Intelligent borehole monitoring

To many operators, borehole performance means knowing if there is water coming out of a borehole or not. Unfortunately, monitoring performance in this way means that the first sign of a problem is when water stops coming out of the tap and consequently, when there is a problem, it is usually serious and costly. By Dr Phil Ham, Envireau Water.

Also, this method of monitoring provides no information about the groundwater resource targeted by the borehole, which means that the sustainability of the abstraction and potential impacts to other nearby operators or sensitive water dependent features cannot be assessed.

Whilst the failure of a pump may result in only a temporary loss of supply, problems with boreholes themselves develop much more gradually and usually result in decreased performance and higher operating costs. In some extreme cases the decrease in performance can result in catastrophic failure; through the collapse of casings or screens, rendering the borehole unusable.

Like any engineering asset, boreholes need to be monitored and maintained to ensure efficiency and performance is maximised, and that groundwater resources are managed in the most effective way, particularly important when there are local, regulatory constraints.

The Practical Application – a case study

Envireau Water is currently working with one of Europe's largest distilleries, which abstracts up to 3 million cubic meters of water from a wellfield comprising several boreholes.

The first borehole was constructed in the 1930s and until 2010 the wellfield was essentially unmanaged. The requirements, design and specifications for new boreholes was led by drilling contractors which led to the construction of several very deep boreholes which did not take account of the hydrogeology of the groundwater system.

A spate of performance issues, ranging from pump failures to complete borehole collapse, coupled with increased pressure from the regulatory authority for the distillery to demonstrate the sustainability of the groundwater resource, led to the installation of an intelligent monitoring system to collect data relating to performance of pumps, boreholes and the groundwater system.

The system performs real time monitoring of parameters including water levels, flow rates and volumes, water quality/chemistry and pump power and electrical load. Key data is interpreted as key performance indicators (KPIs) and presented using appropriate KPI dashboards which are reviewed on a monthly basis.

These KPIs provide information which feeds into planned engineering maintenance actions such as pump changes and borehole rehabilitation. Other KPIs measure the sustainability of the abstraction and groundwater resource.

Pump Performance

Pump performance is monitored as a ratio between abstraction and pump power/load. Since abstraction from the boreholes is reasonably consistent, changes in pump performance are usually attributed to increased electrical load on the pump. Pump performance will decrease over time and it is important that thresholds are set to implement planned pump changes, rather than wait for a sudden failure.

Borehole Performance

Borehole performance is monitored through the 'specific drawdown', which is the ratio of abstraction per unit drawdown in water level inside the borehole.

The drawdown in a borehole is made up of two components: the 'aquifer drawdown' and 'borehole losses'. The aquifer drawdown is dependent on the properties of the formation targeted by the borehole whilst the borehole losses are an effect of the physical construction of the borehole and essentially reflect efficiency.

Theoretically, the aquifer drawdown will always remain the same but the efficiency of a borehole will change as screens clog over time. This means that changes in performance can be attributed to reduced efficiency and deteriorating engineering condition of the borehole.

Again, KPI thresholds are set to determine when planned maintenance and rehabilitation need to be carried out. These actions allow performance to be increased, the costs of pumping to be minimised, and the condition and longevity of the borehole to be prolonged.

Groundwater Sustainability

Long term abstraction, water level and water chemistry data is used to assess trends and the overall sustainability of the groundwater resource. To separate the local effects of abstraction and get an accurate picture of the groundwater response to abstraction, data is collected from both non-pumped and pumped boreholes.

Real Measures of Performance

Monitoring pump and borehole performance at the distillery site has resulted in a dramatic decrease in the number of sudden failures. Borehole performance data has been used to trigger a programme of rehabilitation on one borehole, resulting in a 25% increase in performance. Operational running costs have been minimised through effective abstraction management across the wellfield and the long term capital costs associated with maintenance, rehabilitation and repair have been minimised by using the data to inform a programme of preventative maintenance.

The greatest benefits from the monitoring system have come from a better understanding of the groundwater system and how the boreholes that make up the wellfield interact; allowing abstraction to be effectively managed. The data provides a robust evidence base that demonstrates the real impacts of abstraction and sustainability of the groundwater resource, resulting in a much more relaxed and confident regulatory position going forward.

In summary, in order to get the most out of any borehole, routine monitoring and maintenance as well as an understanding of the hydrogeology of the site is usually all that is required to ensure continued service and sustained performance.

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Borehole management in civil engineering projects

Groundwater wells are common to many civil engineering schemes and their operational performance can play a crucial role in the successful delivery of a project, whether used for construction dewatering, alternative water supplies for facilities or any other application. Whatever the application, the well performance must be optimised and high levels of operational efficiency and service availability achieved.

A groundwater well is a complex hydrodynamic environment. As water passes through the well and the downstream pumping system, it undergoes pressure changes, temperatures changes, is exposed to the atmosphere and comes into contact with artificial surfaces in well screens and pumps. In many cases this creates the ideal conditions for clogging to occur.

Operational problems caused by clogging include reduction in the hydraulic efficiency of the well (increased drawdown, decreased yield, decreased specific capacity), deterioration of water quality, motor burn out of the submersible pump, and encrustation on the pump, column, well screen and reticulation systems.

As a result the energy costs of pumping will increase (due to increased drawdown) and maintenance costs will increase due to greater equipment wear and tear and well rehabilitation costs.

Iron bacteria are one of the most common clogging processes. The potentially turbulent, oxygenated environment in a well and pumping system provides the energy iron bacteria need by oxidising the soluble ferrous iron (Fe^{2+}) present in the groundwater to an insoluble ferric form (Fe^{3+}). The life cycle of the bacteria produces a biofilm that typically appears as a slimy or gelatinous red-brown deposit and this biofouling can be difficult to remove.

Where carbonate clogging occurs, the natural carbon dioxide dissolved in solution is released, resulting in an increase in water pH. As the pH increases in waters with high levels of calcium carbonates, rapid precipitation of white or pale grey calcareous deposits occur in the well and pump (Figure 2).

Boreholes suffering from clogging can be rehabilitated by a range of mechanical and chemical methods. Research has shown that chemical rehabilitation can provide 40 to 60% of the total gain during a combined chemical and hydro- or mechanical rehabilitation. The challenge for the well operator is that each site will have unique aspects, requiring care in the choice of rehabilitation methods and chemical agents. Chemical treatments should be effective against the type of clogging identified, have the necessary regulatory approvals and the post-treatment residues should be harmless and able to be safely disposed.

However, rehabilitation alone is not the optimal solution. The most effective programmes to manage well performance typically incorporate a monitoring and measurement plan alongside a regular chemical treatment. Companies are now starting to routinely deploy planned groundwater well maintenance programmes, with proven benefits in terms of operational cost savings and continuity of pumping.

Regular monitoring, proactive maintenance and knowing when to call in rehabilitation experts can maintain or even increase specific capacity and it is now becoming common to build in such a programme at the design stage rather than waiting until operations commence and a problem occurs

Geoquip Water Solutions from the UK, in partnership with Aquabiotics Industrial Pty from Australia, has been developing a borehole maintenance programme for the last ten years and the programme, which incorporates the BoreSaver range of treatments, has achieved notable successes globally in the management of iron oxide, iron bacteria and other mineral problems. The goal of the BoreSaver borehole maintenance programme is to return borehole production to as close to the original drilled capacity as possible and to help maintain a continual, problem-free water supply. The programme includes a downhole camera survey, bespoke software that analyses the survey results and the available water quality data and BoreSaver, a range of approved borehole rehabilitation treatments that are now used in more than fourteen countries worldwide.

Mike Deed, Managing Director of Geoquip said: "The BoreSaver programme focuses on proactive maintenance. We encourage people to view their water supply system as they would their car, which, if regularly serviced, will give them trouble-free motoring and won't break down. Similarly, with a water supply system, the operation of the pumps and associated equipment, the specific capacity and quality of the water will be optimised if the system is regularly maintained."

An example of the maintenance programme in action is in Australia, where the construction of a new metro system was carried out through a section where groundwater level was within two metres of ground level. Dewatering and associated artificial recharge was required. Within the first six months of dewatering pumping, severe levels of iron-related clogging were discovered with the pumps and pipes so badly clogged that the pumps could not be used to maximum efficiency. There were additional problems with the back-pressure of the artificial recharge system, which reached 1,400 kPa, resulting in low rates of recharge flow. The pumps, pipes and recharge bore were treated with a combined mechanical and chemical treatment using BoreSaver Ultra C and a surging technique. This removed the iron-related deposits and within minutes of the chemical treatment the back- pressure in the recharge system reduced by 550 kPa. A regular chemical treatment regime was then implemented to maintain the recharge flow rates. A weekly treatment of the dewatering pumps with BoreSaver Ultra C was also initiated and the pumps were quickly brought back into full service and maintained at optimum operational levels.

For organisations where there is a need for continual flow to maintain operations, limited monitoring and maintenance regimes can have huge financial implications. Regular monitoring, proactive maintenance and knowing when to call in rehabilitation experts can maintain or even increase specific capacity and it is now becoming common to build in such a programme at the design stage rather than waiting until operations commence and a problem occurs.

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