

Risk Assessment for Securing Drinking Water Supplies

Project Description

Within the vicinity of a former construction waste landfill located at the boundary of a drinking water protection zone, groundwater levels observed in several monitoring wells showed no consistent hydraulic relationship and short-term fluctuations. This significantly complicated groundwater flow modelling. To verify the existing groundwater flow model and to clarify the hydraulic situation, in-situ groundwater flow measurements were carried out in three monitoring wells.

Hydrogeological Setting

Unconsolidated porous aquifer (sand to gravel)

Purpose of Investigation

Detailed investigation for risk assessment and protection of drinking water resources.

Key Findings

Horizontal in-situ groundwater flow measurements demonstrated that both throughflow and underflow beneath the landfill body cause significant hydraulic head differences, explaining the temporal and spatial variations in groundwater levels. Long-term measurements showed largely steady-state groundwater flow conditions despite the fluctuating groundwater levels and provided data for refinement of the hydraulic model. The measurements revealed distinct temporal hydraulic influences caused by daytime road traffic, whereas groundwater flow conditions during nighttime were largely uniform. Also, vertical groundwater flow was identified in wells at the margins of the landfill.

Client Benefits

- Improved understanding of the aquifer system
- Identification of time-variable groundwater flow conditions
- Provision of data for groundwater flow modelling
- Documentation of well construction and condition for future investigations

Client

Municipal Environmental Agency

Services

- Borehole camera inspections
- Groundwater level measurements
- Horizontal in-situ groundwater flow measurements
- Data evaluation and project documentation

Project Scope

- 3 monitoring wells (5-inch diameter)
- Measurement depths: 5–23 m

Project Location

North Rhine-Westphalia, Germany

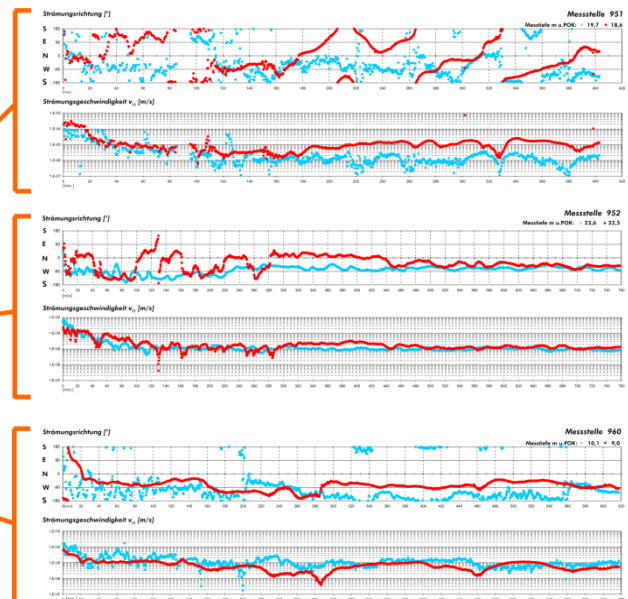
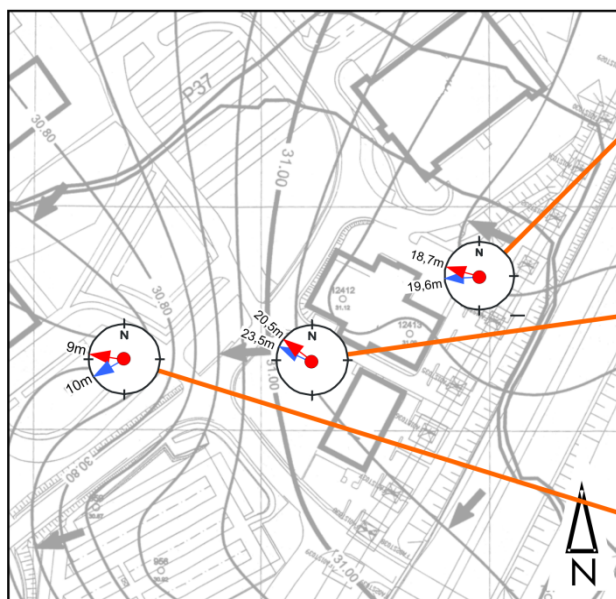
Project Duration

4 days

Special Requirements

Long-term measurements with monitoring periods of 4–12 hours

011P014



Pilot Study on Tidal Influences on Drinking Water Abstraction

Project Description

As part of a pilot study on a North Sea island, the influence of the tidal cycle on groundwater flow within the capture zone of coastal drinking water wells was investigated. Horizontal in-situ groundwater flow measurements were carried out in selected monitoring wells over periods of up to 12 hours in order to cover a complete tidal cycle during active groundwater abstraction. The objective was to identify tide-related changes in groundwater flow and to assess potential effects on drinking water abstraction and the freshwater–saltwater interface.

Hydrogeological Setting

Porous aquifer (sand)

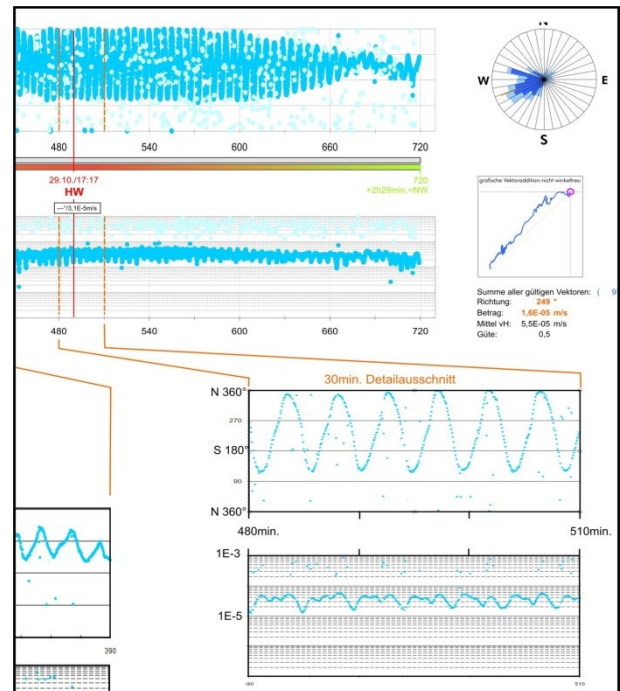
Purpose of Investigation

- Investigation of tidal influence on groundwater flow within the coastal freshwater aquifer
- Characterization of time-dependent changes in groundwater flow direction and velocity over a complete tidal cycle
- Assessment of the interaction between tidal influence and active groundwater abstraction
- Identification of potential effects on the freshwater–saltwater interface
- Provision of a data basis for the long-term planning and safeguarding of drinking water abstraction

Investigation Results

The long-term measurements revealed a clear spatial difference in the influence of the tides. No distinct tide-related changes in groundwater flow were observed in monitoring wells located further inland. In coastal monitoring wells, however, changes in groundwater flow associated with the tidal cycle were observed during active drinking water abstraction.

The results indicate that the hydraulic interaction between tidal fluctuations and groundwater abstraction in coastal areas may affect flow conditions in the vicinity of the freshwater–saltwater interface. The measurements therefore provided important information for assessing potential mixing and displacement processes and their relevance to the long-term safeguarding of drinking water abstraction. In individual monitoring wells, oscillating flow movements were also recorded in association with tidal changes. However, a clear causal relationship could not be conclusively established within the



scope of the investigation. The long-term measurements thus revealed time-variable groundwater flow processes that would not have been captured by individual short-term measurements.

Hydrogeological Challenges

Groundwater flow within the coastal aquifer is influenced by several time-variable hydraulic factors. In addition to the natural tidal cycle, active groundwater abstraction affects the local groundwater flow field. Short-term measurements can therefore provide only snapshots of different hydraulic conditions. Long-term measurements covering a complete tidal cycle made it possible to characterize time-dependent changes in groundwater flow direction and velocity and to compare coastal monitoring wells with areas located further inland.

Customer Benefits

- Improved understanding of the hydraulic interaction between tides, the aquifer and drinking water abstraction
- Characterization of time-variable groundwater flow over a complete tidal cycle
- Spatial differentiation between tide-influenced and largely unaffected parts of the aquifer
- Identification of potential effects on the freshwater–saltwater interface

Pilot Study on Tidal Influences on Drinking Water Abstraction

- Provision of directly measured groundwater flow data for further groundwater flow modelling
- Data basis for the long-term planning and safeguarding of drinking water abstraction
- Verification of monitoring well construction and condition

Client

State authority / public-sector client

Services

- Contribution to the investigation concept
- Borehole camera inspections
- Horizontal in-situ groundwater flow measurements
- Data evaluation, hydrogeological interpretation, project documentation and project presentation

Project Scope

- 13 monitoring wells (2–3-inch diameter)
- Measurement depths: 20–100

Project Location

Schleswig-Holstein, Germany

Project Duration

12 days

Special requirements

long-term measurements of up to 12 hours

141P161

Groundwater Flow Investigation to Support a Contaminant Transport Model

Project Description

At a contaminated site, contaminant migration was found to be higher than predicted by the existing contaminant transport model. Due to the low groundwater gradient and a heterogeneous sediment sequence containing carbonaceous and peaty layers, the actual distribution of groundwater flow paths was insufficiently understood. A heavily used railway line runs directly adjacent to the investigation area. Horizontal in-situ groundwater flow measurements were carried out to characterize local flow conditions, identify time-variable flow processes, and verify and refine existing model assumptions regarding contaminant transport.

Hydrogeological Setting

Heterogeneous porous aquifer consisting of silt and sand with interbedded carbonaceous and peaty layers

Purpose of Investigation

- Detailed investigation for risk assessment and characterization of contaminant transport
- Characterization of time-variable groundwater flow
- Verification and refinement of the existing contaminant transport model

Investigation Results

In a groundwater monitoring well located approximately 10 m from the railway line, simultaneous horizontal in-situ groundwater flow measurements

were carried out at depths of 8 and 9 m over a period of 12 hours. At both measurement depths, recurring short-duration and pronounced peaks in flow velocity were observed. Comparison with the train schedule showed a clear temporal correlation between these hydraulic impulses and passing trains, particularly freight trains.

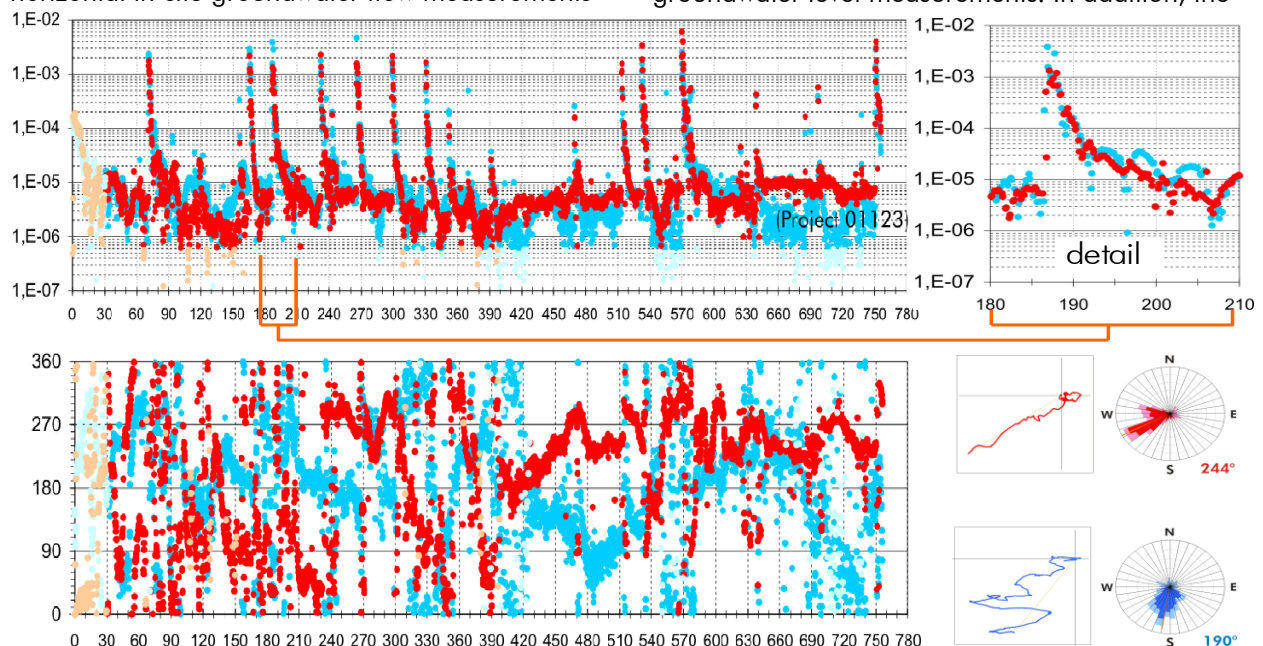
Monitoring wells located in the immediate vicinity of the railway line also showed unusually high water turbidity and increased transport of suspended particles. The results indicate that vibrations generated by passing trains can induce short-term hydraulic impulses within the aquifer and mobilize previously deposited fine particles.

This process provides a plausible explanation for the observed increased mobilization of particle-bound contaminants and thus for part of the discrepancy between the existing contaminant transport model and the actual contaminant migration observed at the site.

The long-term measurements therefore revealed short-duration dynamic groundwater flow and transport processes that would not have been identifiable from groundwater level measurements or individual short-term flow measurements alone.

Hydrogeological Challenges

The low natural groundwater gradient and heterogeneous sediment sequence make it difficult to derive clearly defined groundwater flow paths from groundwater level measurements. In addition, the



Groundwater Flow Investigation to Support a Contaminant Transport Model

local groundwater flow system is superimposed by short-term, externally induced hydraulic impulses. These events are of short duration and are therefore difficult to capture with individual measurements. Only simultaneous, depth-resolved long-term measurements made it possible to identify the recurring flow impulses and compare their timing with external events.

Customer Benefits

- Identification of previously unrecognized dynamic influences on groundwater flow associated with railway traffic
- Improved understanding of time-variable groundwater flow and transport processes within the aquifer
- Identification of potential mechanisms for the mobilization of fine particles and particle-bound contaminants
- Additional data basis for explaining elevated contaminant migration
- Provision of directly measured groundwater flow data for further groundwater flow and contaminant transport modelling

Client: Research Institute

Services

- Borehole camera inspections
- Horizontal flow measurements
- Evaluation, project documentation

Project Scope

- 12 monitoring wells (5" diameter)
- Measurement depths: 10–30 m

Project Location

Saxony, Germany

Project Duration

16 days

051P166+051P172

Investigation of Time-Varying Groundwater Flow at an Industrial Site

Project Background

A locally limited groundwater contamination was identified at an industrial site. Due to existing buildings and infrastructure, only a limited number of groundwater monitoring wells are available for investigating local groundwater flow conditions and contaminant migration. The hydraulic gradient is low, and groundwater level measurements do not provide sufficiently reliable information on the direction of contaminant migration. In addition, ongoing industrial operations transmit vibrations into the subsurface, accompanied by short-term fluctuations in groundwater levels. Horizontal in-situ flow measurements were conducted to obtain additional information on groundwater flow direction and velocity.

Hydrogeological Setting

Porous aquifer consisting of layers ranging from fine sand to fine gravel

Purpose of Investigation

Detailed investigation of groundwater flow dynamics and contaminant migration at an industrial site.

Investigation Results

Initial in-situ flow measurements conducted during daytime and during industrial operations revealed highly transient flow conditions with frequent changes in groundwater flow direction. Long-term measurements allowed individual measurement series to be integrated over extended periods, enabling prevailing flow directions to be identified despite the short-term variations. More stable flow conditions and reliable flow data were obtained during overnight measurements when industrial activity was reduced. The results demonstrate that, under conditions of low natural groundwater flow

velocities, operationally induced hydraulic influences can temporarily have a significant impact on local groundwater flow. The resulting time-varying flow conditions contribute to the spatial spreading of contamination in the downgradient area and were therefore taken into account when planning the groundwater remediation system.

Client Benefits

- Information on groundwater flow direction and contaminant migration
- Characterization of time-varying groundwater flow conditions, proof of operational influences
- Provision of data for groundwater flow modelling and Information for adapting the groundwater remediation strategy
- Documentation of well construction / condition

Client

Engineering consultancy on behalf of the responsible party

Services

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

Scope of Field Work

3 monitoring wells / 4" diameter
Measurement depths: 5–10m

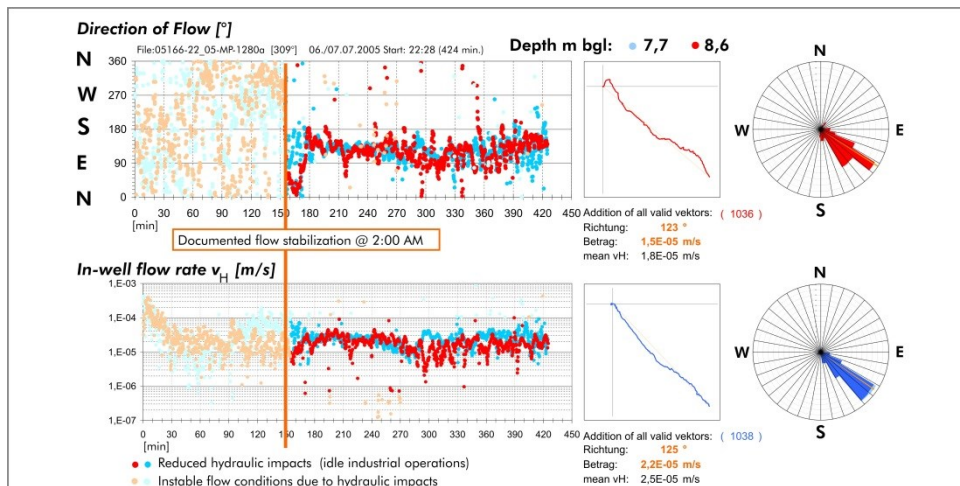
Location

North Rhine-Westphalia, Germany

Duration of Field Work

5 days

051P066



Long-Term Monitoring of Hydraulic Containment under Alternating Pumping Conditions

Project Background

At a remediation site, a gallery of extraction wells is operated as a hydraulic containment system to prevent downgradient contaminant migration. Due to the limited capacity of the groundwater treatment system, groundwater abstraction is alternated between several remediation wells. As a result, the hydraulic boundary conditions and the capture zones of the individual wells change over time. Assessing the effectiveness of the hydraulic containment system therefore requires consideration not only of the spatial flow pattern but, in particular, of the temporal evolution of groundwater flow conditions.

Hydrogeological Setting

Sandy-gravelly porous aquifer

Purpose of Investigation

- Verification of hydraulic containment performance under alternating pumping conditions
- Characterization of time-dependent changes in capture zones and groundwater flow conditions
- Assessment of the containment effect at the margins of the remediation area
- Data basis for optimizing the switching cycle between remediation wells
- Provision of directly measured groundwater flow data for groundwater flow modelling

Investigation Results

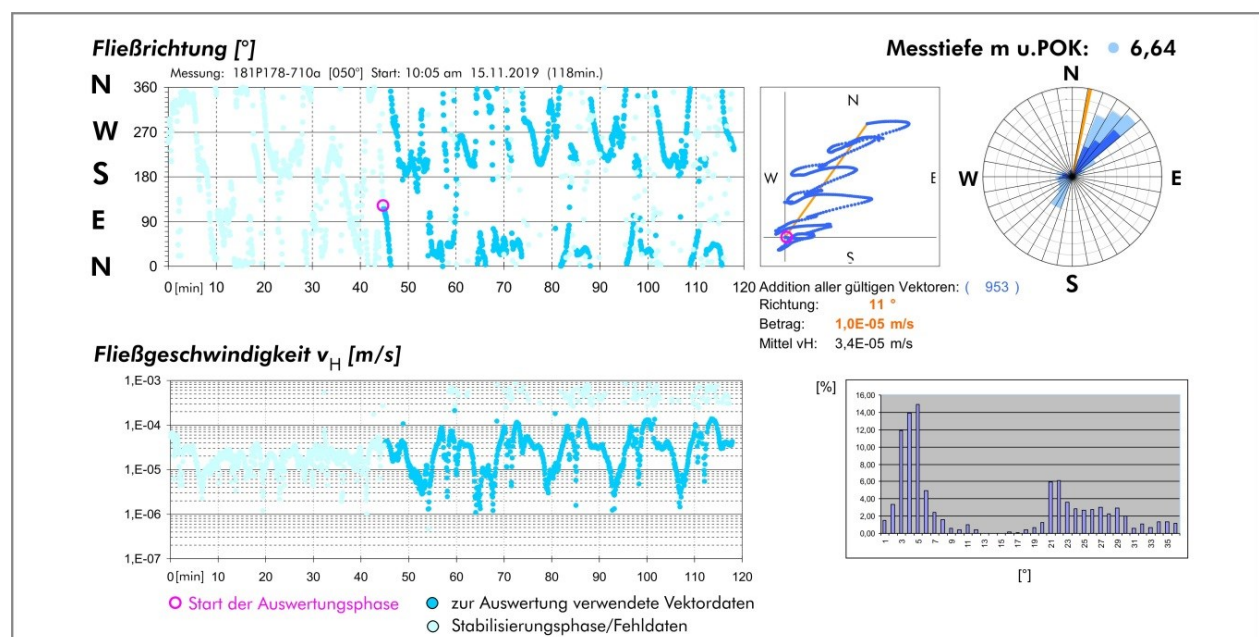
Long-term horizontal in-situ groundwater flow measurements demonstrated that the hydraulic containment effect of the well gallery was generally maintained despite alternating pumping conditions. However, temporarily reduced capture-zone extents were observed at the margins of the remediation area and were associated with changes in the operating conditions of the remediation wells. The measurements therefore enabled direct assessment of the temporal response of the groundwater flow field to different pumping conditions.

During long-term monitoring, recurring changes in groundwater flow were also detected at one remediation well, indicating intermittent pumping operation. Subsequent technical inspection identified a defective water-level sensor as the cause. The malfunction resulted in incorrect pump control and consequently reduced pumping capacity.

The long-term measurements therefore not only verified the effectiveness of the hydraulic containment system but also revealed operational irregularities through their direct effects on the groundwater flow field.

Hydrogeological Challenges

Alternating operation of the remediation wells continuously changes the local groundwater flow field. Flow direction, flow velocity and capture-zone extent are therefore time-dependent and cannot be adequately characterized by individual short-term



Long-Term Monitoring of Hydraulic Containment under Alternating Pumping Conditions

measurements. Long-term measurements make it possible to continuously monitor the hydraulic response of the aquifer to different pumping conditions and to identify temporary changes in containment performance as well as operational irregularities.

Customer Benefits

- Verification of hydraulic containment performance under alternating pumping conditions
- Identification of temporarily reduced capture-zone extents at the margins of the remediation area
- Characterization of the hydraulic response of the aquifer to different pumping conditions
- Detection of intermittent pumping operation through time-variable groundwater flow behaviour
- Identification of a technical malfunction and prevention of persistently reduced pumping capacity
- Data basis for optimizing the switching cycle between remediation wells
- Provision of directly measured groundwater flow data for groundwater flow modelling

Client

Joint venture of groundwater remediation contractors

Services

Monitoring well camera inspections

Horizontal in-situ groundwater flow measurements

Long-term groundwater flow monitoring

Data analysis and project documentation

Scope of Field Work

7 monitoring wells / 5" diameter

Measurement depths: 5–23 m

- Wirkungsnachweis der hydraulischen Abstromsicherung bei wechselndem Förderbetrieb

Location

North Rhine-Westphalia, Germany

Duration of Field Work

9 days

017P188