Project: Sustainable Hydro Assessments and Groundwater Recharge Projects
Project acronym: SHARP

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APPENDIX: Long version of good practices

GP 16	Artificial ground water recharge @ Andritz

Project Partner:
Holding Graz Services | Water (HG)

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Abstract

Being Austria's fourth largest water-supply company, the Holding Graz Services, has ensured the successful water-supply of the Styrian capital for many decades. The city of Graz, with approximately 250 000 inhabitants, is Austria's second largest city. The average daily water demand of the area amounts to about 50.000 m³. Approximately 30 % of the total demand is covered by the bulk water supply from the Zentral Wasser Versorgung Hochschwab Süd. The waterworks Andritz, which cover the additional 30 % of the water demand, operate by means of artificial ground water recharge plants where horizontal filter wells serve as drawing shafts. In Graz ground water management and artificial ground water recharge have a long tradition. The first ground water recharge system operated in the 1920s. In the 1980s the artificial ground water plants in Andritz were commissioned. The ground water recharge systems serve to increase the productivity of the aquifer and to reduce the share of the infiltration from the river Mur. Protection areas have been identified to ensure that the water quality of the aquifer stays at optimal levels. The protection areas are divided into zones indicating various restrictions for usage and planning. Two respective streams serve as the source for the water recharge plants. The quality of the surface water is measured by means of a turbidity meter and if the turbidity of the water exceeds a defined level, water withdrawal is automatically stopped. After passing through intake- and sedimentation tanks, the water enters a horizontal gravel filter system and the infiltration plants. Different infiltration systems are utilised. The sand filter and lawn basins and operate intermittently. Each of the various

artificial ground water recharge systems displays specific advantages and disadvantages in terms of operation as well as maintenance which have to be taken into account before selecting an infiltration plant.

Introduction

In Graz artificial ground water recharge systems have been successfully operating since the beginning of the last century. Because of a long drought period and the increased water consumption, ground water recharge was introduced in Graz for the first time in 1921. In the environment of the waterworks at Andritz as it functions at present, certain natural basins are flooded by draining the so called Mühlgang (a small artificial stream with water from the Mur river). In 1921 the nearest well had a distance of close to 50 m. In the first year the artificial infiltration and resulting ground water recharge operated for about 2 weeks. The average daily extraction from the Mühlgang was 4,300 m^3, which amounts to approximately 12 % of the present daily well capacity. The Mühlgang's maximum discharge reached up to 40 l/s. No negative influence on the drinking water quality was recorded. In the 1920s the main target was to increase the capacity of the aquifer. Later in Graz the demands on the ground water recharge systems would change. A few years later in 1923, small dams were constructed in the area of Andritz in order to increase the basin's infiltration area rate. Because of these successful experiments at the onset of the last century, this period can be regarded as the establishment of the artificial ground water recharge in Graz. Ground water resources serve as the only supply for drinking water in Graz.

For the actual operation of the total water supply systems, the following three ground water resources are used (Figure 1):

- The waterworks Friesach which is 12 km north of the city of Graz. About 40 % of the total demand is drawn from the local aquifer. In Friesach several artificial ground water recharge plants operate.
- The waterworks Andritz is located in the northern part of Graz. The aquifer system is managed by artificial ground water recharge systems. The water works Andritz covers about 30 % of the total water demand.
- The bulk water supply from the Zentral Wasser Versorgung Hochschwab Süd covers approximately 30 % of the total demand.

Additionally, the waterworks Feldkirchen, with a maximum capacity to provide 50 % of the city's demand when necessary, serves as a malfunction reserve. At present the ground water management in Feldkirchen, which boasts 2 horizontal and 4 vertical filter wells, does not operate.

The two waterworks facilities of Andritz and Friesach are operated by the Holding Graz Services. Both are located very close to the Mur River and the artificial ground water recharge systems are operated regularly. Currently the systems are being operated to increase the quantity of the aquifers and to reduce the infiltration rate from the Mur River. Because of the strict regulations on sewage drainage and waste water treatment, the water quality of the Mur River has improved during the past few years and therefore the demands on the reduction of the infiltration rate from the river were reduced. A stringent monitoring program is nevertheless being carried out to ensure the high drinking water quality. For this purpose, wide protection areas have been identified in the region of Andritz. The protection zones in Friesach are currently being redefined.

Total water supply in Graz

The city of Graz, with around 250,000 inhabitants, is the second largest city in Austria. Approximately 30,000 students live in Graz part-time during the year. Recent statistics show that up to 70,000 people from the regions surrounding Graz commute into the city on a daily basis. The overall water demand totals approximately 50,000 m3 per day. The total length of the water supply network is close to 850 km and an actual amount of 32,000 house connections can be considered. To ensure the supply pressure, which is normally between 2 and 6 bar, 20 pumping stations and 8 wind vessel plants are operated. 20 reservoirs serve as storage for the total capacity of 36,000 m3. The system is operated with different pressure zones. By means of the normal pressure zone, the centre of the city is supplied. For the higher-lying areas in the city, located up to approximately 450 meter above sea-level, two further high pressure zones have been installed. The pumping stations and reservoirs are governed by a central remote-controlled system. A future challenge will be the integration of the ground water recharge facilities to optimise the operation mode.

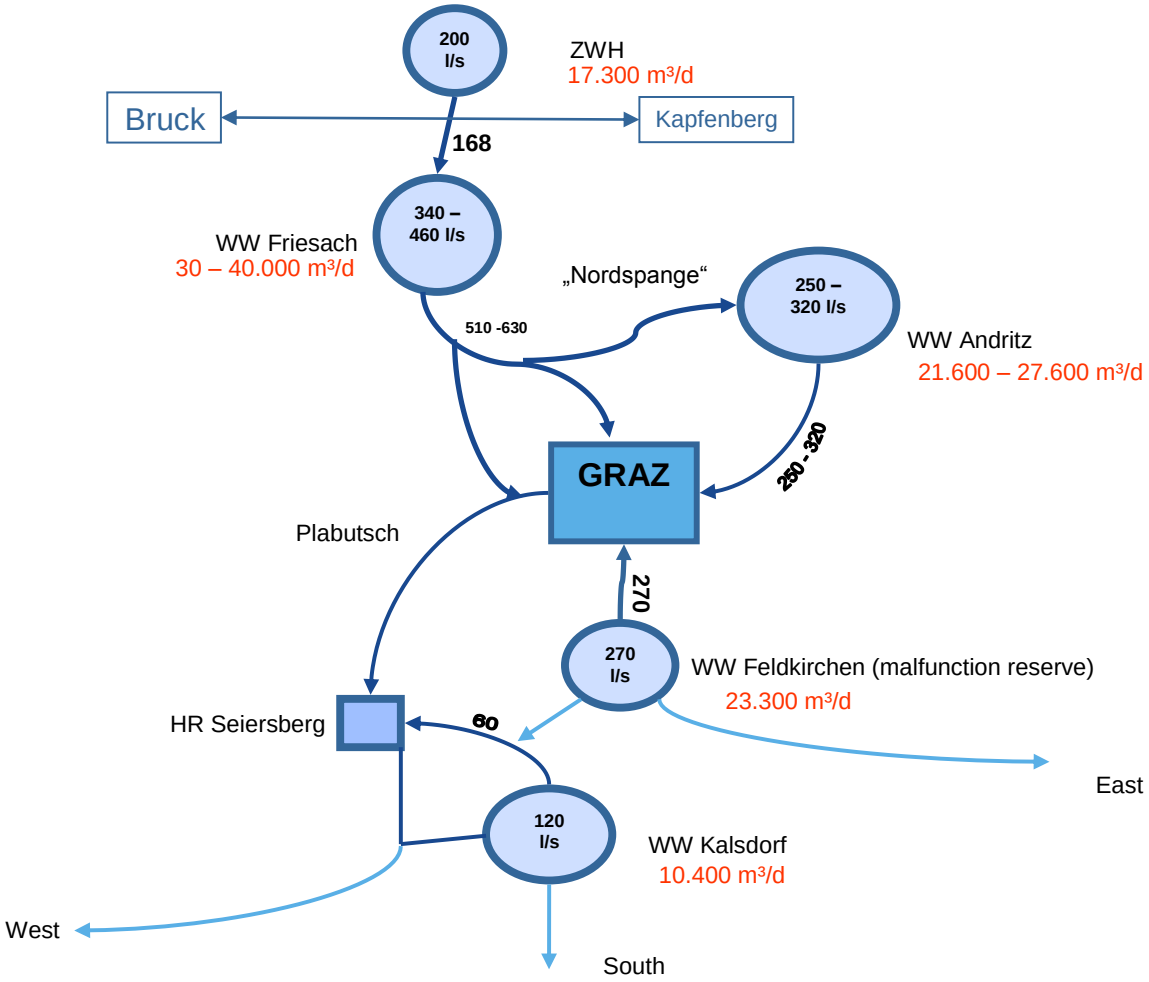

Figure 1: Schematic diagram of the water supply system in Graz.

Waterworks Andritz

The poor water quality of the Mur River lead to the decision that the Mühlgang cannot longer serve as a sustainable source for infiltration water. In the 1930s first investigations were initiated to utilise the surface water of the Andritzbach for the groundwater recharge. In comparison with the quality of the Mur River, the Andritzbach showed much better values (i.e. no treatment of any kind before the infiltration is necessary) and therefore in the 1940s an intake facility was constructed. The weir, settlement tank and the 600 m long concrete pipe with a diameter of DN = 700 mm is still used for the groundwater recharge in Andritz. The maximum extraction quantity of 250 l/s is also presently still valid. The infiltration basins were surrounded by artificial earth dams and were operated until the 1980s. Then, because of the drastic decrease in the water quality of the Mur River, the Holding Graz Services improved and adapted the groundwater recharge plants. The challenge was to decrease the share of the infiltration rate of the Mur River by installing a hydraulic gradient with the ability to recharge the ground water artificially. The predominant groundwater flow direction in the aquifer is in general parallel to the Mur river with an average slope of about 0.5%. The overall aquifer is built of quaternary sand and gravel fluvial sediments of locally strong varying conductivity and thickness.

Based on the results of pilot plants, comprehensive research activities regarding the aquifer system and monitoring of the raw water quality, the recharge system functions as depicted in the following scheme (Figure 2).

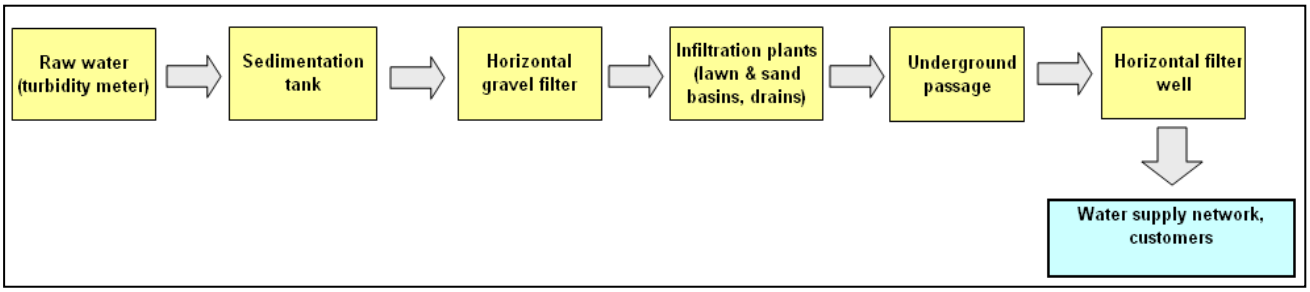

Figure 2: Scheme for artificial ground water recharge in Graz.

Experience has shown that when the turbidity level of the raw water exceeds a certain level, operating problems in the pre-filtration basins are encountered. A turbidity meter has therefore been installed at the system's inlet point in the Andritzbach. If the turbidity level exceeds 5 FNU, the inflow to the recharge plants is stopped by means of an automatic closing gate.

Following the raw water inlet a settlement tank, consisting of two chambers each with a capacity of 220 m^2, has been installed. As mentioned above, the water flows through the old concrete pipes before entering the pre-purification (gravel) basins. For the operation of these two horizontal flow plants a certain granular size was defined. The results of pilot plants in the 1980s have shown that a granular size of 8/16 mm provide the best results for the removal of suspended solids. The observed removal rate is between 50-70%. A certain reduction of organic biomass was also monitored. The two basins have the following dimensions: L = 30 m, W = 10 m, H = 1.3 m. The volume of gravel per basin is approximately 400 m^3. After an operation period of 2 to 3 years, the filter material has to be removed. Following the horizontal filter system passage, the water is distributed by several valves and cascades into the infiltration basins. The cascades serve to increase the oxygen content of the water. In Andritz two different types of infiltration plants exist.

A lawn basin, with a total area of approximately 2,000 m^2, shows an infiltration capacity in the region of 1-2 m per day. The lawn basin has two different layers. The lower stratum, with a thickness of 20 cm consists of 8/16 mm gravel granules. The top layer consists of humus and was originally planted with grass. Due to the natural concurrence situation the grass has been displaced by local moss. Research activities regarding the best suitable natural plants or grass respectively are ongoing. The lawn basin in Andritz operates intermittently for a period of 10 days. After an intermission of a further 20 days, the basin is flooded again. The lawn basin has to be mowed several times a year. The operational halt of 10 days is necessary to avoid the grass and moss dying, which would lead to blockage of the basin.

Additionally two sand filter basins (Figure 3) with a total area of 3,000 m^2 are used for the artificial groundwater recharge as well. The uppermost 50 cm sand layer has a granular size between 0.06-2 mm. The average infiltration capacity is currently 1.5 times higher than the infiltration capacity encountered at the lawn basin. The sand basins are operated alternatingly, i.e. at least one is always operating. Each of the sand basins is flooded for 3 days. Especially during the warm summer months problems with the emergence of algae occur. The sand layer has therefore to be cleaned regularly. Both type of infiltration basins are build with an overflow, which drains into the Mur River.

The underground passage ensures the high quality of the drinking water. The subsurface travel time between the infiltration locations and the pumping wells is less than 20 days and it varies between the river Mur and the two wells between 20 and 80 days. The groundwater level and quality is continuously monitored by means of a vast number of inspection wells. A special monitoring program has therefore been compiled by the Holding Graz Services. Only 2 – 7% of the withdrawn water comes from the river Mur. The recovery rate of the infiltrated surface water at the recharge site is relatively high (92%).

Figure 3: Lawn and sand basins in Graz Andritz.

In the end of the 1960s two horizontal filter wells (HFB 3 and HFB 4) were constructed. Both wells show a depth of 21.5 m and have 26 horizontal filter strings, each of them showing a length between 20 and 30 m. The wells were constructed according to the Ranney system. Both wells have 2 vertical pumps and operate intermittently. The average ground water level has a depth of about 7 m under the surface.

To ensure the water quality in Andritz four types of protection areas have been identified and a comprehensive monitoring scheme is being carried out. For protection area type I with an area of 26 ha, agricultural use is

prohibited completely. This high-level protection area is bordered by a fence. All groundwater recharge plants and horizontal filter wells are located inside the protection area type I. The remaining groundwater protection areas with different usage restrictions have a total size of 120 ha. Drinking water in Graz does not need any further treatment or disinfection. The amount of nitrate is below 10 mg/l and pesticides are below the detection limits. The degree of hardness is approximately 16 ° d.H.

Management concept (O&M)

For the operation and maintenance (O&M) of the groundwater resources in Graz a management system is being carried out. The management system defines different operational modes in terms of water quality and operational costs. The following operational parameters have been taken into consideration:

- Drawing shafts for the horizontal filter wells
- Raw water discharge and recharge quantity
- The groundwater level

Figure 4 shows a comparison of the monthly infiltration quantities and the pumped water from the drawing shafts based on the developed management system.

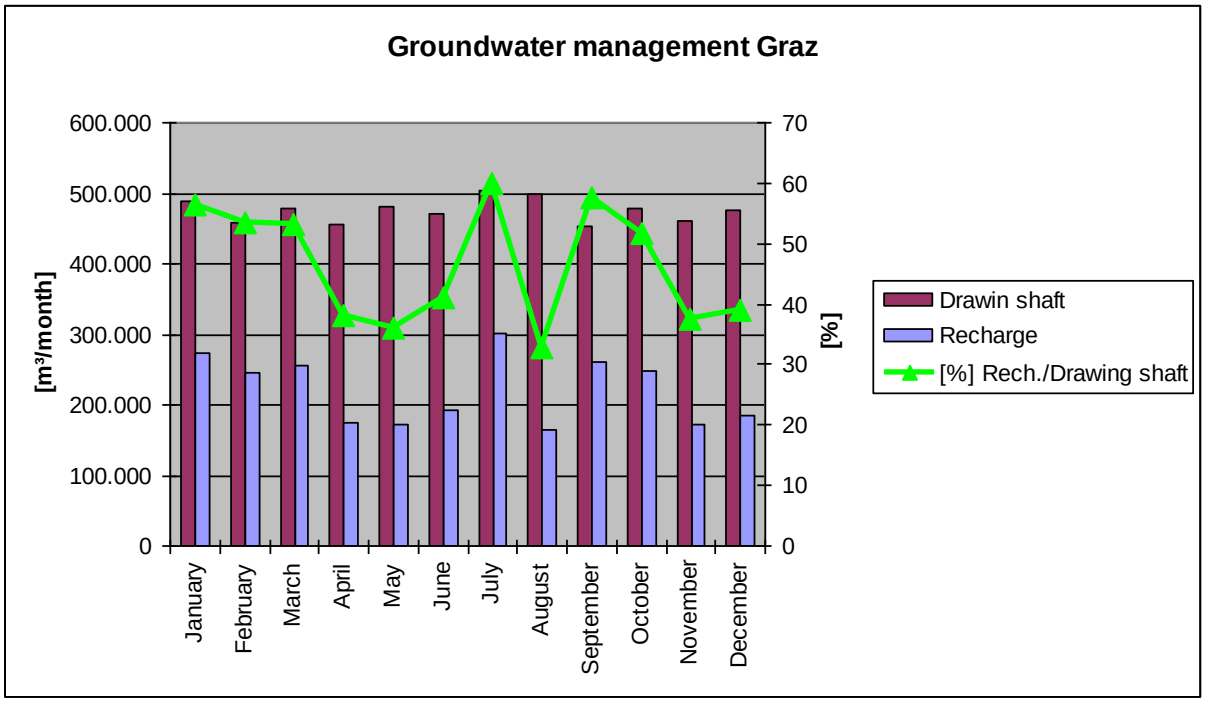

Figure 4: Infiltration rate and pumped water from the drawing shafts at the waterworks Andritz (2010).