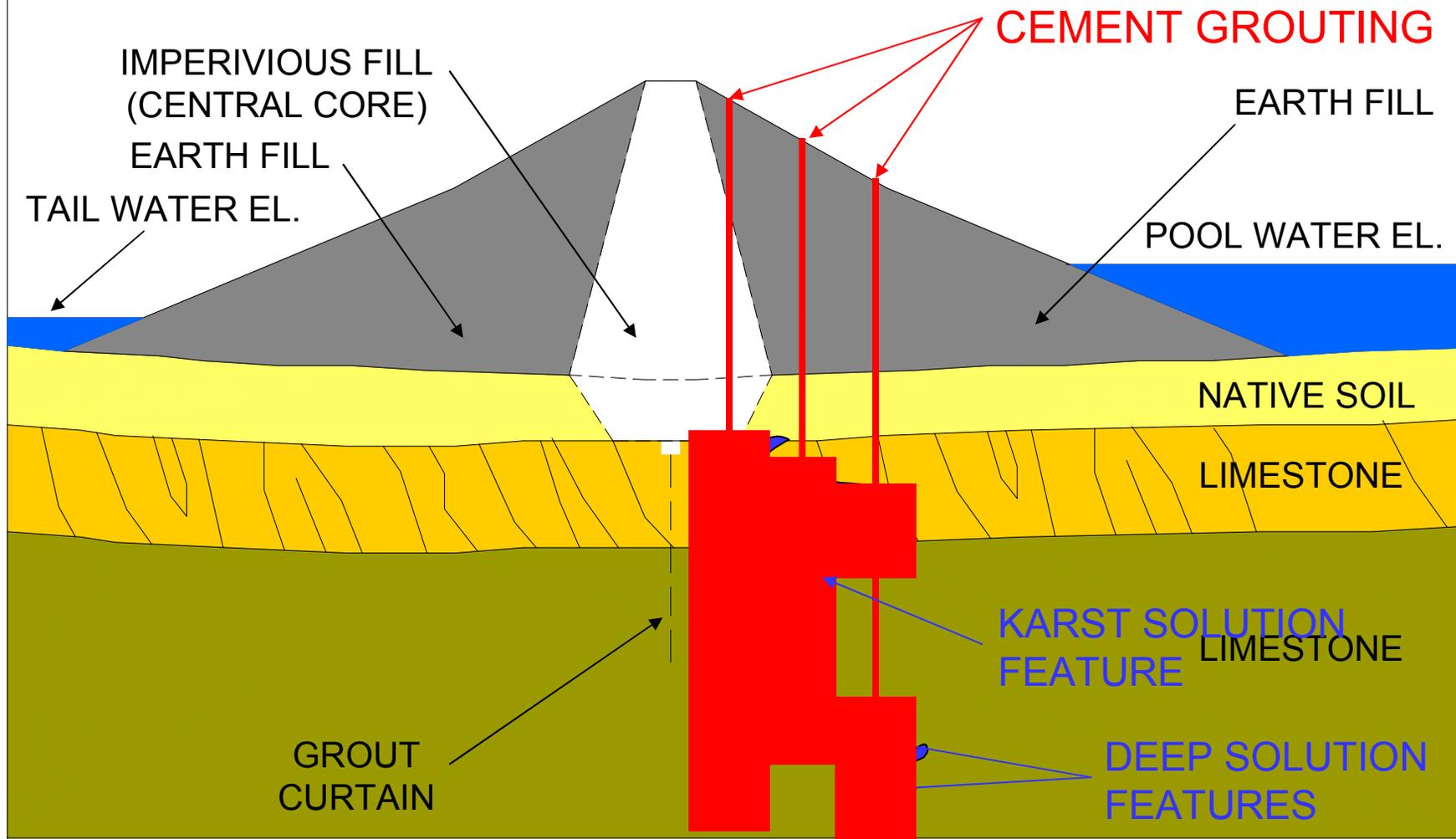
Downstage Water Testing



Downstage Grouting

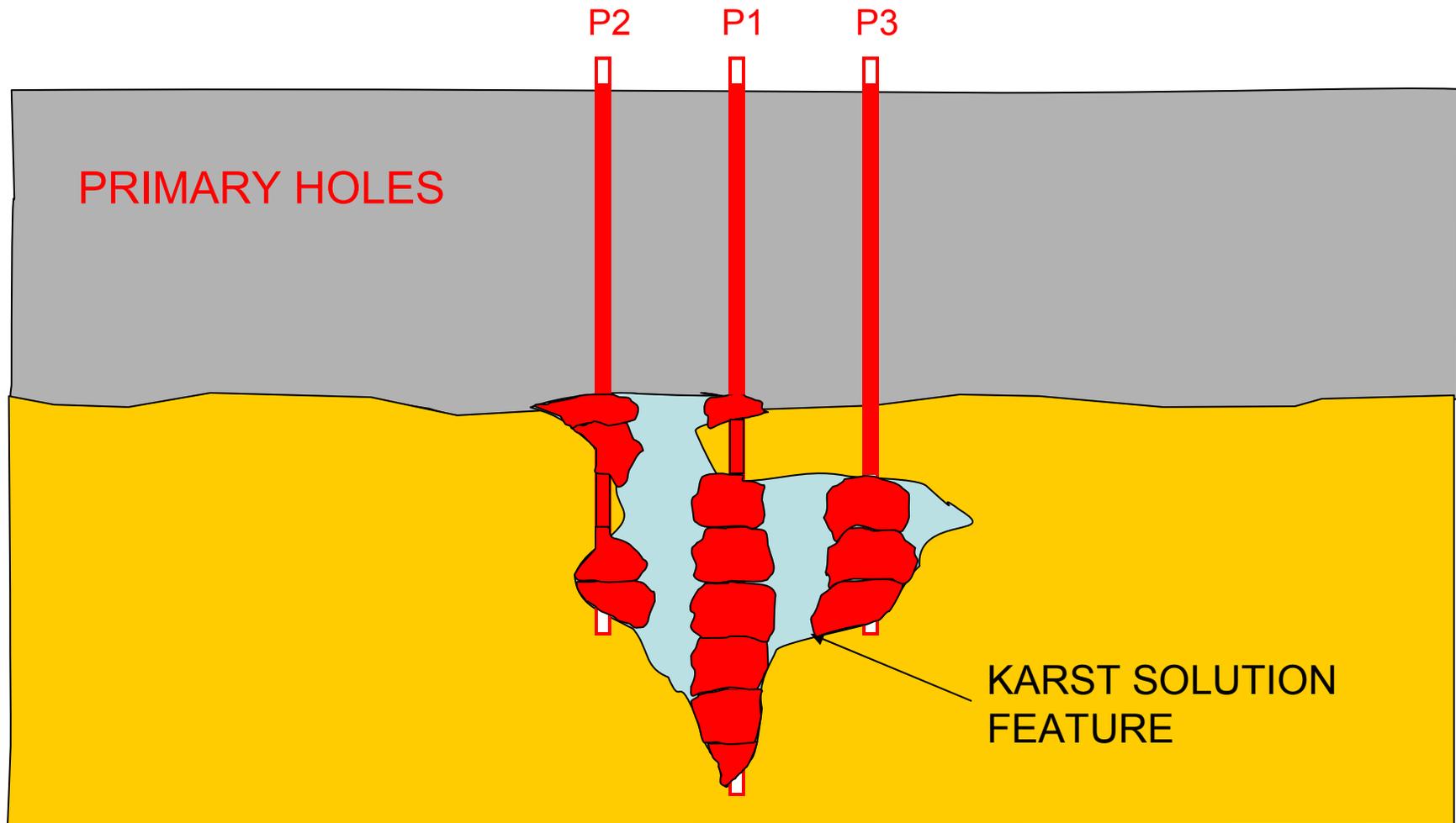


Probable Solutions for Karst Solution Features

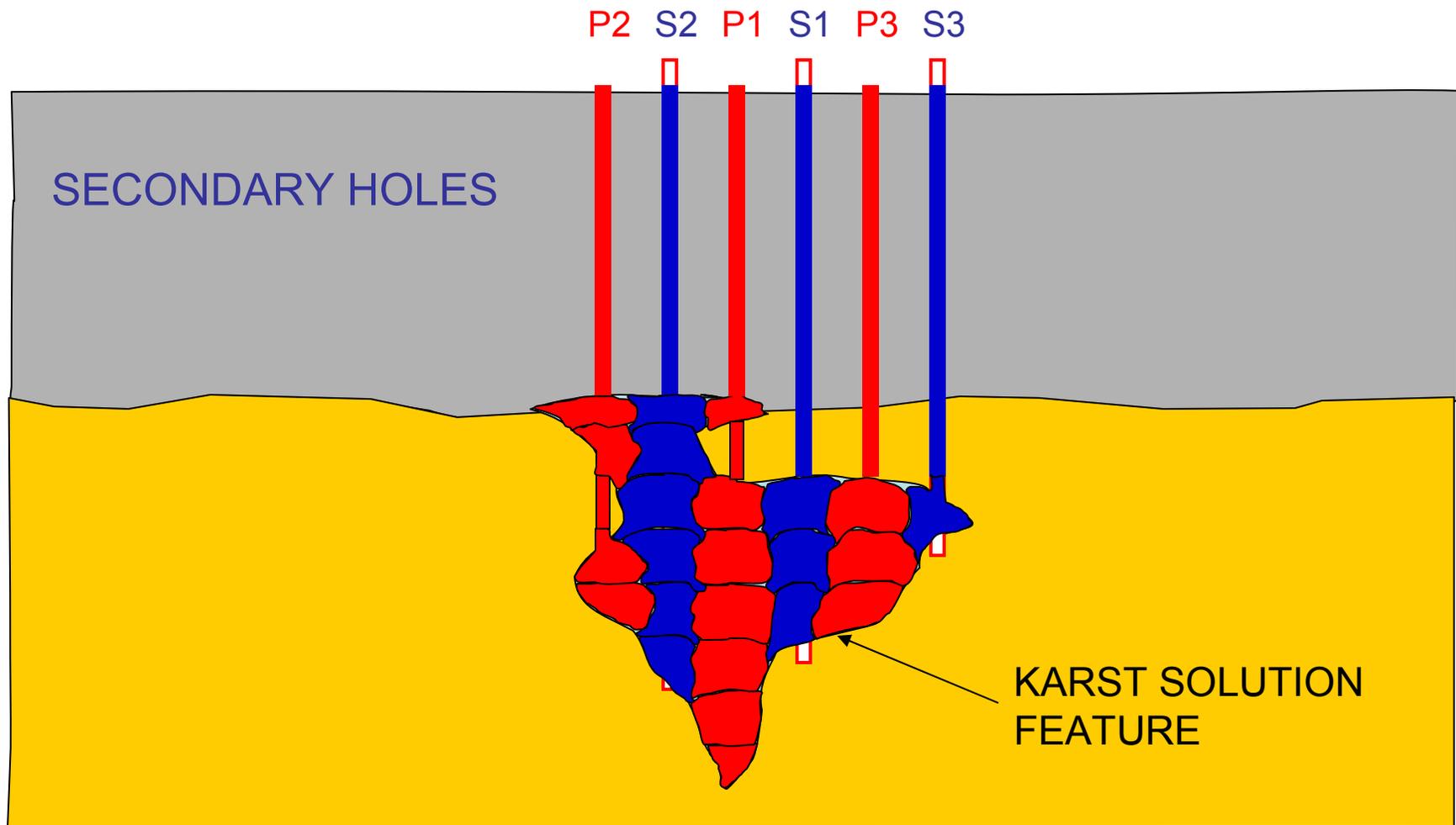


Solution Feature Remediation

(Upstage Casing Extraction (LMG or HMG))

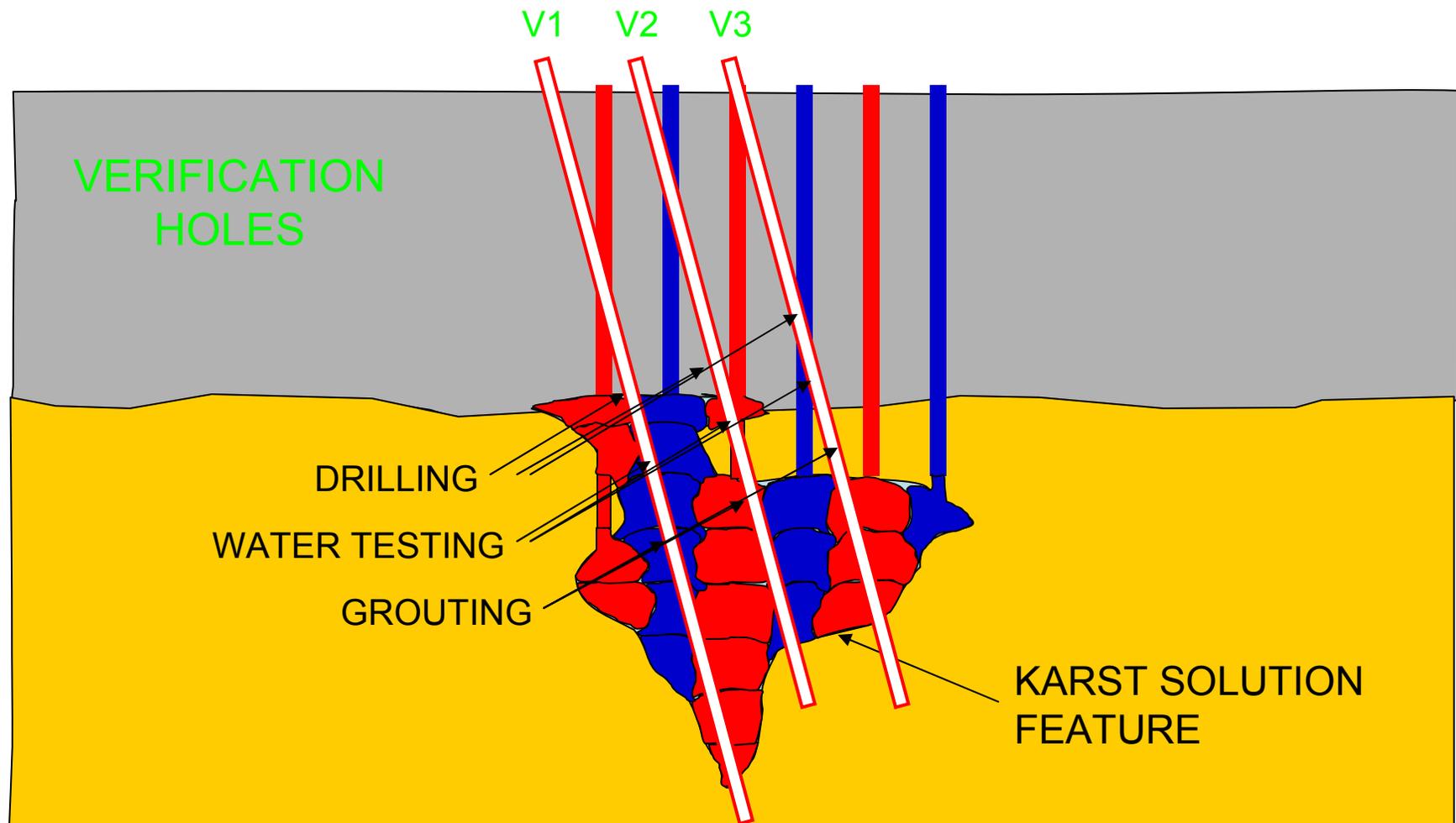


Solution Feature Remediation (Upstage Casing Extraction (LMG or HMG))

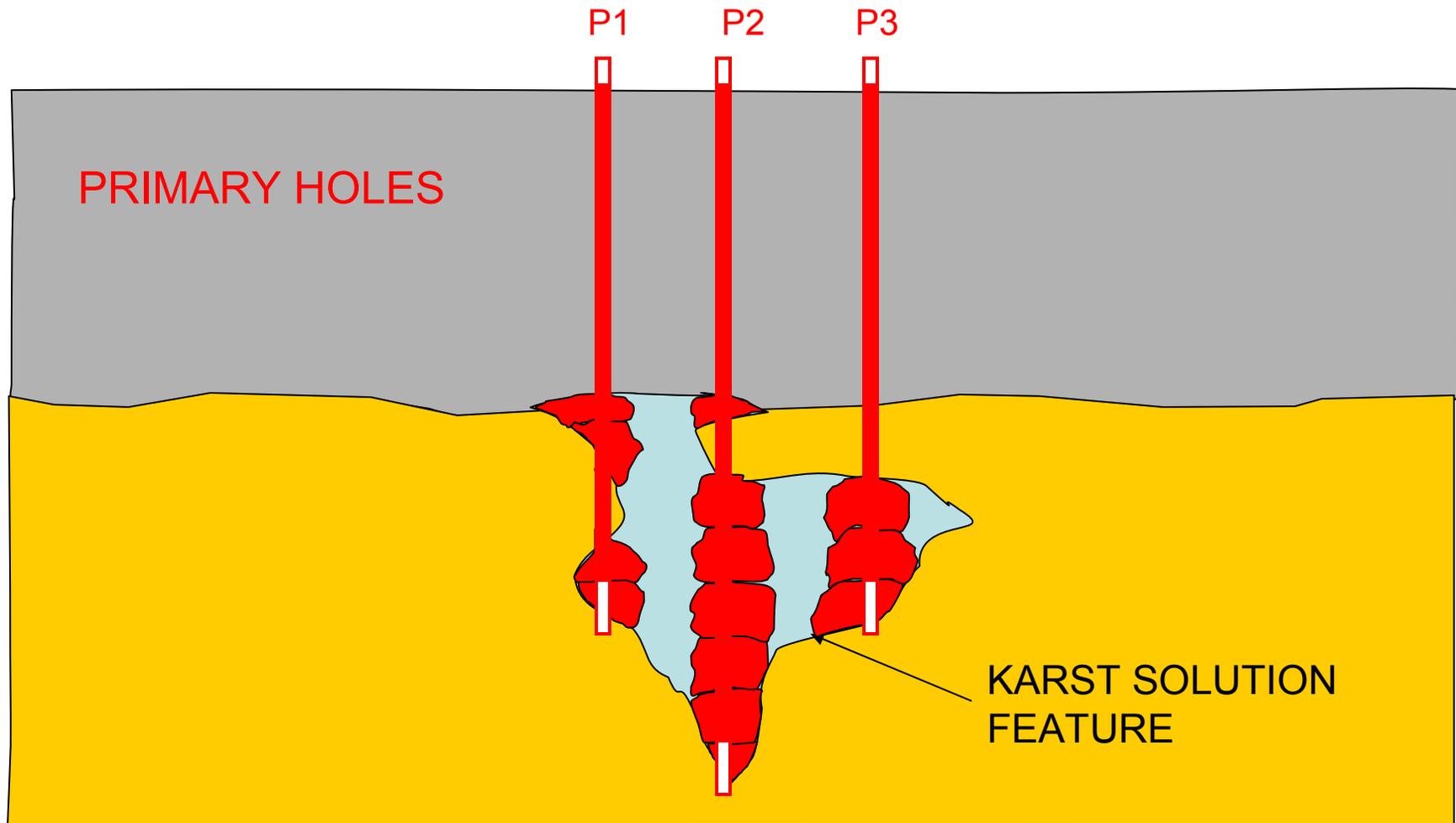


Solution Feature Remediation

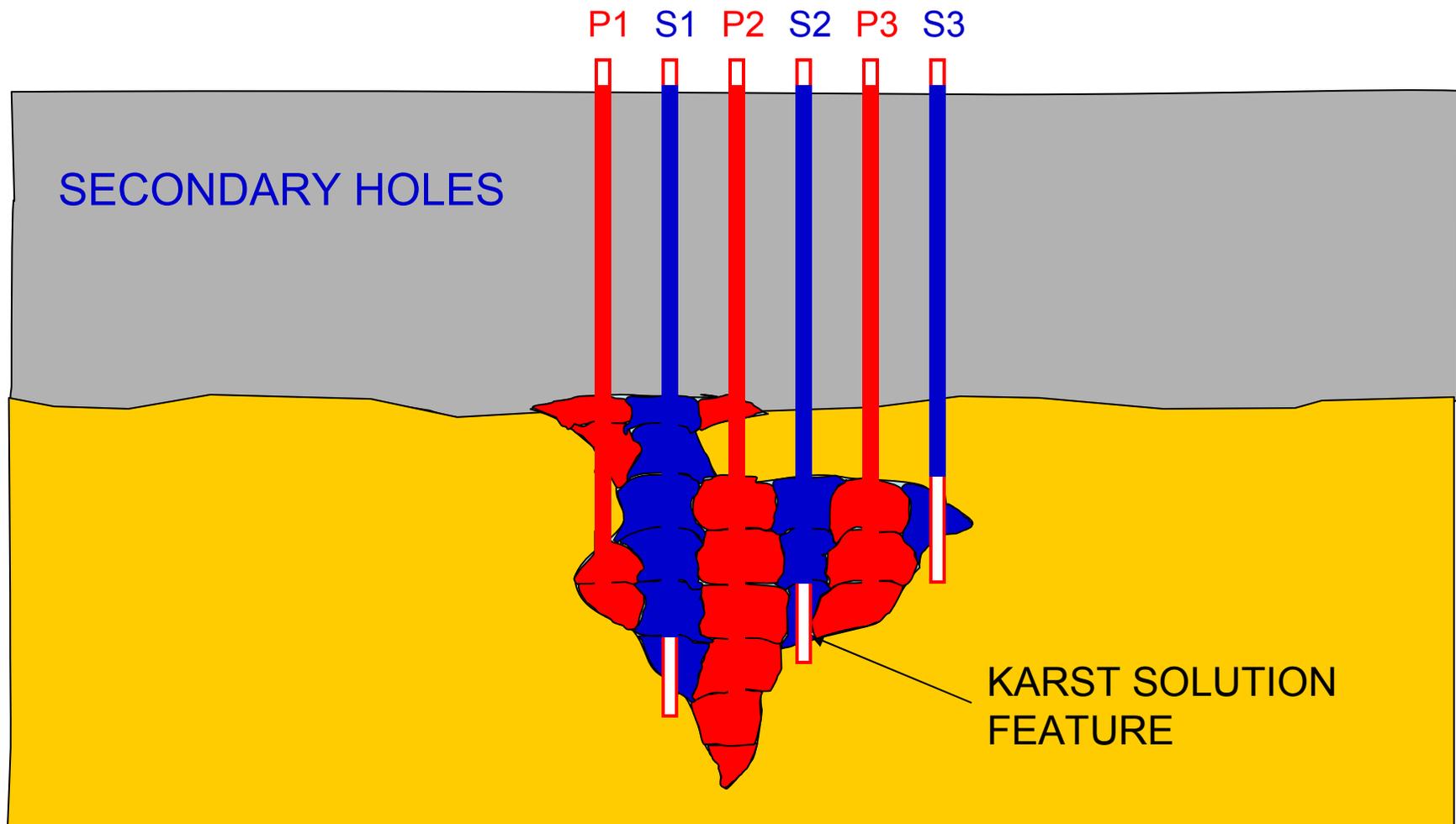
(Upstage Casing Extraction (LMG or HMG))



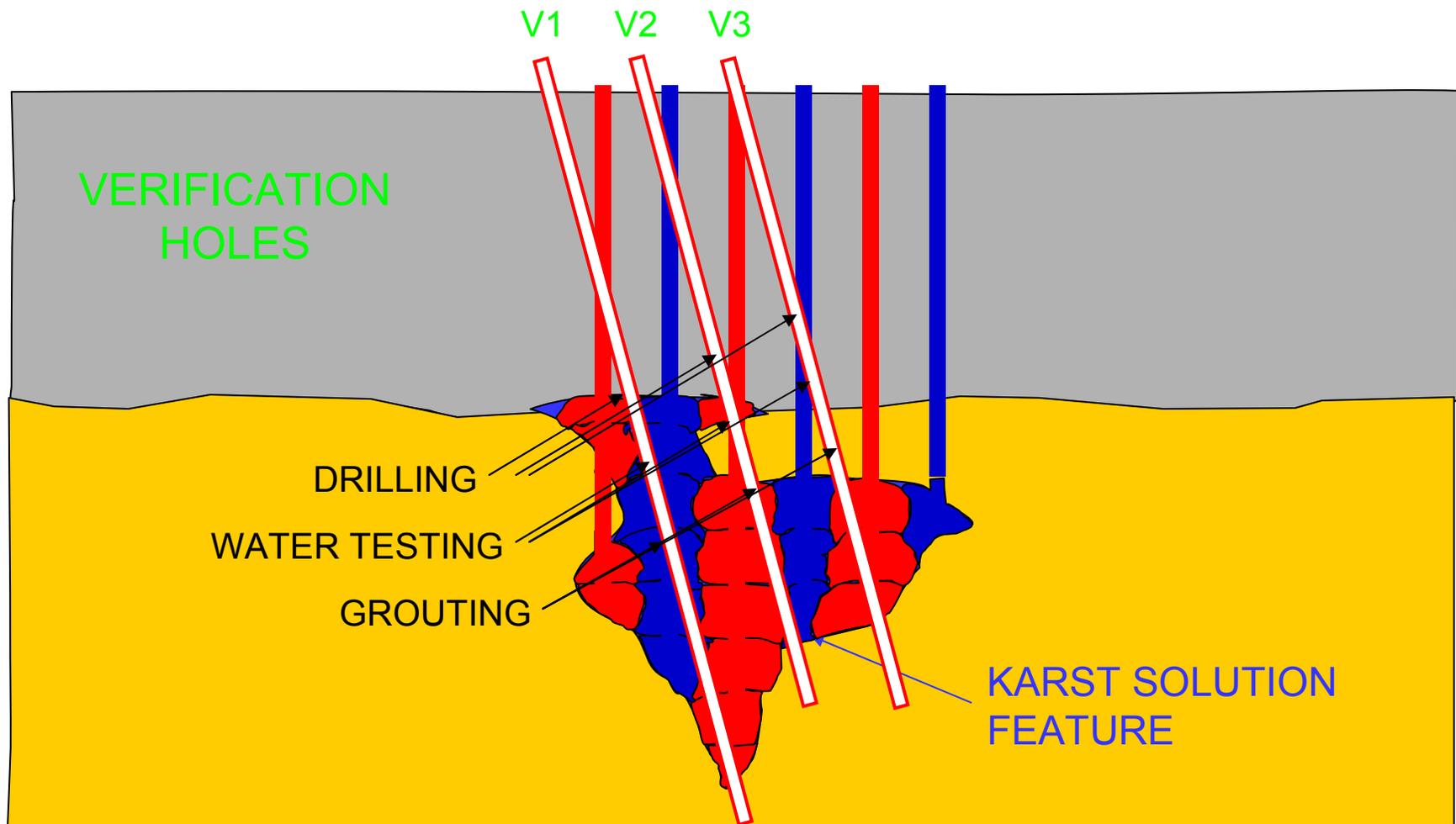
Solution Feature Remediation (Downstage Grouting (LMG or HMG))



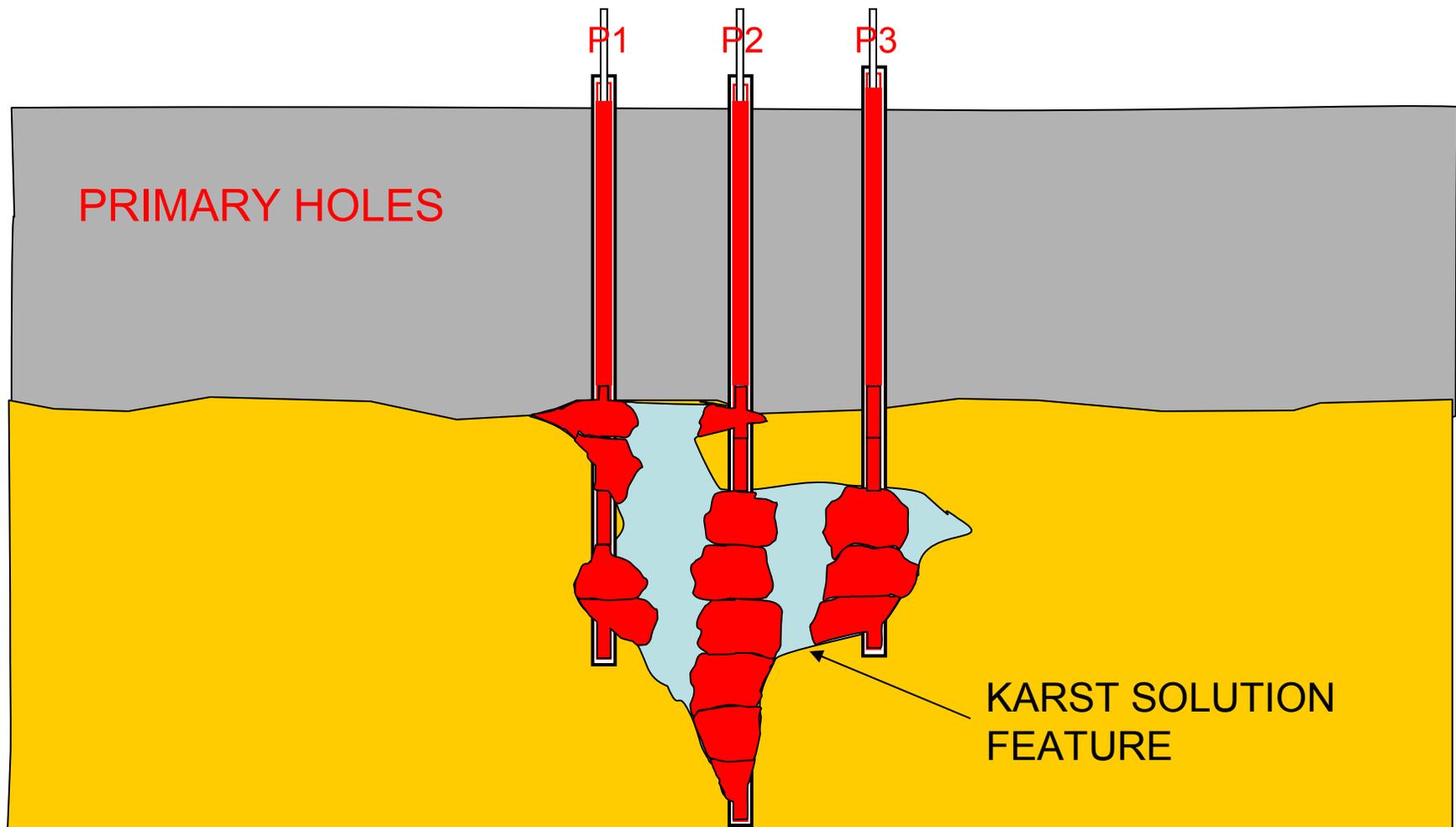
Solution Feature Remediation (Downstage Grouting (LMG or HMG))



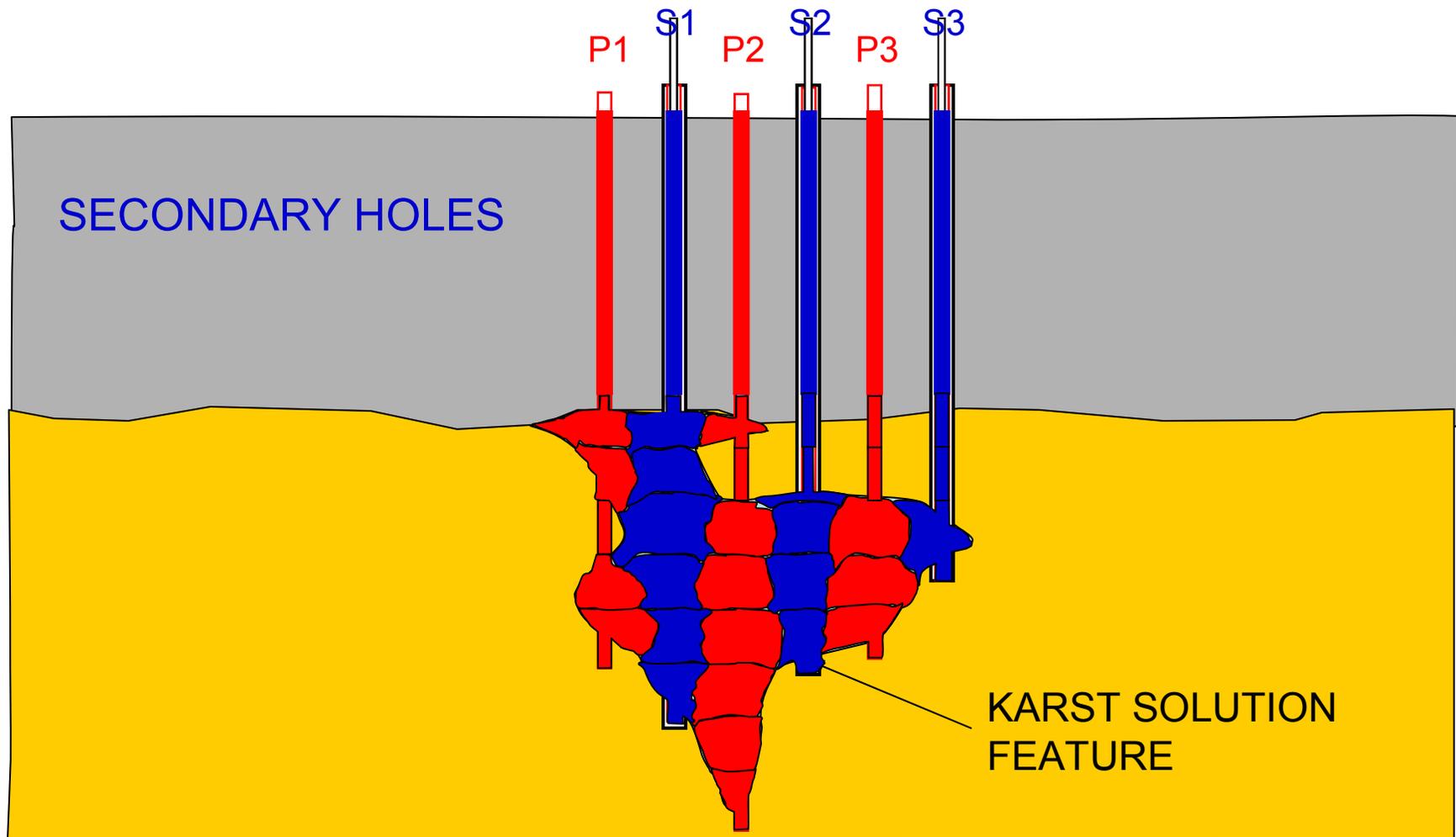
Solution Feature Remediation (Downstage Grouting (LMG or HMG))



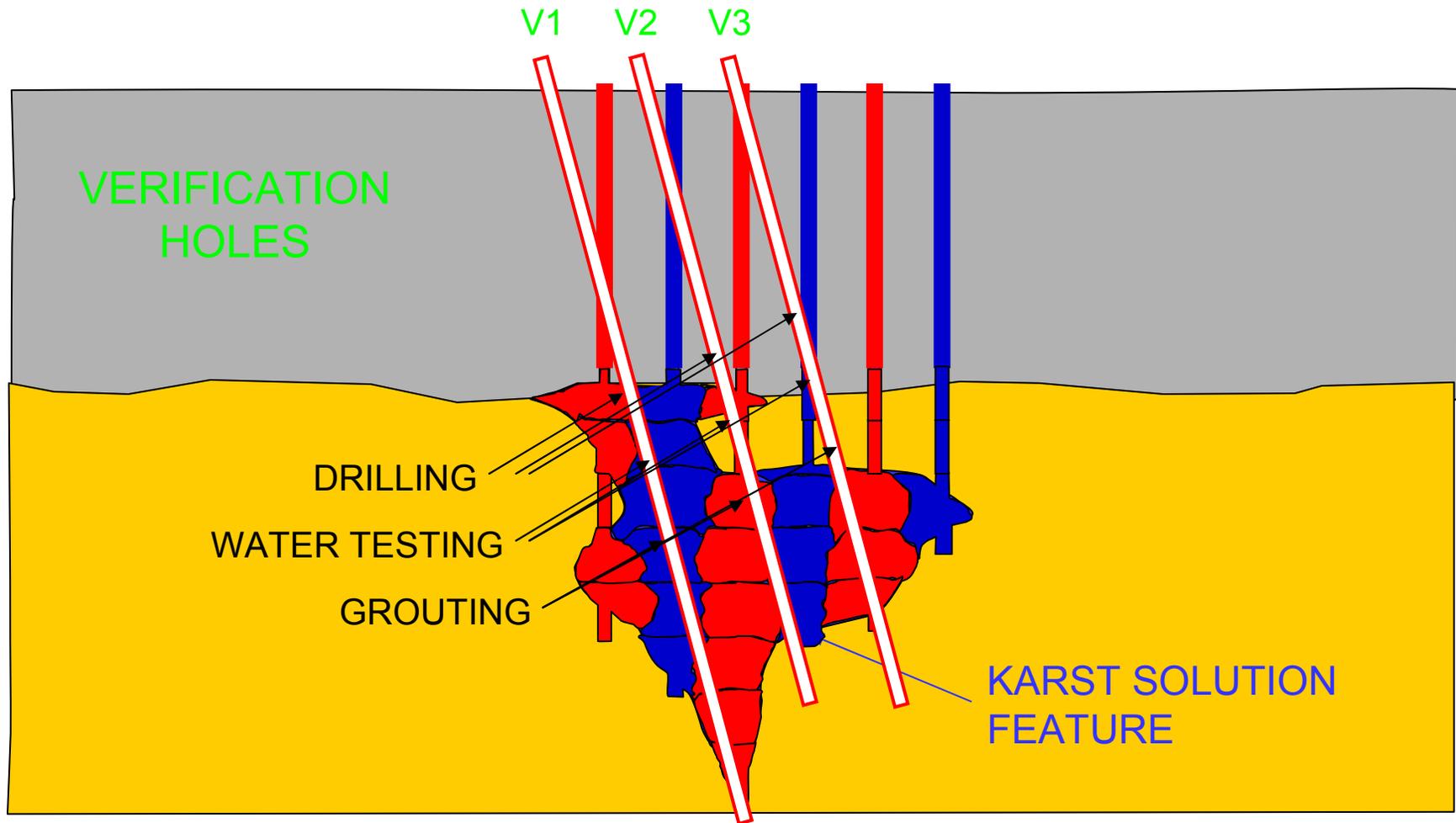
Solution Feature Remediation (Upstage Sleeve Pipe Grouting (HMG))



Solution Feature Remediation (Upstage Sleeve Pipe Grouting (HMG))



Solution Feature Remediation (Upstage Sleeve Pipe Grouting (HMG))



Key Elements for Drilling and Grouting Embankment Dams

- Exploration
 - Site Characterization
- Execution
 - Grouting Method
- Verification

THANK YOU

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