

Detailed Investigation to Support a Groundwater Discharge Model

Project Description

In the downgradient area of a landfill, the hydrogeological setting is characterized by glacial deposits and buried Pleistocene channel systems, significantly complicating the modelling of local groundwater flow conditions and contaminant transport. In-situ groundwater flow measurements were carried out to support the refinement of the hydraulic and transport models.

Hydrogeological Setting

Partially heterogeneous porous aquifer (sand, gravel and boulders)

Purpose of Investigation

Characterization of groundwater flow conditions in different sedimentary structures to obtain information on the distribution of preferential flow paths.

Key Findings

The horizontal in-situ groundwater flow measurements showed that the shallow-screened monitoring wells exhibit a general groundwater flow direction towards the north, whereas the deeper-screened monitoring wells indicate an easterly flow direction following a channel structure.

The measurements further demonstrated that groundwater flow velocities in the upper aquifer are approximately one order of magnitude higher than those in the deeper aquifer.

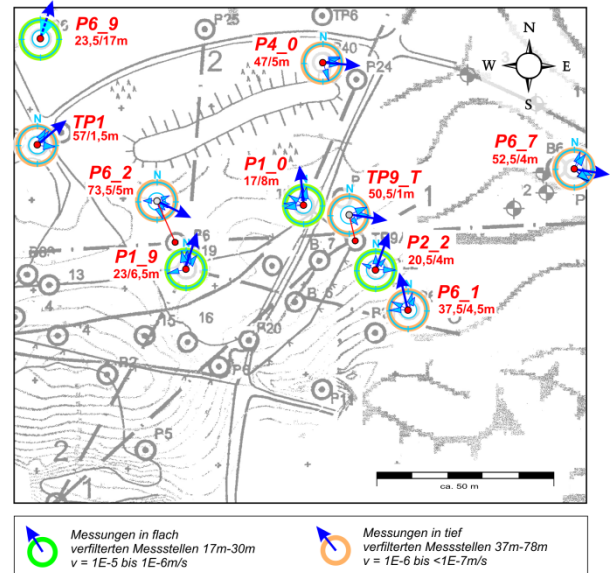
The results were used to confirm and refine the hydraulic model and to support the assessment and quantification of monitored natural attenuation (MNA) processes along the contaminant transport pathway.

Client Benefits

- Plausibility assessment and refinement of the groundwater flow model
- Improved understanding of the aquifer system
- Provision of data for further groundwater flow modelling and remediation planning
- Verification of well construction and condition

Client

Engineering consultancy



Services

- Borehole camera inspections
- Electrical conductivity and temperature measurements
- Horizontal in-situ groundwater flow measurements
- Data evaluation and project documentation

Project Scope

- 10 monitoring wells, DN125 (5-inch diameter)
- Measurement depths: 17–80 m
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Project Location

Mecklenburg-Western Pomerania, Germany

Project Duration

7 days

031P047

Depth-Resolved Investigation of Groundwater Flow in a Heterogeneous Porous Aquifer

Project Background

Downstream of a groundwater contamination site, a heterogeneously structured porous aquifer is accessed by a groundwater monitoring well with an 11 m screened interval. To assess contaminant migration and verify existing model assumptions, detailed information on groundwater flow dynamics throughout the aquifer profile was required.

Hydrogeological Setting

Heterogeneous porous aquifer (silt / sand / gravel)

Purpose of Investigation

- Detailed investigation of groundwater flow dynamics throughout the aquifer profile
- Plausibility check of the existing contaminant transport model
- Acquisition of directly measured groundwater flow data for model refinement

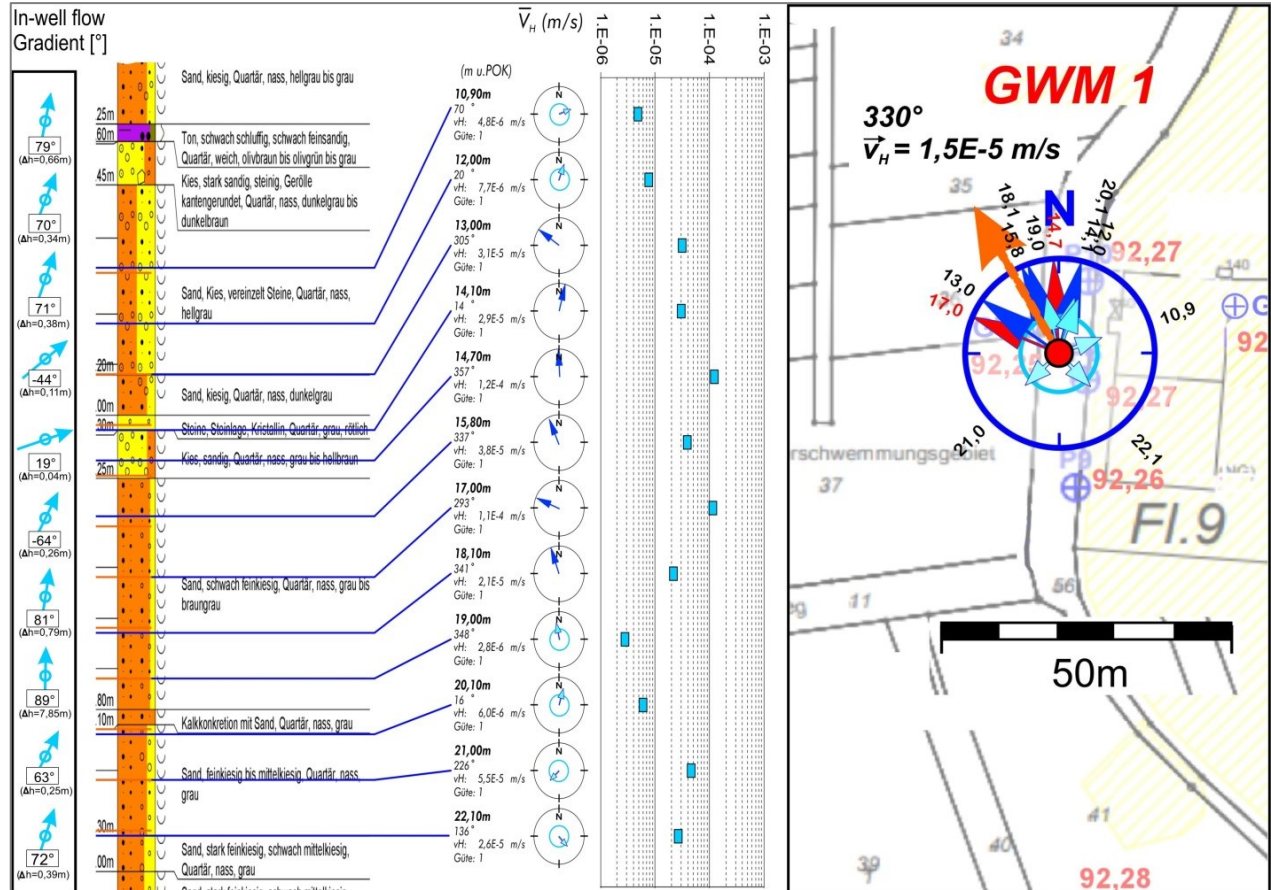
Investigation Results

A camera inspection conducted prior to the flow measurements revealed deposits within the monitoring well, while the screen slots remained open

throughout the entire screened interval. Due to the 11 m long screen, vertical in-situ flow measurements were performed first. These measurements revealed consistently upward-directed vertical flow throughout the screened interval.

Subsequent horizontal in-situ flow measurements were conducted in multi-level mode using flow-guiding devices simultaneously at three measurement depths. This provided a high vertical measurement resolution throughout the aquifer profile while substantially reducing the influence of the existing vertical flow within the monitoring well on the horizontal flow measurements. Horizontal measurements showed flow velocities ranging from 0.2 to 8.6 m/day and revealed a pronounced depth-dependent flow distribution within the aquifer. A depth interval with particularly high flow was identified between 14 and 17 m. Although the measured flow directions showed considerable variability, the large number of depth-resolved measurements allowed the prevailing groundwater flow direction to be reliably determined.

The combined evaluation of vertical and horizontal flow data enabled hydraulic gradients within the



Depth-Resolved Investigation of Groundwater Flow in a Heterogeneous Porous Aquifer

monitoring well to be characterized and potential vertical contaminant migration along the screened interval to be identified. The upward vertical flow also indicates hydraulic connection between different depth horizons through the long-screened monitoring well and therefore the potential for vertical contaminant mass transfer along the screened interval. The considerable variability of the results across the monitoring well profile may partly be attributed to differences in hydraulic conductivity within the sediment sequence. In this particular case, however, well ageing processes associated with the contaminant load are considered to be an additional important factor influencing the observed flow variations.

Client Benefits

- Detailed information of depth-dependent groundwater flow distribution within the aquifer
- Identification of vertical flow within the long-screened monitoring well
- Assessment of potential vertical contaminant mass transfer along the screened interval
- Supplementary directly measured flow data for the contaminant transport model
- *Data for refinement of groundwater flow and contaminant transport models
- Verification of monitoring well construction and condition for subsequent investigations

Client

Engineering consultancy on behalf of an environmental authority

Services

- Monitoring well camera inspection
- Vertical in-situ groundwater flow measurements
- Horizontal in-situ groundwater flow measurements
- Data analysis, hydraulic assessment, and project documentation

Scope of Field Work

2 monitoring wells / 5" diameter
Measurement depths: 11–22 m

Location

Hessen, Germany

Duration of Field Work

2 day

261P236

Detailed Investigation of time-varying Groundwater Flow Conditions at a Groundwater Contamination Site

Project Background

A groundwater contamination site is located south of a navigation canal with a permeable bed that is directly hydraulically connected to the groundwater system. Depending on fluctuations in groundwater and canal water levels, groundwater either infiltrates into the canal or canal water exfiltrates into the surrounding aquifer. Thus, local groundwater flow conditions are strongly influenced by the hydraulic conditions within the canal. Both flow direction and water level in the canal vary naturally and are also affected by artificial regulation. These changes have a direct impact on local groundwater flow conditions and, consequently, on the spatial distribution and migration of groundwater contamination. Due to the limited number and unfavorable spatial distribution of groundwater monitoring wells, the local groundwater flow pattern cannot be reliably determined from groundwater level measurements alone.

Hydrogeological Setting

Porous aquifer (silt to medium sand)

Purpose of Investigation

Investigation of local groundwater flow conditions under a specific hydraulic situation in the canal to assess contaminant migration and mobility resulting from the hydraulic interaction between the canal and the groundwater system.

Investigation Results

At the time of the measurements, canal flow was directed westward and hydraulic conditions resulted in groundwater inflow into the canal. Correspondingly, the monitoring wells investigated showed groundwater flow directed towards the northwest, with low flow velocities. During an earlier project phase conducted under different hydraulic conditions, groundwater flow directions ranging from southwest to southeast had been observed. The results demonstrate that changing canal water levels have a significant influence on local groundwater flow and

thereby contribute to the spatial redistribution of groundwater contamination. During the measurements, which extended over several hours, an influence of passing vessel traffic was also identified. Passing vessels produced short-term increases in flow velocity accompanied by changes in groundwater flow direction.

Client Benefits

- Improved understanding of the hydraulic system
- Characterization of time-varying groundwater flow conditions
- Provision of data for flow modelling
- Documentation of monitoring well construction and condition

Client

Engineering consultancy

Services

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

Scope of Field Work

- 2 monitoring wells / 6" diameter
- Measurement depth: 18 m

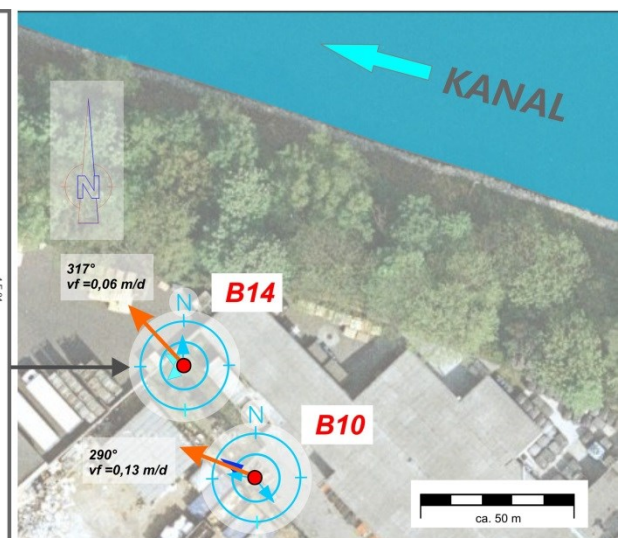
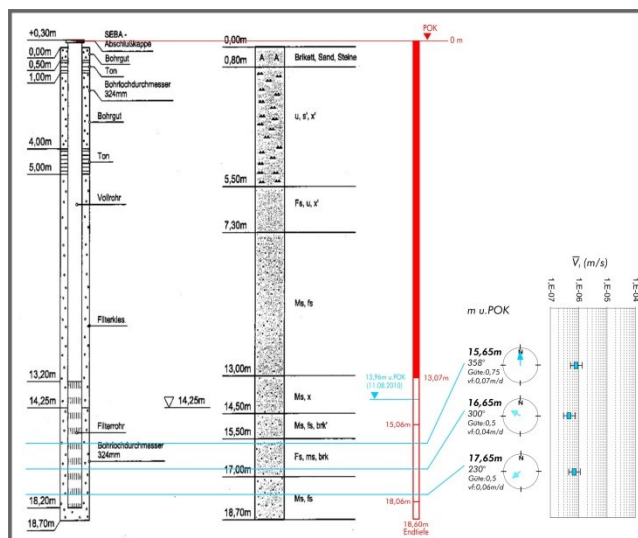
Location

Berlin, Germany

Duration of Field Work

**3 days

101119/101P124



Verification of Groundwater Flow within the Capture Zone of a Groundwater Remediation System

Project Background

An operating groundwater remediation system based on groundwater abstraction is located within a porous aquifer. To the east of the remediation site, a lake is directly hydraulically connected to the aquifer. Local groundwater flow conditions are influenced by fluctuating lake water levels, with surface water infiltrating from the lake into the aquifer. This contributes to a wider distribution and dilution of the groundwater contamination. Due to existing site constraints, only a limited number of groundwater monitoring wells were constructed and available for groundwater level measurements and the development of a groundwater flow model. Consequently, additional information was required to assess the extent of the remediation system's hydraulic influence towards the south.

Hydrogeological Setting

Porous aquifer consisting predominantly of layers of silt, sand, and gravel

Purpose of Investigation

To verify the extent of the capture zone south of the remediation system, in-situ groundwater flow measurements were conducted to obtain additional flow information for groundwater flow modelling in this area.

Investigation Results

Horizontal in-situ flow measurements were conducted at multiple depths within the monitoring wells. At almost all measurement depths, groundwater flow was directed northward towards the remediation system. Flow velocities were low and relatively uniform throughout the investigated depth

profiles. No preferential flow horizons were identified. During each measurement series, groundwater flow remained consistent in both direction and velocity, with no significant flow reversals or transient changes observed. This indicates stable hydraulic conditions during the measurement period.

Client Benefits

- Verification of groundwater flow direction and velocity towards the remediation system
- Information on groundwater flow behavior over the observation period and across the investigated aquifer profile
- Provision of data for flow modelling
- Documentation of monitoring well construction and condition

Client

Public-Sector Client

Services

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

Scope of Field Work

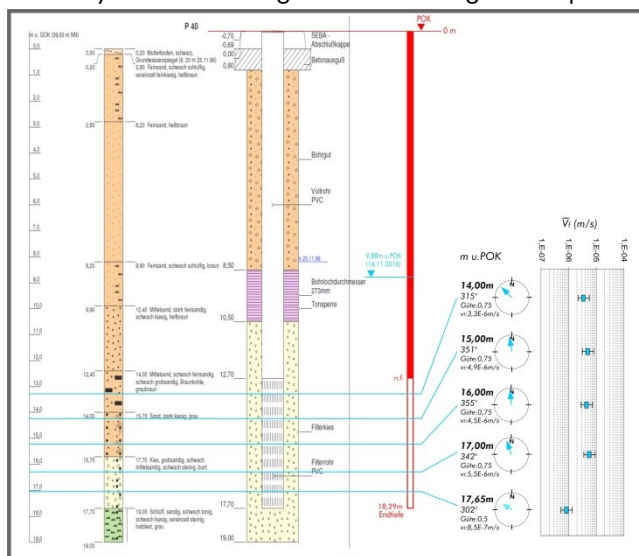
- Two monitoring wells / 5" diameter
- Measurement depth: 18 m

Location

Brandenburg, Germany

Duration of Field Work

3 days



Detailed Investigation of Groundwater Flow around a Funnel-and-Gate System

Project Background

Downstream of a groundwater contamination site, a funnel-and-gate system was installed to a depth of approximately 10 m, extending down to the underlying aquitard. Groundwater backing up on the western, upgradient side of the funnel resulted in uncertain flow conditions at the southern end of the system. Of particular concern was the possibility that contaminated groundwater could bypass the treatment system to the south without passing through the gate.

In addition, insufficient information was available on groundwater flow conditions upgradient of the funnel and within the gate area, limiting the assessment of the hydraulic performance of the system. Further investigations were therefore conducted to address these information gaps.

Hydrogeological Setting

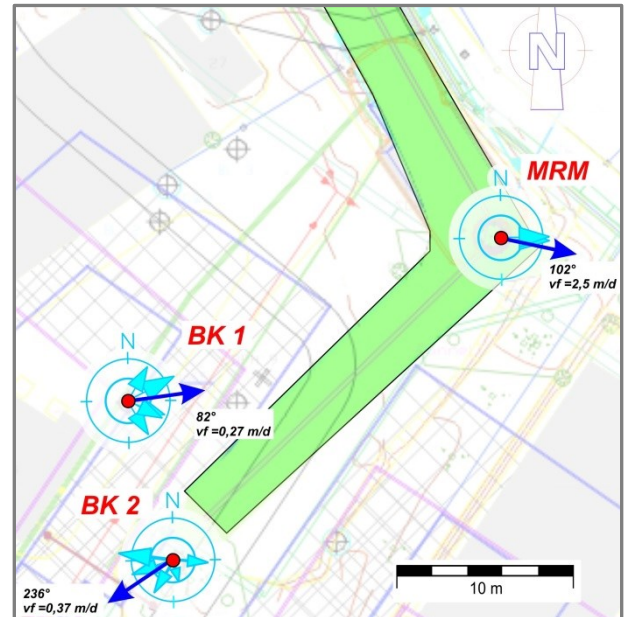
Heterogeneous porous aquifer (fine to coarse sand)

Purpose of Investigation

- Assessment of the hydraulic performance of the funnel-and-gate system
- Investigation of groundwater flow within the upgradient capture area of the funnel
- Characterization of groundwater flow within the gate area
- Investigation of groundwater flow at the southern end of the system to determine whether groundwater bypasses the treatment system

Investigation Results

To clarify the local groundwater flow conditions, horizontal in-situ flow measurements were conducted in three groundwater monitoring wells. Within the southern part of the funnel area, measurements in monitoring well BK1 showed groundwater flow directed eastward towards the gate rather than southward past the system. Measurements within the gate area (MRM) revealed a comparatively high flow velocity of 2.5 m/day, confirming that groundwater was being directed through the gate and supporting the hydraulic functionality of the funnel-and-gate system. At the southern boundary of the system (BK2), measurements throughout the aquifer profile showed low flow velocities and predominantly southwestward flow directions. These results indicate that there was no direct bypass flow around the southern end of the system towards the east. The southwestward flow directions indicate



locally modified groundwater flow conditions influenced by the proximity of the structure.

Client Benefits

- Verification of the hydraulic functionality of the funnel-and-gate system
- Verification of groundwater flow conditions immediately adjacent to the southern boundary of the system, with no indication of eastward bypass flow
- Provision of data on groundwater flow through the system and for groundwater flow modelling
- Documentation of monitoring well construction and condition

Client

Engineering consultancy

Services

- Monitoring well camera inspections
- Horizontal in-situ flow measurements
- Data analysis, hydraulic assessment, project documentation

Scope of Field Work

3 groundwater monitoring wells / 5" diameter
Measurement depth: approximately 10 m

Location

Hessen, Germany**

Duration of Field Work

3 days

051P070

Detailed Investigation of Flow Paths in a Complex Volcanic Aquifer System

Project Description

A complex groundwater system comprising several perched aquifers and a deeper basal aquifer has developed within a Quaternary volcanic sequence of unconsolidated deposits interbedded with volcanic rock layers. Existing model assumptions regarding flow paths within these aquifer systems were to be verified and refined using directly measured groundwater flow data. Of particular interest were the drainage directions of the perched aquifers, groundwater flow in the vicinity of a tectonic fault zone, and the flow conditions in areas affected by known groundwater contamination.

Hydrogeological Setting

Volcanic sequence of unconsolidated deposits interbedded with volcanic rock layers; perched aquifers overlying a basal aquifer

Purpose of Investigation

- Detailed investigation of flow paths within perched and basal aquifers
- Verification and refinement of the existing groundwater flow model
- Investigation of groundwater flow conditions in the vicinity of a tectonic fault zone
- Directly measured flow data for the assessment of potential contaminant migration pathways
- Provision of supplementary data for further groundwater flow and contaminant transport modelling

Key Findings

In-situ groundwater flow measurements were carried out in both the perched aquifers and the basal aquifer. Within the investigated perched aquifers, the respective drainage directions could be directly determined, allowing key assumptions regarding their hydraulic connection to the basal aquifer to be verified. Within the basal aquifer, the measurements provided particularly valuable information on local groundwater flow in the vicinity of a tectonic fault zone and supported existing model assumptions in this area. However, due to the wide spacing of the monitoring well network, the individual measurements did not provide a continuous regional flow pattern in all areas. The results therefore had to be evaluated on a site-specific basis, taking the respective hydrogeological conditions into account. The directly measured groundwater flow data thus com-



plemented the existing groundwater flow model, particularly in areas where the complex geological structure made it difficult to reliably derive actual flow paths from groundwater level data alone.

Hydrogeological Challenge

The interbedding of unconsolidated volcanic deposits and volcanic rock layers results in a vertically and laterally complex aquifer system. Several perched aquifers occur above a continuous basal aquifer and may drain into deeper parts of the aquifer system along their margins. Tectonic fault zones further influence local groundwater flow paths. This complex three-dimensional structure makes it difficult to derive actual groundwater flow paths from groundwater levels and to represent them reliably in a groundwater flow model. Directly measured flow directions and velocities were therefore used to verify model assumptions on a site-specific basis and to improve the assessment of potential contaminant migration pathways, particularly in areas affected by groundwater contamination.

Customer Benefits

- Direct identification of drainage directions from perched aquifers
- Improved understanding of the complex volcanic aquifer system

Detailed Investigation of Flow Paths in a Complex Volcanic Aquifer System

- Verification and site-specific refinement of existing model assumptions
- Direct flow information in the vicinity of a tectonic fault zone
- Data basis for assessing potential contaminant migration pathways
- Provision of directly measured flow data for groundwater flow and contaminant transport models

Client

International consulting company acting on behalf of a military authority.

Services

- Borehole camera inspections
- in-situ groundwater flow measurements
- Data evaluation, hydrogeological interpretation and project documentation

Project Scope

- 24 monitoring wells (3" to 5" diameter)
- Measurement depths: 7m–85 m

Project Location

Azores, Portugal

Special Requirements

Transport logistics by air freight

081P111/111P136/111P129/121P146