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Urban Online – Modeling at Zurich Water Supply

Zurich Water Supply (WVZ) has the goal to build up a new hydraulic modeling system to online monitoring the network. The idea is that the hydraulic model of each defined pressure zone is connected with the relevant operation information of the existing SCADA system.
We are planning to install sensors for surveying the hydraulic parameters (pressure/flow in online and offline mode) and for chemical and physical analysis in an offline mode.

To test the facilities and services of the new system, to calculate simulations and to analyze operational special situations, the supply zone “Sonnenberg” was selected as the pilot area.

The goal of this online simulation and the network modeling is to detect water quality changes, hydraulic effects or operational manipulations in the water network. This should be achieved by activities of the network operational management.

The first modeling experiences and the verification of the results with the calibrated, real values of the supply zone are to be expected before summer 2014.

Zusammenfassung:

Das Ziel der Wasserversorgung der Stadt Zürich (WVZ) ist, ein neues System aufzubauen, das die hydraulische Modellierung einzelner Trinkwasserzonen mit den betrieblich relevanten Informationen des Projektleitsystem (PLS) SCADA verbindet, überwacht und Abweichungen registriert. Es ist vorgesehen, das hydraulische Modell mit einer Anzahl von Sensoren und mit verschiedenen Analysefunktionen (Offline und Online Modus) auszurüsten.

Um die Möglichkeiten und die Leistungen eines neuen System zu testen, Simulationen zu rechnen und betriebliche Sondersituationen zu analysieren, wurde die Versorgungszone „Sonnenberg“ als Pilotgebiet ausgewählt. Das Ziel der Online-Simulation und Modellierung ist darauf ausgerichtet, Veränderungen der Trinkwasserqualität, der Rohrnetzhydraulik oder die Auswirkungen von betrieblichen Massnahmen in der Wasserverteilung zu erkennen. Dies soll durch entsprechende Steuerungsmöglichkeiten und Massnahmen des Rohrnetzmanagement erreicht werden.

Erste Erfahrungen zur Modellierung und Verifizierung der Ergebnisse mit den kalibrierten, realen Werten der Versorgungszone sollen im 2. Quartal 2014 vorliegen.

Résumé:

Société des eaux Zurich (WVZ) a pour but de mettre en place un nouveau système de modélisation hydraulique pour la surveillance en ligne du réseau. L'idée est de relier le modèle hydraulique de chaque zone de pression définie à l’information de fonctionnement correspondante du système SCADA existant. Nous avons prévu

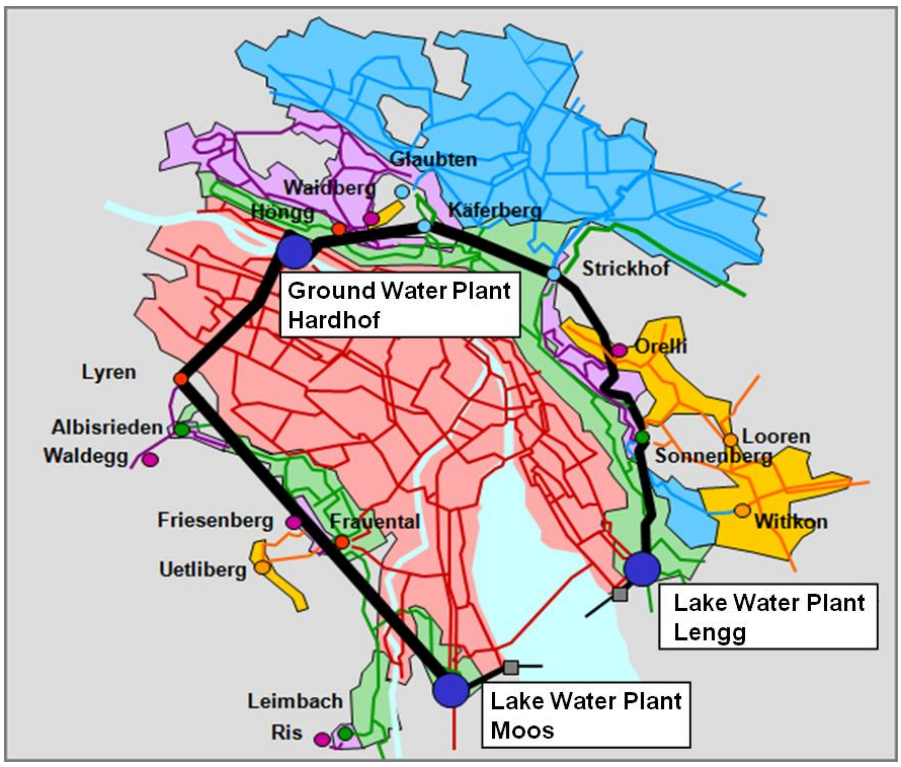
d'installer des capteurs afin de mesurer les paramètres hydrauliques (pression/débit) en ligne, et de mener l'analyse chimique et physique hors ligne.

La zone d'approvisionnement „Sonnenberg" a été choisie comme zone pilote afin de tester les installations et les services du nouveau système, de faire des calculs sur les simulations et d'analyser les situations de fonctionnement particulières. Le but de cette simulation en
ligne et de la modélisation du réseau est de détecter les changements de qualité de l'eau, des effets hydrauliques ou des manipulations opérationnelles dans le réseau d'eau. Cet objectif devrait être atteint grâce aux activités de la gestion opérationnelle du réseau.

Les premières expériences de modélisation et la vérification des résultats avec les valeurs réelles calibrées de la zone d'approvisionnement sont attendues avant l'été 2014.

1. Introduction

The Water Supply Zurich (WVZ) provides in the city and agglomeration of Zurich over 800'000 people with drinking water. Lake water, ground water and spring water are treated to guarantee high quality drinking water in three production plants. A large-diameter, deep water tunnel and chamber system ensures the distribution between the water treatment plants and the reservoirs. This main ring system, also connecting the pressure zones and reservoirs, delivers water to the partners around the city of Zurich. This main system is used especially to fill the reservoirs along the water tunnel. From a hydraulics point of view, the transport pipe system is almost completely separated from the smaller drinking water distribution network. This operation regime gives a define flow and pressure in the approximately 1500 km long water distribution network.



Picture 1 Water main system and distribution network in Zurich

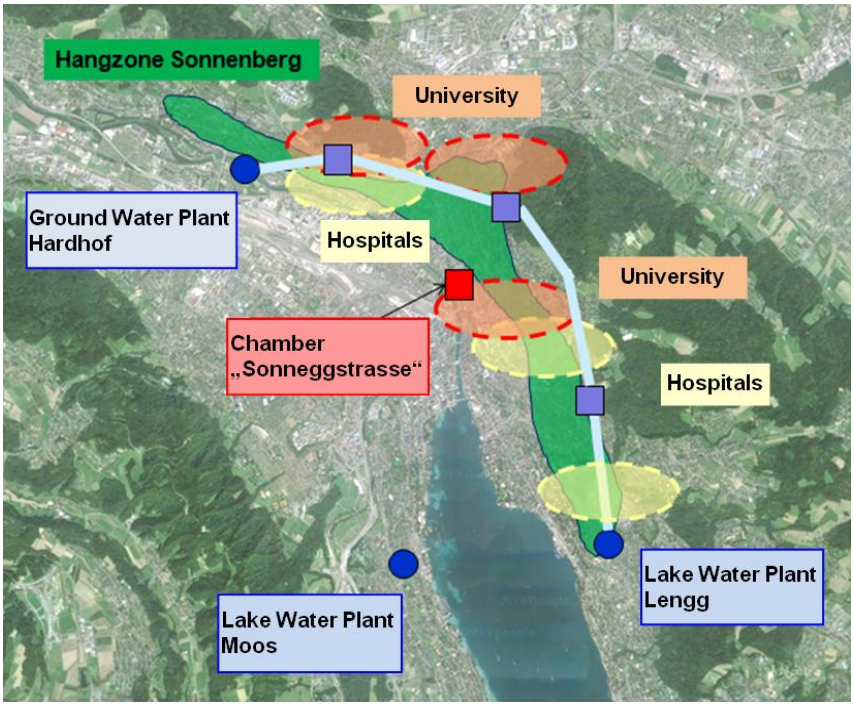
2. Goals and Vision of Online Monitoring

With the possibility of the continuous monitoring of the water supply system, the utility has the chance to detect incidents or irregularities concerning the water quality or the distribution network on time. With a network of multi-parameter sensors for monitoring the hydraulics and water parameter, the water quality changes in the distribution network can be detected. The online mode is used for the measurement.

With the online model it would be possible to calculate a forecast operating situation. If there is an incident, for example water pollution in a surveyed zone, the model should also be able to calculate the hindcast scenario. With the improved online monitoring, the reaction time in case of water pollution would be reduced. This allows more time to initiate measures and to inform customers and the public in time.

To learn more about the hydraulic situation and hygienic aspects in a water network we have to collaborate interdisciplinary. Different internal specialists and disciplines are touched by this goal.

The Water Supply Zurich started the pilot project in the “Hangzone Sonnenberg (HZ)”. All results of the pipe network hydraulics and the network modeling are calculated in this zone. The results of the water sensors are measured in the chamber “Sonneggstrasse”.



Characteristics of the zone:

1 Reservoir

Pumping stations (12) in and out the zone

About 136 km pipe network length

Approx. 1900 house connections

22‘000 nodes and links (GIS)

Approx. consumption: 1570m^3/h

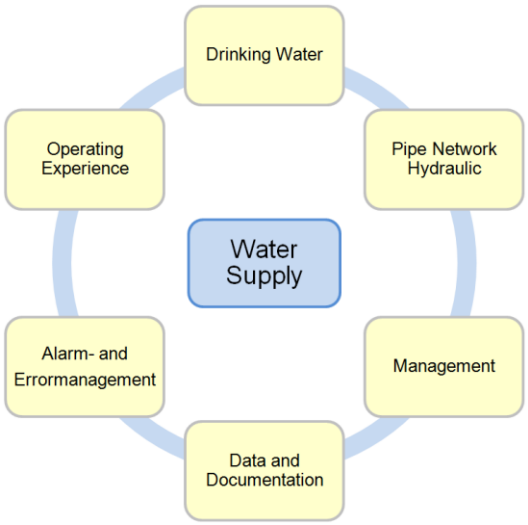
Picture 2 Overview of the zone “Sonnenberg (HZ)” with hospitals and universities

3. Characteristic of the “Hangzone Sonnenberg (HZ)”

The “Hangzone Sonnenberg” is supplied by the two waterworks “Hardhof” (ground water”) and “Lengg” (lake water). The two treatment plants are connected by the main ring system and the reservoir “Sonnenberg” is a part of this zone. Depending on the operation modus of the waterworks, the zone is used for transit water to other, also high pressure zones. Important clients with a high priority and high consumption are situated in this zone (hospitals, universities).

4. Requirements to the model

Due to the two different raw water sources (lake water and ground water) the identification of changes from the normal water quality state is very difficult. The changes in the water composition, the water is supplied by different sources, needs to be identified by the sensors. For this reason the requirements to the accuracy of the collection of the hydraulic modeling are very high. With additional measurements of the hydraulics, as pressure and flow, nearly precise consumption date of big and important clients can be captured. The goal for the simulation is an accurate modeling of the real hydraulic situation and consumption. For this reasons we will do additional water consumption measurement by the important clients.



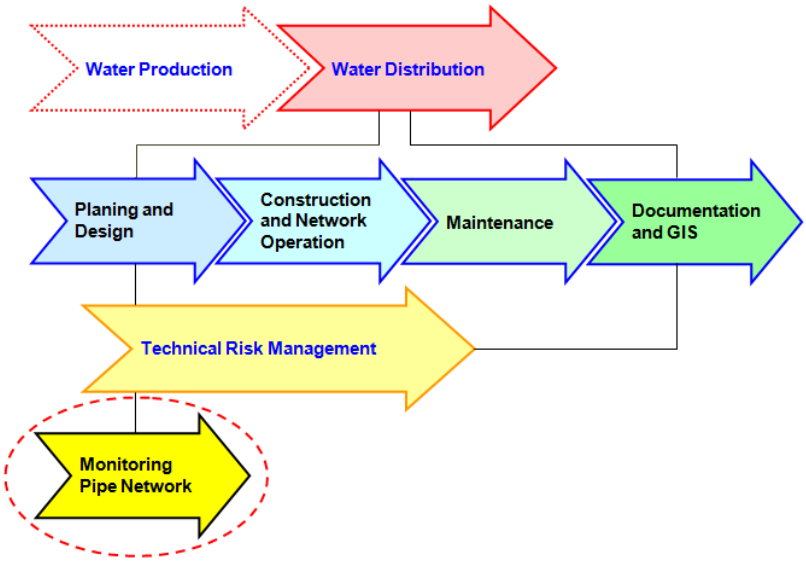
Picture 3 Influencing factors on monitoring distribution network

The optimal placement of the sensors should be defined in the pilot zone. It is a multiple requirement to optimize placement of the sensors, detecting water quality changes, measuring water flow and to aware the priority of water clients. The online simulation should also be used to calculate different operational scenarios of the drinking water supply.

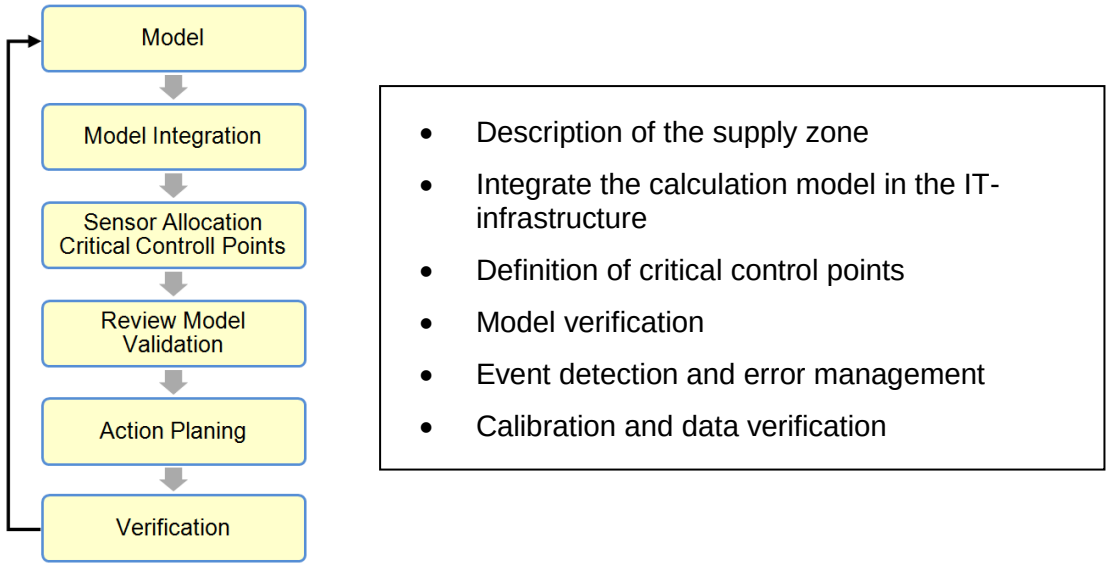
A local pollution in the pipe network or the dealing with alarms can be finally simulated and checked. The SCADA control, an operation system, gives the input to the online model. For example, main or pipes sections, which are out of service, are checked by the GIS and updated for the online model. For the hydraulic calculation we are using the DHI-software MIKE-URBAN and for the GIS the GEONIS-expert and ArcGIS 10.1 software. For the sensor allocation we will use the open source software CANARY (event detection) and TEVA-SPOT (sensor placement), developed by the US Environmental Protection Agency (EPA).

5. Monitoring is a business process at Zurich Water Supply

The Water Supply Zurich is organized in processes. The monitoring of water distribution, as a business case, is a part of the “Technical Risk Management” and based on the following sub-processes steps listed below.



Picture 4 Water network monitoring as a sub-process of the "Technical Risk Management"



Picture 5 The „Technical Risk Management" process is the basis for the development of the online monitoring

For the development of the model, we described this listed steps. Finally, the calibrated online simulation model is the basis for tests and analysis of errors. This is a repetitive process, the accuracy of the results is continuously improved by verification of the input parameters, like the water flow or water consumption. The defined goals at the beginning, can only be achieved by a functioning online model, it is a must to know the water age at all times at the defined sensor points.

6. What and where should be measured?

Zurich Water Supply produces drinking water in three different waterworks. The water plants supply water for all the pressure zones. In nearly all pressure zones, it may have water from more than one production plant.

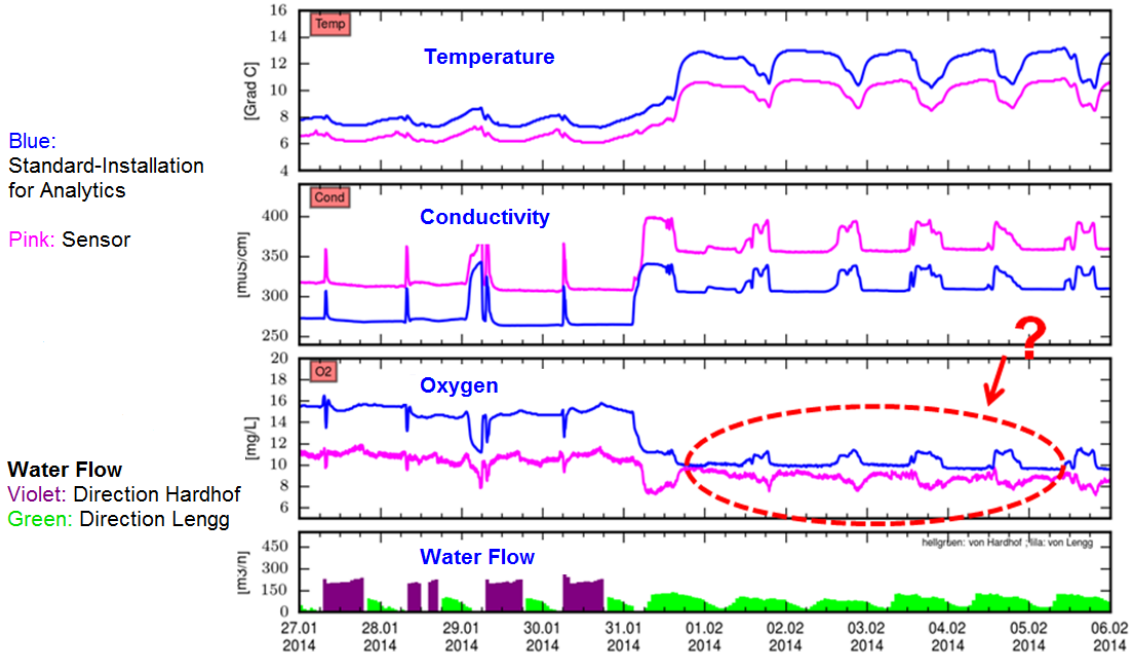
The multi-parameter sensors have to measure typical parameters to identify treated water from the lake or groundwater, like temperature, conductivity, oxygen, RedOx etc.. During this pilot project we worked with different multi-parameter sensors from

four European manufacturers. In addition to the quality and hydraulic parameters, we planned the detection of leakages at selected points in the network. All the results are submitted to the SCADA operation system. With a limited and optimized number of sensors, we have to survey the network. Additional requirements for the sensor allocation are

- Accessibility to the pipe and using existing chambers or manholes
- Direct connect to the pipe, a pipe sluice needed
- Independent power supply and data transmission with link to the SCADA system
- Protection against weather and vandalism
- Security of the water supply and priority of the pipe
- Number and priority of the customers who are touched by the water pollution.

Currently we are doing quality measurements with different sensors in the chamber "Sonneggstrasse". This chamber is well situated, the entrance to the chamber is from a pedestrian underpass, and the experts can enter the chamber on the same level. A main pipe, two distribution pipes and a spring water pipeline pass this shaft. All measurements are transmitted by a fiber optic cable to our control system, so the project responsible can follow and analyze the results online without disturbing the daily network operations. Additionally we installed a standard water quality control station, with online measurement equipment used in the water treatment plants.

The next picture shows a typical measurement with a multi-parameter sensor (pink line) comparing the results from the standards equipment (blue line). The sensor results are significantly different to the standard results during the time with higher water temperature from the Lengg plant (green graph).



Picture 6 Results of a standard water analytic station and the results of the multi-parameter sensor station during the same period of time.

7. Summary

The quality of drinking water is very important to the consumer and they put great confidence in the water suppliers. Drinking water is one of those goods with a high priority regarding security of the supply and distribution. Drinking water is one of the critical infrastructures in a city and the supply of excellent, controlled drinking water in emergency situations or during accidents to consumers is absolutely necessary. Reasons for emergency situations are many, like accidents, sabotage or natural disasters.

As result of the process online monitoring in the drinking water network and the sensor placement at the critical control points, we get a better surveying of the network. The water supplier has now the chance to install an early warning system in case of contamination or significant changes of the water parameters. The availability of real-time data and the network of different sources and software, gives the possibility to the water suppliers to create an online-simulation model for different operation tasks.

The Zurich Water Supply is on the way to install this pilot project “Hangzone Sonnenberg”. Supported by this project, we expect feedback to questions like the optimized sensor network and sensor placement. We will collect information about investment costs and operation costs and get feedback about the needed qualification of our employees and experts. The online monitoring is an important step to a better network management and to preview and to avoid bursts or damages. The monitoring optimizes the planning process and helps the responsible persons to a better hydraulics understanding for the water network.

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