

Detailed Investigation for Leakage Detection and Flow Path Identification within an Embankment

Project Description

Subsidence was observed along the crest of an embankment dam and in the vicinity of adjacent buildings as a result of a suspected dam leakage and the associated internal erosion (suffusion). The embankment consists of heterogeneous porous fill material and is protected on the waterside by layers of interlocked basalt blocks. The location of the leakage was unknown. Several monitoring wells had been installed along the embankment. However, the observed groundwater levels showed no apparent hydraulic correlation, and local modelling of groundwater flow within the embankment was therefore not possible and the location of a potential leakage could not be determined. Multi-well tracer tests were considered unlikely to succeed because of the expected high flow velocities and the spatial limitations at the site. For this reason in-situ flow measurements were suggested.

Hydrogeological Setting

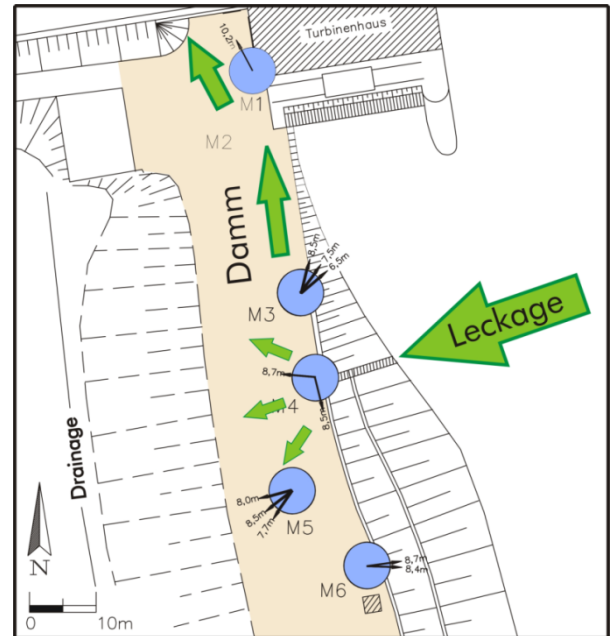
Heterogeneous, artificial porous aquifer (silty sand, partly boulders)

Purpose of Investigation

- Detailed investigation for risk assessment
- Localization of the embankment leakage and identification of preferential flow paths
- Planning basis for repair measures and remediation strategy

Key Findings

To identify the location of the leakage, horizontal in-situ groundwater flow measurements were carried out in monitoring wells installed along the crest of the embankment. The measurements revealed very high flow velocities as well as a high load of suspended fine-grained material. This indicated the erosion and redistribution of fine sediments and, consequently, the development of highly permeable preferential flow paths within the embankment. In particular, a major preferential flow path could be identified parallel to the underground building structures, allowing the location of the leakage zone to be determined. The results proved highly valuable for assessing the urgency of remedial action and for developing an appropriate remediation strategy.



Client Benefits

- Identification of the dam leakage
- Evidence of internal erosion within the embankment
- Identification of preferential flow paths within the embankment
- Assessment of the urgency of remedial measures
- Planning basis for repair works and remediation strategy

Client

International civil engineering company

Services

- Monitoring well camera inspections
- Horizontal in-situ groundwater flow measurements
- Evaluation, Project documentation, Analysis

Project Scope

- 5 monitoring wells (2-inch diameter)
- Measurement depths: 1–10 m
- Total measurement time: 10 hours

Project Location

Baden-Württemberg, Germany

991P123

Groundwater Flow around a Tunnel Structure

Project Description

To monitor the risk of groundwater backing-up in front of a tunnel structure and a groundwater corridor associated with fluctuating river water levels in an urban environment, an annual monitoring program is carried out at several monitoring wells. The results are compared with an existing standard groundwater flow model.

Hydrogeological Setting

Unconsolidated porous aquifer (fine sand to gravel)

Purpose of Investigation

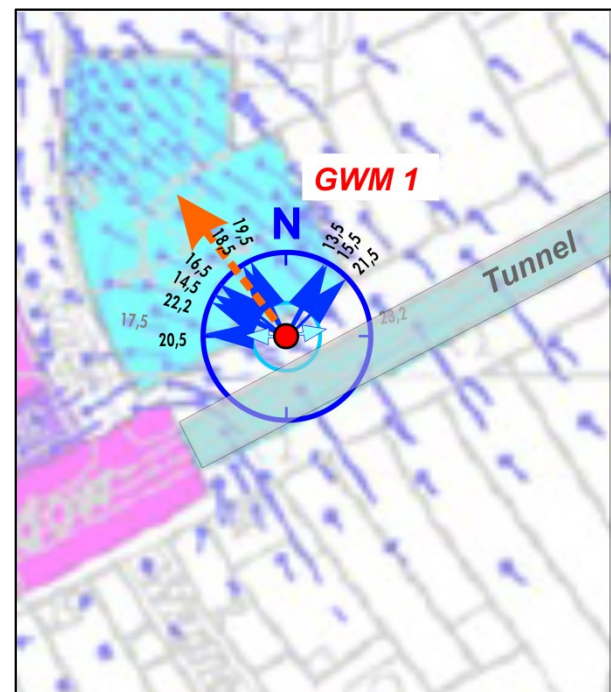
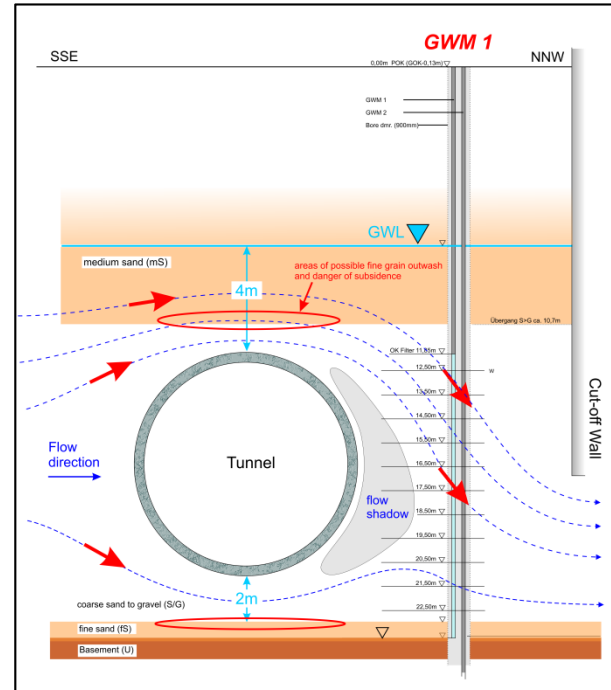
- Monitoring of potential groundwater damming upstream of the tunnel structure
- Validation of groundwater flow models
- Risk assessment and long-term hydraulic monitoring

Key Findings

The results presented here refer to one monitoring campaign conducted at groundwater monitoring well GWM 1. The combination of vertical and horizontal in-situ flow measurements allows a coherent and reliable interpretation of the complex groundwater flow conditions in the vicinity of the tunnel structure shown in the upper figure. The horizontal flow measurements confirm the groundwater flow model shown in the figure below and demonstrate that, at the time of investigation, the tunnel structure acted as a highly effective hydraulic barrier to the upstream groundwater flow, bearing the risk of groundwater backing up. Ground-water is diverted around the structure both over the tunnel roof and beneath the tunnel basement, perpendicular to the tunnel axis.

The flow along the tunnel roof and the subsequent flow under a cut-off wall running parallel to the tunnel axis generate high downward-directed vertical flow movements in this area. The monitoring well itself demonstrably acts as a preferential vertical flow pathway.

The flow measurements support the interpretation of the groundwater flow conditions illustrated in the upper figure. Considering the lithological conditions, high flow velocities may result in the erosion and redistribution of fine-grained sediments in the vicinity of the tunnel roof and basement.



The results also indicate that the upgradient area requires particular protection with regard to potential contamination, as groundwater remediation would likely be complex.

Groundwater Flow around a Tunnel Structure

Technical Challenges

Horizontal groundwater flow measurements are significantly influenced by vertical flow components within the monitoring well. This results in high deviations of measured horizontal flow direction in the well screen profile. By using flow-conditioning devices with bypass function developed by PHREALOG, the influence of vertical flow on the horizontal measurements could be substantially reduced, as the vertical flow components were largely diverted through the bypass. The variability of the horizontal flow directions along the screened interval of the monitoring well caused by vertical flow movement within the gravel pack surrounding the well consequently required an increased number of horizontal flow measurements in order to determine a statistically robust mean flow direction (lower figure).

Client Benefits

- detailed proof of a complex groundwater flow situation
- Validation of an existing groundwater flow model for a specific hydraulic situation
- Annual reassessment of groundwater backing-up risks

Client

Civil Engineering consultancy on behalf of a Municipal authority

Services

- Borehole camera inspections
- Vertical and horizontal in-situ groundwater flow measurements
- Data evaluation and project documentation

Project Scope

- * 2–3 monitoring wells (5-inch diameter)
- * Measurement depths: 10–25 m

Project Location

North Rhine-Westphalia, Germany

Project Duration

Annual monitoring program since 2011 (presented results: November 2024)

241P230

Groundwater Flow Investigation for the Design of a Ground Freezing System for a Tunnel Cross-Passage

Project Description

As part of an urban tunnel construction project running in a north–south direction, tunnel cross-passages are to be constructed within groundwater-saturated Quaternary sediments under the protection of artificially frozen ground bodies. Local groundwater flow is influenced by a groundwater dewatering system operated north of the tunnel alignment.

To assess the risk of flow-induced thermal erosion of the frozen ground bodies, reliable information on local groundwater flow direction and velocity was required. In-situ groundwater flow measurements were therefore carried out in surrounding monitoring wells, with particular focus on the flow conditions at the depth of the planned tunnel cross-passages.

Hydrogeological Setting

Quaternary sandy-gravelly porous aquifer

Purpose of Investigation

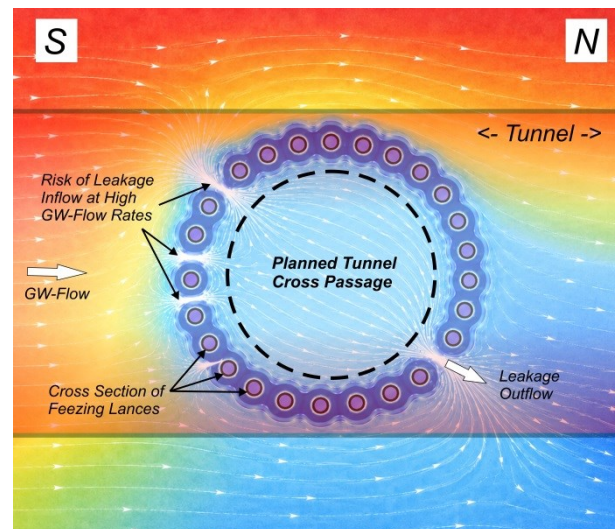
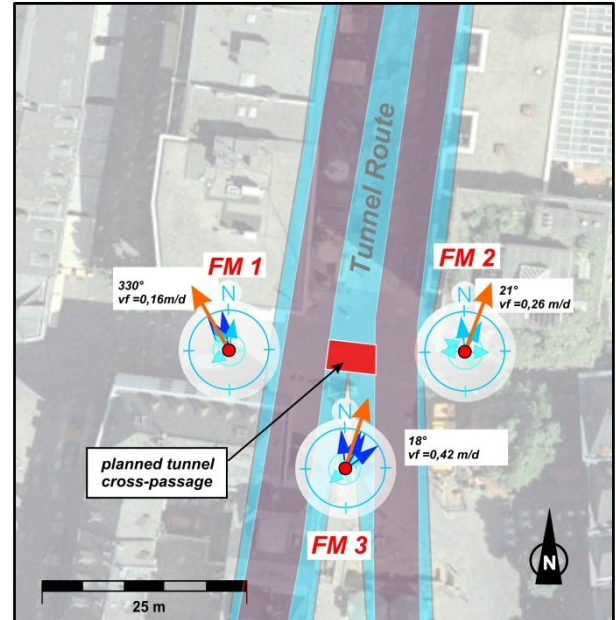
Hydrogeological site investigation for the design of a ground freezing system for a tunnel cross-passage. The objective was to assess the risk of flow-induced thermal erosion and the resulting potential weakening or leakage of the frozen ground body.

The measured groundwater flow data provided a hydrogeological basis for the design and arrangement of the freezing pipes and for dimensioning the ground freezing system, including its required energy demand.

Investigation Results

In-situ groundwater flow measurements in four monitoring wells positioned along the tunnel alignment showed predominantly northward groundwater flow parallel to the tunnel alignment and towards the operating groundwater dewatering system. The measured flow velocities were low and provided an important basis for assessing the expected flow-induced heat transfer in the vicinity of the planned frozen ground bodies.

The directly measured groundwater flow directions and velocities were used as additional



hydrogeological input data for assessing the risk of thermal erosion and for dimensioning the ground freezing system.

Additional groundwater flow measurements under modified hydraulic boundary conditions supplemented the data set and enabled the effects of different groundwater dewatering scenarios on local groundwater flow, and consequently on the design of the tunnel cross-passages, to be evaluated.

Groundwater Flow Investigation for the Design of a Ground Freezing System for a Tunnel Cross-Passage

Customer Benefits

- Directly measured groundwater flow data for assessing the risk of thermal erosion of the frozen ground body
- Additional hydrogeological data basis for the arrangement of freezing pipes, the dimensioning of the ground freezing system and for thermal modelling
- Assessment of the influence of local hydraulic boundary conditions on groundwater flow
- Evaluation of the effects of different groundwater dewatering scenarios on the design of the ground freezing system
- Provision of directly measured flow data for groundwater flow
- Verification of monitoring well construction and condition

Client

Joint venture of civil engineering contractors and a municipal public transport company

Services

- Monitoring well camera inspections
- Horizontal in-situ groundwater flow measurements
- Project documentation and Presentation

Project scope

- 4-8 Monitoring wells (5-6 inch diameter)
- Measurement depth: 12-30m

Location

North Rhine-Westphalia, Germany

Duration

4 days

081P106

Investigation into the Cause of a Hydraulic Heave Failure at an excavation enclosure

Project Overview

Following the construction of an approximately 25 m deep excavation enclosure, a local hydraulic heave failure occurred above the base sealing layer. To investigate the cause of the failure and assess the local groundwater flow conditions, vertical and horizontal in-situ groundwater flow measurements were conducted in several surrounding monitoring wells

Hydrogeological Setting

Unconsolidated porous aquifer (pyroclastic deposits /pumice, fine sand to coarse gravel)

Purpose of Investigation

The objective of the investigation was to identify the hydraulic pathways responsible for the inflow and to provide data for the ongoing design of the foundation concept.

Key Findings

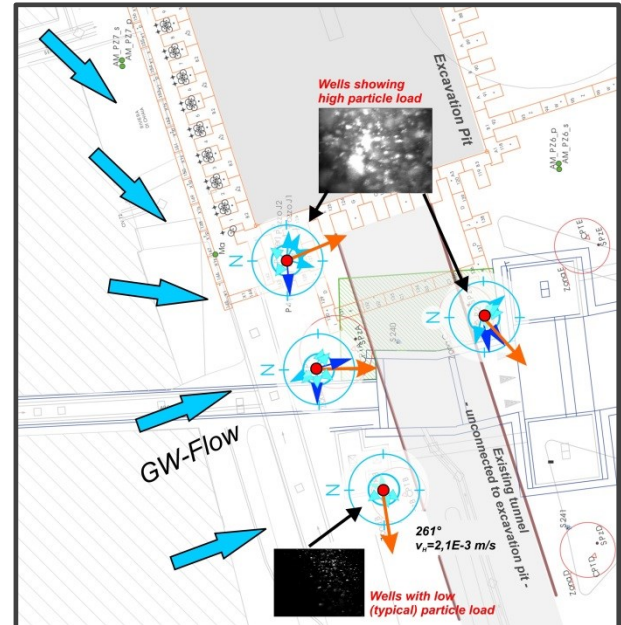
In-situ flow measurements revealed distinct hydraulic pressure horizons, high groundwater flow velocities, and significant fine-particle mobilization in monitoring wells located within the flow field around the excavation pit. The information obtained was important for identifying the underlying causes of the hydraulic failure and for planning the subsequent measures. The measurements demonstrated that incoming groundwater was flowing along highly permeable volcanic layers and around the excavation enclosure. As a result, at the level of these permeable layers, the cement grout within the bored-pile walls had been eroded during construction in the peripheral areas of the box structure. As excavation progressed, groundwater was able to enter the excavation through these eroded zones. The measurement results therefore provided a consistent explanation for the observed hydraulic failure and an important data basis for further construction and remediation planning

Client

International civil engineering contractor

Client Benefits

- Information to support identifying the cause of the hydraulic heave failure
- Identification of preferential groundwater flow paths along highly permeable volcanic layers
- Evidence of high groundwater flow velocities and mobilization of fine-grained material



- Detailed understanding of the hydraulic conditions around the excavation support system
- *Data basis for further construction and remediation planning
- Directly measured groundwater flow data for groundwater flow modelling
- Documentation of hydraulic conditions for evidence preservation

Services

- Vertical and Horizontal in-situ groundwater flow measurements
- Data evaluation, project documentation

Project Scope

18 monitoring wells (4–6 inch diameter)
Measurement depths: 10–35 m

Project Duration

2.5 weeks

Site location

Italy

Special Requirements

- Transport logistics
- Extensive project preparation
- Administrative coordination

141P156+141P157

Hydrogeological Investigation for a Flood Protection Structure

Project Description

A flood protection structure was planned in a riverbed underlain by highly permeable sediments to compensate for fluctuations in downstream water levels caused by variable releases from an upstream dam. To support the design of the structure, it was necessary to investigate groundwater flow within the entire aquifer profile, with particular emphasis on the deeper sections of the riverbed. The objective was to obtain reliable hydraulic data for the design of the cement grout and to assess the potential transport and washout of the grout by groundwater flow during injection.

Hydrogeological Setting

Unconsolidated porous aquifer (sand to gravel) overlying bedrock

Purpose of Investigation

- Hydrogeological site investigation for foundation design
- Investigation of groundwater flow dynamics throughout the aquifer profile
- Provision of data for the design of cement grouting works
- Assessment of the risk of grout losses due to high groundwater flow velocities

Key Findings

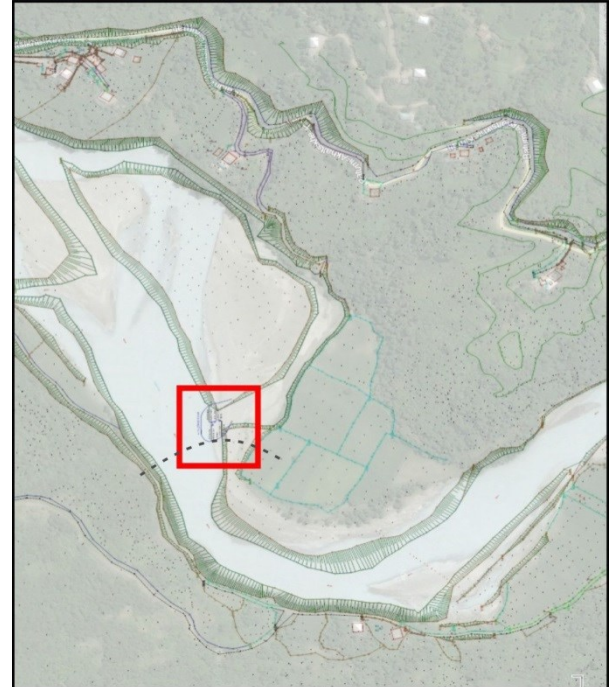
The in-situ groundwater flow measurements conducted in the monitoring wells revealed unexpectedly high flow dynamics extending locally down to the base of the riverbed. Even within the deepest investigated sections, high flow velocities and locally highly irregular to turbulent flow conditions accompanied by mobilization and redistribution of fine-grained material were observed.

The measurements demonstrated that hydraulically highly active zones were not restricted to the shallow subsurface but extended down to the planned foundation level of the cut-off structure.

The measured flow data provided important input for the foundation design, the design of the cement grouting works, and the assessment of potential grout losses during injection.

Client Benefits

- Data basis for project and foundation design
- Evidence of high groundwater flow dynamics extending down to the base of the riverbed
- Detailed understanding of depth-dependent groundwater flow conditions
- Data for the design of cement grouting works and assessment of potential grout losses
- Directly measured groundwater flow data for groundwater flow modelling



- Verification of monitoring well construction and condition

Client

International civil engineering Company

Services

- Borehole camera inspection
- Horizontal in-situ groundwater flow measurements
- Data processing, interpretation and project documentation
- Presentation of project results

Project Scope

8 monitoring wells (4-inch diameter)

Measurement depths: 7–30 m

Site location

Country of Georgia

Project Duration

9 days

Special Requirements

- International transport logistics
- Technical project preparation
- On-site coordination under demanding field conditions

121P141

Groundwater Flow Investigation for Micropile Installation in an Underwater Concrete Base Slab

Project Description

As part of the rehabilitation of a ship lock chamber, the underwater concrete slab is to be secured against uplift using vertical micropiles. To assess the risk of the concrete suspension placed into the pile boreholes using the Tremie-method being washed out by groundwater flow, in-situ flow measurements were conducted in two temporarily installed groundwater monitoring wells along the depth profile of the planned micropiles. As the lock structure represents a significant hydraulic barrier for the passing groundwater, increased groundwater flow was expected particularly beneath the structure within highly permeable sediment layers.

Hydrogeological Setting

Unconsolidated porous aquifer (sand to gravel)

Purpose of Investigation

- Detailed investigation for risk assessment during micropile installation
- Assessment of the risk of groundwater-induced washout of fresh concrete
- Provision of data to support micropile quality and load-bearing capacity

Key Findings

Horizontal in-situ groundwater flow measurements at five depths in each monitoring well showed that groundwater flow velocities within the depth interval relevant to the planned micropiles were low despite the high permeability of the surrounding sediments. The measured groundwater flow was predominantly directed parallel to the lock structure towards the downstream side. Based on the measured flow conditions, the risk of groundwater-induced washout of the fresh micropile concrete was assessed as low. The measurements therefore provided direct data for assessing the geotechnical risk and supporting quality assurance during micropile construction.

Client Benefits

- Direct data for assessing the risk of concrete wash-out
- Reduction of uncertainties related to subsurface conditions during micropile installation
- Support for ensuring micropile quality and load-bearing capacity
- Contribution to quality assurance and cost certainty
- Directly measured groundwater flow data for further groundwater flow modelling

Client

Federal Waterways and Shipping Administration

Services

- Monitoring well camera inspections
- Horizontal in-situ groundwater flow measurements
- Data analysis and project documentation

Project Scope

- 2 monitoring wells / 2" diameter
- Measurement depths: 12–19 m

Site location

Rhineland-Palatinate, Germany

Project duration

2 days

Technical Challenges

- Working in a Restricted-Access Area
- Difficult Site Access

181P194

