VIRTUAL

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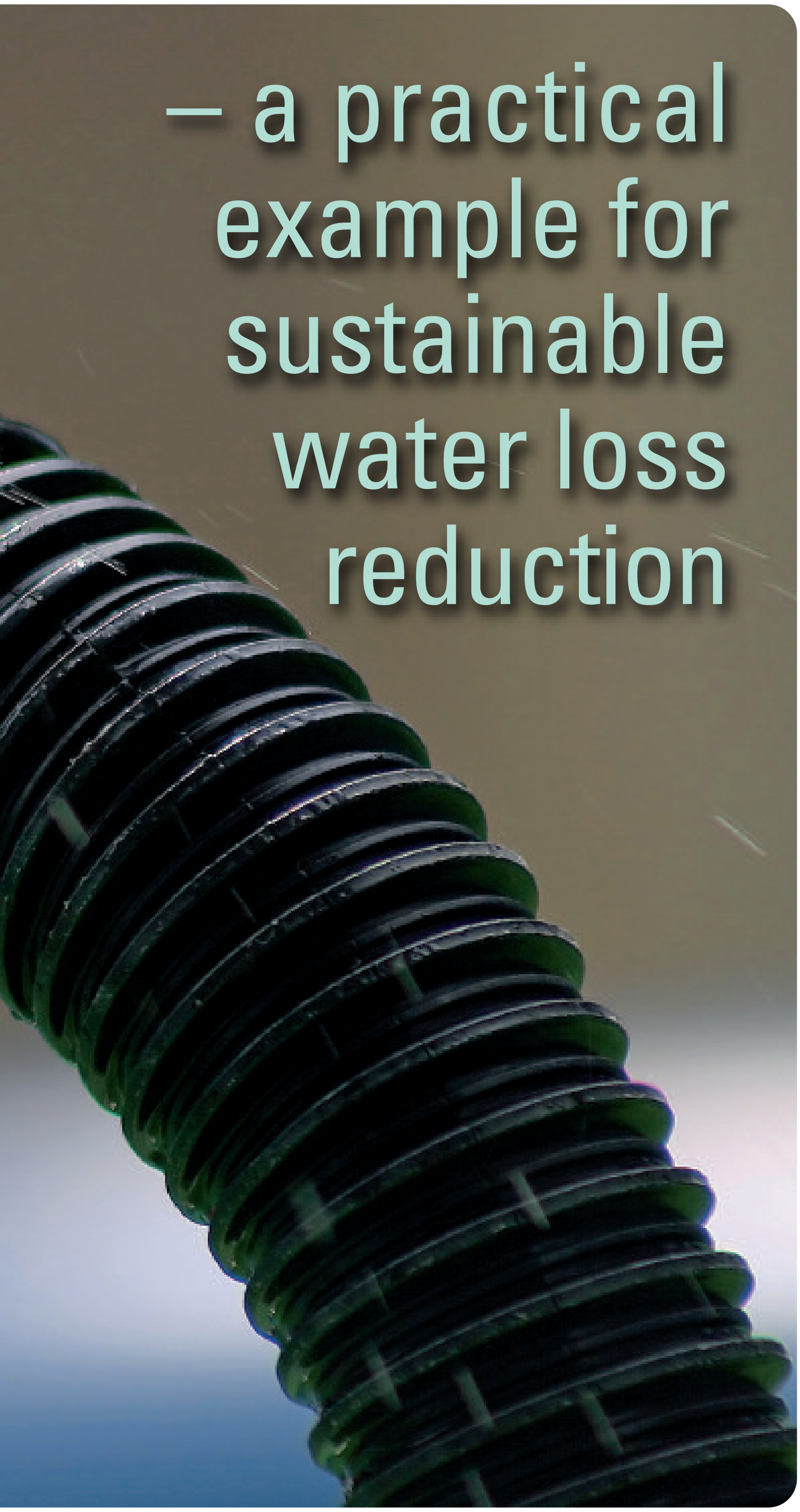
DMA

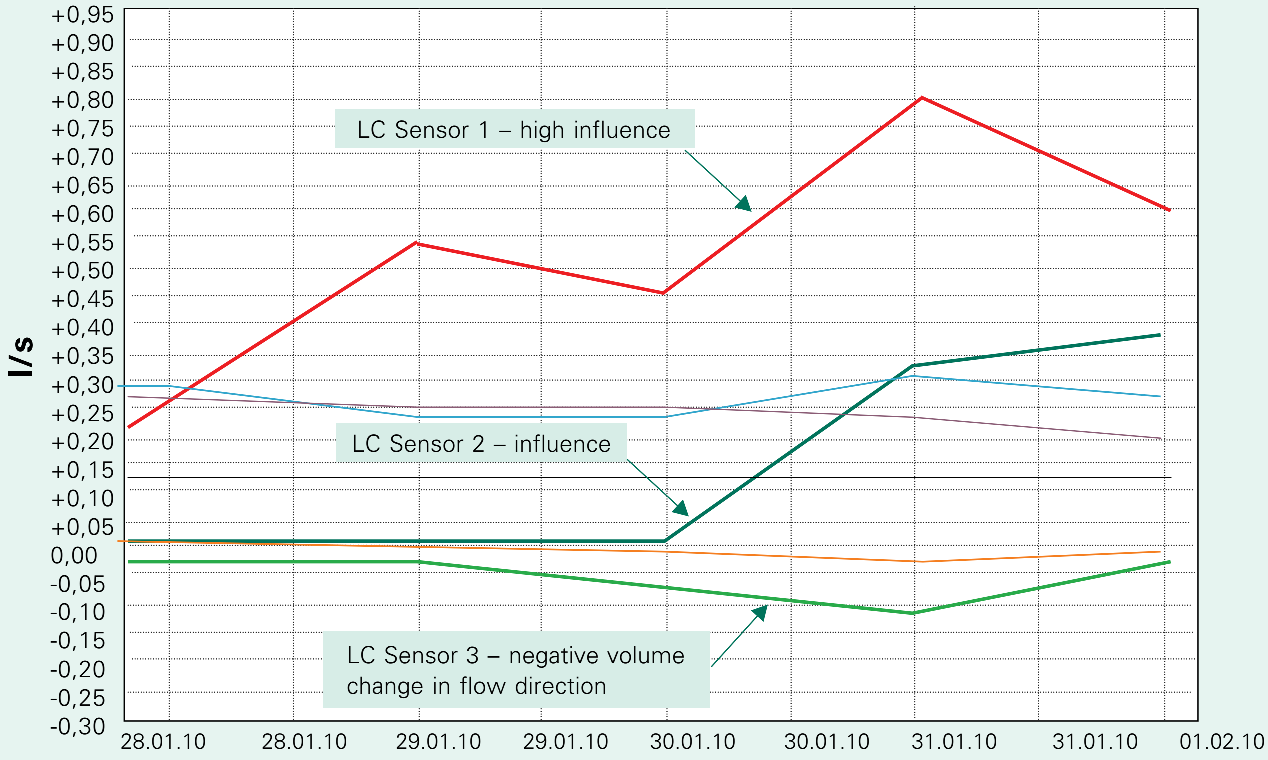
– a practical example for sustainable water loss reduction



Source: Jamie Wilson – Fotolia.com

The time between occurrence, realisation and repair of a leakage is next to the number of failures an important factor in water loss reduction. With flow meter positioned on strategic points, the network can be divided into virtual DMAs. With a combination of the measured flow data and a hydraulic calibrated model the area of a leakage position and therefore the expense for pinpointing is reduced dramatically. This article presents a practical approach on a water supply system.

Neben der Anzahl an Leckstellen in einem Versorgungsnetz ist vor allem die Zeit zwischen Auftreten, Erkennen und Reparieren einer Leckage ein entscheidender Parameter in der Wasserverlustreduzierung. Mit Hilfe von strategisch platzierten Durchflussmessgeräten im Versorgungsnetz können virtuelle Überwachungszonen definiert werden. Durch die Verknüpfung dieser Durchflussdaten mit einem entsprechend angepassten hydraulischen Modell kann die Region einer Leckstelle somit deutlich reduziert und der Aufwand für die Lokalisierung drastisch verringert werden. Anhand eines praktischen Beispiels wird die Vorgehensweise beschrieben.



Even in highly developed industrial countries with a water supply system in good condition and low water loss like Austria, Switzerland and Germany, the maintenance of systems and the reduction of water loss are becoming more and more important. But even in those countries the pipe systems have become much older and vulnerable to damage which will lead to an increase in water loss. Especially for an efficient management of supply and rehabilitation, the knowledge of failure rate and water loss is important for indication of the system condition. The application of a GIS, hydraulic network computation software and an adequate Asset Management System is state of the art.

In order to quantify water loss and to determine methods for reducing loss, a reference level or a limit level is necessary. National and international associations (IWA, DVGW), have published performance indicators and reference levels, whose calculation is influenced by several different input factors. The results should support and inform the water supply company about the actual condition of the supply network and make it possible to establish methods for the reduction of water loss. These methods cannot be compared to financial consideration concerning the water volume saved in short term periods. Beside financial aspects for reduction of water loss also technical, economic and ecological aspects become more and more important.

District metering

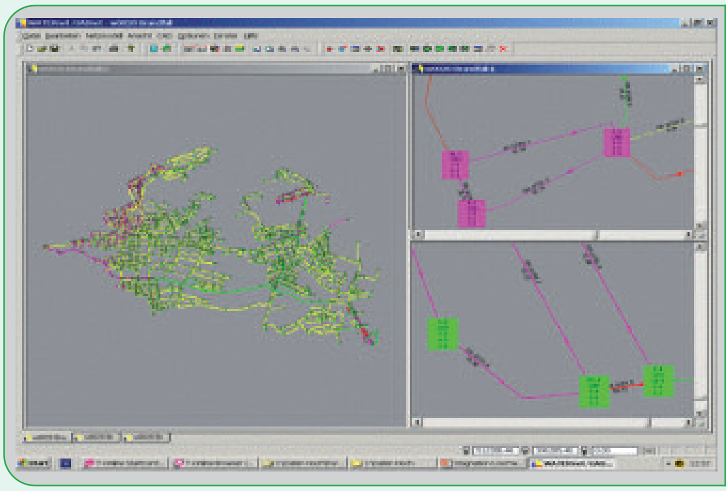
The International Water Association (IWA) proposes to separate the distribution system in district metered areas – DMA. A district metered area is an area with strict hydraulic boundaries within a distribution system with measured inflow in each district. The measured night minimum inflow is compared to the customer's night consumption to calculate water loss (Morrison et. al., 2007).

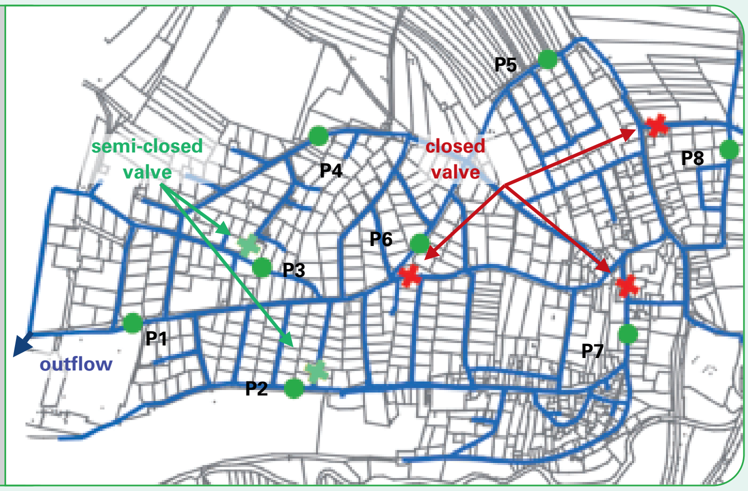
The advantage of a hydraulically separated area is to measure the system input easily by clearly defined input flow meters. By closing valves the points of inflow are clearly defined. When considering the minimal night flow, the change in inflow will picture the growth of a leakage.

According to the DMA Guidance Notes (Morrison et. al., 2007) a district should have between 500 and 3,000 service connections. When a DMA is too large, changes in flow rate (velocity) measured with an inflow meter can be hardly identified. With an increasing volume of the system inflow, the probability of identifying even smaller leaks with system inflow measurement is decreasing.

When there is a lack of information regarding the hydraulic condition, as well as the flow or pressure situations, a separation into districts with strict boundaries is a simple and efficient method to get an overview of the actual condition. This leads to a possibility to classify water loss by water balance (Kober, 2007).

The disadvantage of district metered areas is the separation into hydraulically discrete areas with decreasing the flexibility and performance of the system. When a break





▲ Fig. 2: Sample of a mathematical model

Source: RBS wave 2012

◀ Fig. 1: change in flow volume at different sensors caused by a leak

Source: Gangl, 2010

occurs in an open network, a supply of the customers is normally possible; water can flow through the surrounding pipe sections to the customers. The water supply needed in cases of fire fighting can also be better secured in an open network, because the hydrant gets its water from the surrounding pipelines. Creating discrete areas with strict boundaries can result in zones with stagnation, reduced flow velocity and higher retention time with sedimentation or hydraulic problems. Furthermore the implementation of DMA structures usually is cost intensive (installation of additional valves, prevention of dead ends with ring closure…).

Monitoring of an open network with a virtual DMA

So far, it has been explained how the described monitoring systems used for drinking water distribution networks have limits. For that reason, the effectiveness and economics of each method has to be proved. The basic methodology of monitoring a virtual DMA is to continuously measure the flow rate (velocity) at several points and compare the metered data with reference values. When measuring the night minimum flow, a comparison with former metered data allows a statement to the occurrence of new leaks. In theory every leak will lead to a specific change in flow, but the localization of a leak will depend on the accuracy of the water meter.

If the system is not divided into district metered areas the meters have to be positioned at hydraulically relevant positions (pipes) over the distribution system to meter con- ►

▲ Fig. 3: Methodology and result of a simulation with LeakControl position optimizer in Stuttgart

▶ Fig. 4: Difference in flow situation between night and day

Source: Gangl, 2011

spicuous changes in the flow velocity. If these conspicuous changes are stable for more than two or three days (nights), this change is based on a leakage and not an influence of customer habits. This change in flow velocity is metered by the installed measuring instruments regarding their hydraulic position (closeness) to the leak **(Fig. 1)**. With the strategic position of the meters in the network, virtual DMAs are introduced between the meters. Analysis of the influenced meter spread over the distribution system results in a first rough estimation of the localisation of the leak.

When the distribution system is separated into several district metered areas, the actual installed inflow meters can be used as a support for the monitoring system. In large DMAs where small leaks have less influence on the district inflow, additional flow meters are necessary for a consistent and continuous monitoring of the system.

Complex Network – Analysis Management

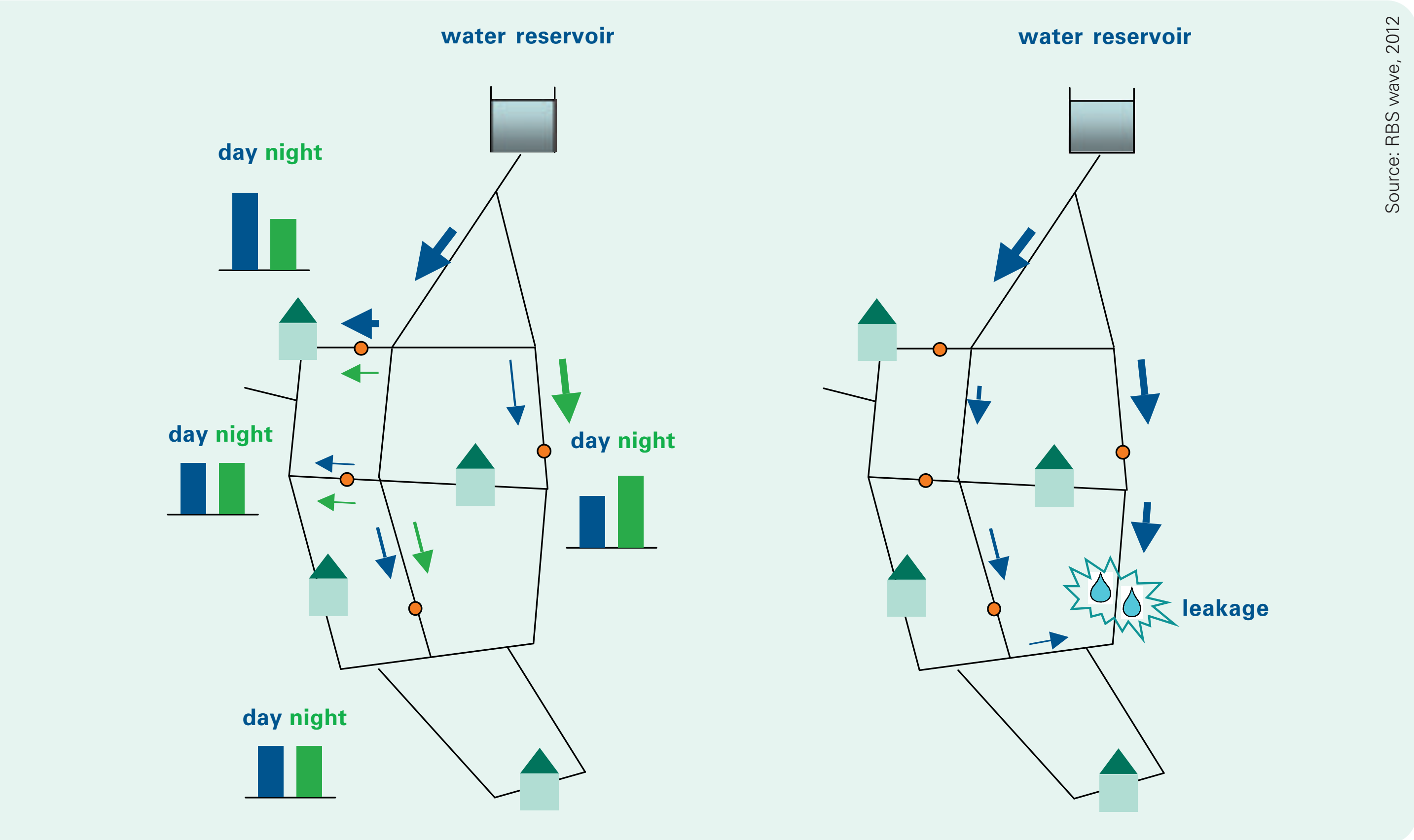
For a high-grade intermeshed supply structure, the right positioning of a water meter for measuring the flow-velocity is an essential question. In that case, a calibrated hydraulic model of the supply system is a necessary support. The hydraulic performance of a system can be analysed by using a mathematical model **(Fig. 2)**. Generally, models should be calibrated by on site measurements (pressure and flow) to eliminate and identify faults such as closed valves, incrustations, wrong pipe data or pipe connections. A calibrated model is the basis of assessment of pressures and flows in a system and is used for the complete design work.

Flow meter position optimizer

The idea of optimizing the position of a water meter (e. g. LeakControl) is to visualize the influence of a leakage on the flow condition in the network. With a hydraulic software model it is easy to calculate, which changes in the flow condition will result in the surrounding pipes if a leak of e. g. 1 l/s occurs at a specific point in the network. Depending on factors like diameter, material and incrustation, some pipes will have a conspicuous change; others will be uninfluenced of change in flow velocity.

The optimal position of a flow meter for setting a virtual DMA is now depending on the accuracy of the water meter, the existing structure of the network (diameter, night consumption). The experience of the author's show, that a flow meter with an accuracy of $v = 0.0025$ m/s and a low meter barrier of < 1 cm/s can monitor a virtual DMA between 10~20 km length. This area strongly depends on the hydraulic structure and should be seen as a first range.

Figure 3 shows a supply system with a net length of 75 km and a night minimum flow of 60 l/s. It represents the DMA "Niederzone Vaihingen" as one of the 58 pressure zones in the supply system of Stuttgart, Germany and has a high industrial percentage in the southern area. The whole supply zone of 170 km is divided into two parts with



three water meters (red dots). The analysis was realized with a leakage rate of 1.4 l/s.

The first result of the analysis was that a strict separation of the supply zone with the marked three water meters is not the best solution for monitoring the system. For a pipe with

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a diameter of DN 600, the change of the flow velocity caused by a leakage of 1.4 l/s is in that intermeshed structure in the area of 0.004 m/s and close to the low meter barrier of normal water meter. The red lines in the right hand side of Figure 3 show those pipes that are highly influenced by the calculated leakage. The results of the computations will lead to a proposal for the optimal hydraulic points for a monitoring system. In that case the monitoring system would exist of six sensors which represent a meter frequency of 1 sensor per 12 km. The existing meter on the DN 600 is not included.

LeakControl – Leak Finder

In the former chapter, the positioning of a monitoring system with virtual DMAs was explained. For finding a leakage, a calibrated hydraulic model can also be used. As mentioned before, a leakage on a pipe will lead to a typical change in the flow velocity in the surrounding area. This characteristic change can be used for locating a leakage based on a hydraulic model.

Normally the annual customer consumption multiplied with factors for different load cases is the basis for a hydraulic analysis. A calibration of the system is executed with a defined outflow and a pressure measurement on several points to identify the pressure reduction in the system. In reality the customer consumption differs more or less between the night and day consumption, therefore differs the theoretical and practical flow situation in the network.

If a meter measures the real system inflow of the water reservoir and the flow velocity during the night times on defined pipes, an ongoing calibration of the hydraulic model is possible **(Fig. 4)**. On basis of this model, the characteristic flow situation of a leak in the system can be calculated. Hence, the leak shown in Figure 4 will lead to a typical change in the flow velocity on the influenced sensors marked with the orange dots.

Case Study

For a city in Baden-Württemberg, Germany with 44,000 inhabitants, a part of the network is monitored with the System LeakControl. The virtual DMA is realised with ultrasonic flow meters with a high accuracy, a low meter barrier and transfer of the measures data via GPRS. The flow data of the virtual DMA can be controlled via a web-based solu-

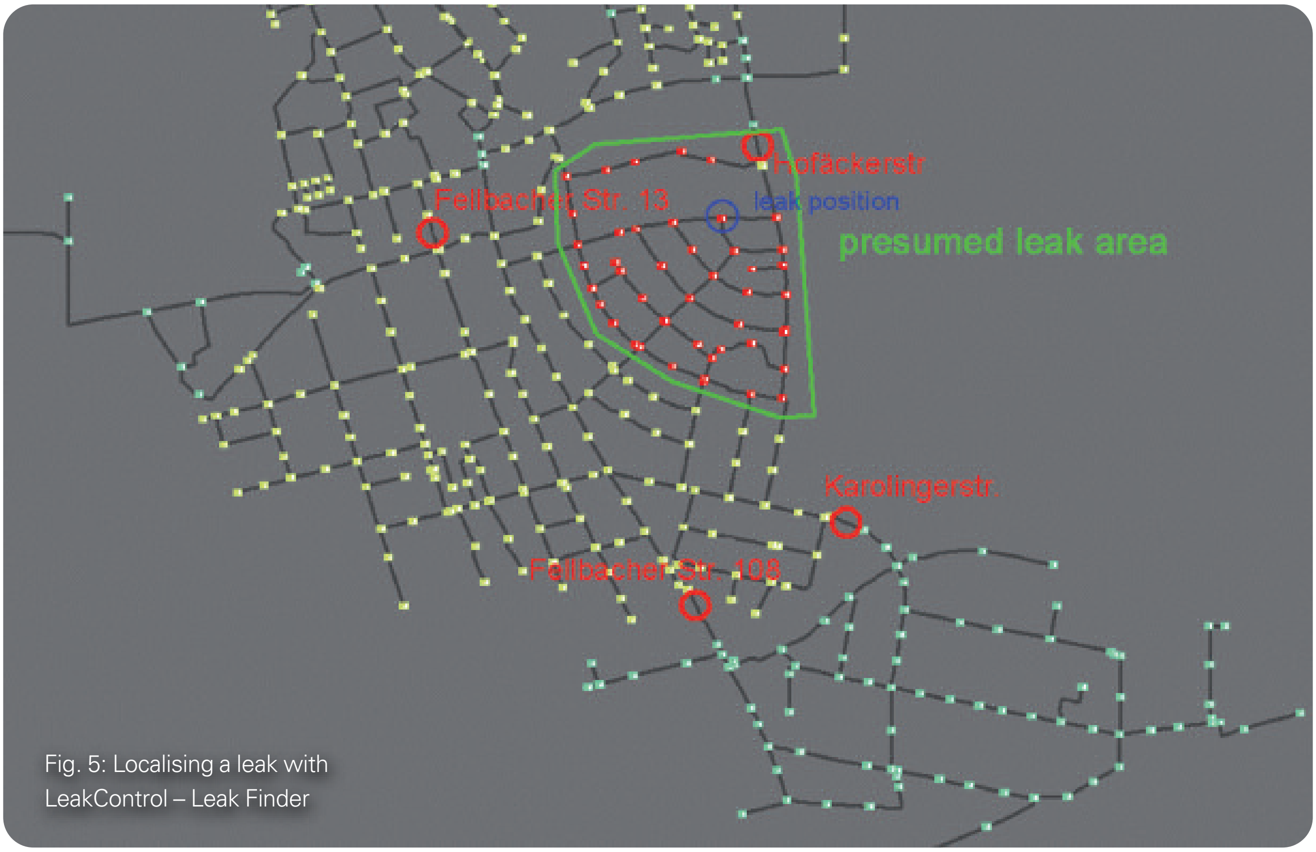

Fig. 5: Localising a leak with LeakControl – Leak Finder

Source: RBS wave 2012

tion. The virtual DMA has a minimum night consumption of 7.2 l/s, a net length of 60 km and 20,300 inhabitants.

The metered values of the LeakControl sensors get compared with different calculations of the calibrated hydraulic model (Software WATERnet) explained in the former chapter and leakage probabilities are computed for each pipe section as well as the probable quantity of the loss rate.

Figure 5 shows the result of the area of a possible leakage as well as the detected loss rate. In that case, the detected loss rate was 1.0 l/s and the area had a size of 350 · 350 m. With this information, the time for pinpointing the leakage for the operational staff is reduced to a minimum.

Conclusion

For monitoring and measuring water loss in a distribution system, several methodologies are common, which are influenced by material, diameter and other factors. The advantages and disadvantages have to be taken into consideration to find the optimal technique for water loss management in the respective supply system. The strategic methodology presented in the paper is based on a hydraulic model compared with online flow data.

With this idea, on the one hand an online water loss monitoring for an overview of the system's condition is easy to realize. On the other hand a short term localisation of a leak with the additional information of the volume of lost water is the advantage.

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RBS wave (2012) interne Auswertungen

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