INFORMATION for the CULS and BOKU students!!

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Excursion

Suchdol Station of the DWR and Káraný Waterworks

Date: Thursday afternoon and Friday, May 19 - 20, 2016

The bus for Káraný will leave the Campus on May 20, 2016 at 8:00 exactly from parking oposite to Menza

Location Suchdol

- **„Experimental site for monitoring of transport processes and soil moisture content dynamics" – DWR research base**
  - The field research station is located in Prague 6 – Suchdol (50°8'N, 14°23'E, 286 m a.s.l).
  - Average annual temperature and precipitation are 9.1 °C and 495 mm, respectively.
  - The soil is Udic Haplustoll or Haplic Chernozem of loamy texture on an aeolic loessial substrate.

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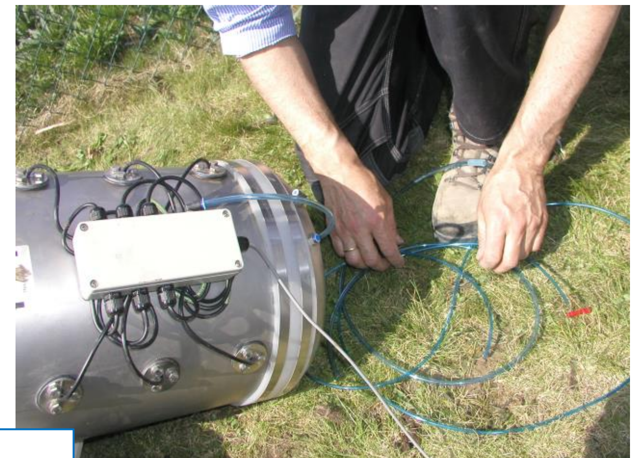
- There is virtually no textural difference between topsoil and subsoil. The boundary between the A and C horizons lies at about 35 cm. The transitional A/C horizon is only about 10 cm thick. The layer between about 15 and 25 cm of depth, i.e. the lower part of topsoil and the plough sole, is perceptibly more compacted than the rest of the profile.
- The fine earth contains 22–32.5 % sand, 39.5–54 % silt and 22–28 % clay, while the saturated hydraulic conductivity (100 cm^3 cores) varies roughly between 6×10^{-4} and 4×10^{-1} cm min^{-1} and the total porosity varies between 0.40 (plough sole) and 0.54 (topsoil) $cm^3\ cm^{-3}$, its mean value (0–100 cm) being 0.457 $cm^3\ cm^{-3}$.
- The topsoil dry matter contains about 2.5 % of total organic carbon and 7.8 % of calcium carbonate. No groundwater (i.e., a permanently saturated zone) exists either in the soil profile or in the underlying loess down to at least few meters.

- The soil has a moderate capacity to swell and shrink. During dry spells, cracks about 1 to 3 mm wide appear at the surface, lying 15 to 20 cm apart. The structure is granular in the A-horizon and sub-polyhedric in the loessial C-horizon. At the higher level of organization, the structure is prismatic.
- The average water retention curve obtained from 100 cm^3 cores can be approximated e.g. by the single-porosity van Genuchten equation with the saturated water content θ_s = 0.475, the residual water content θ_r = 0,001, the capillary rise parameter α = 0.06548 cm^{-1} and the shape factor n = 1.11534.
- The soil had been ploughed for several centuries. Grass was sown in spring 2009 and is maintained since then as a short lawn. The site is neither irrigated nor tile-drained. The grass often suffers from water stress. The terrain is flat. Local short-term ponding of water can be very rarely observed on the surface during very intensive rainstorms.

Instrumentation

- Two smart field lysimeters SFM-30 (UMS GmbH München), 30 cm in diameter, 30 cm deep, automatic weighing, automatic maintenance of bottom suction at the same value as in that the native soil around (measured by T4 or T8 tensiometers at 30 cm depth). The newer type is also equipped with automatic registration of percolate mass; the older type requires the volume of percolate to be measured manually.

- Chemical analysis of the percolate is possible but has not yet been done. Soil water content and temperatures is measured inside the lysimeter at three depths (soil water suction and bulk electrical conductivity are also measured in the newer lysimeter).
- The meteorological data are collected



Lysimeter

Lysimeter and grass cover

25.4.2013

9.5.2013

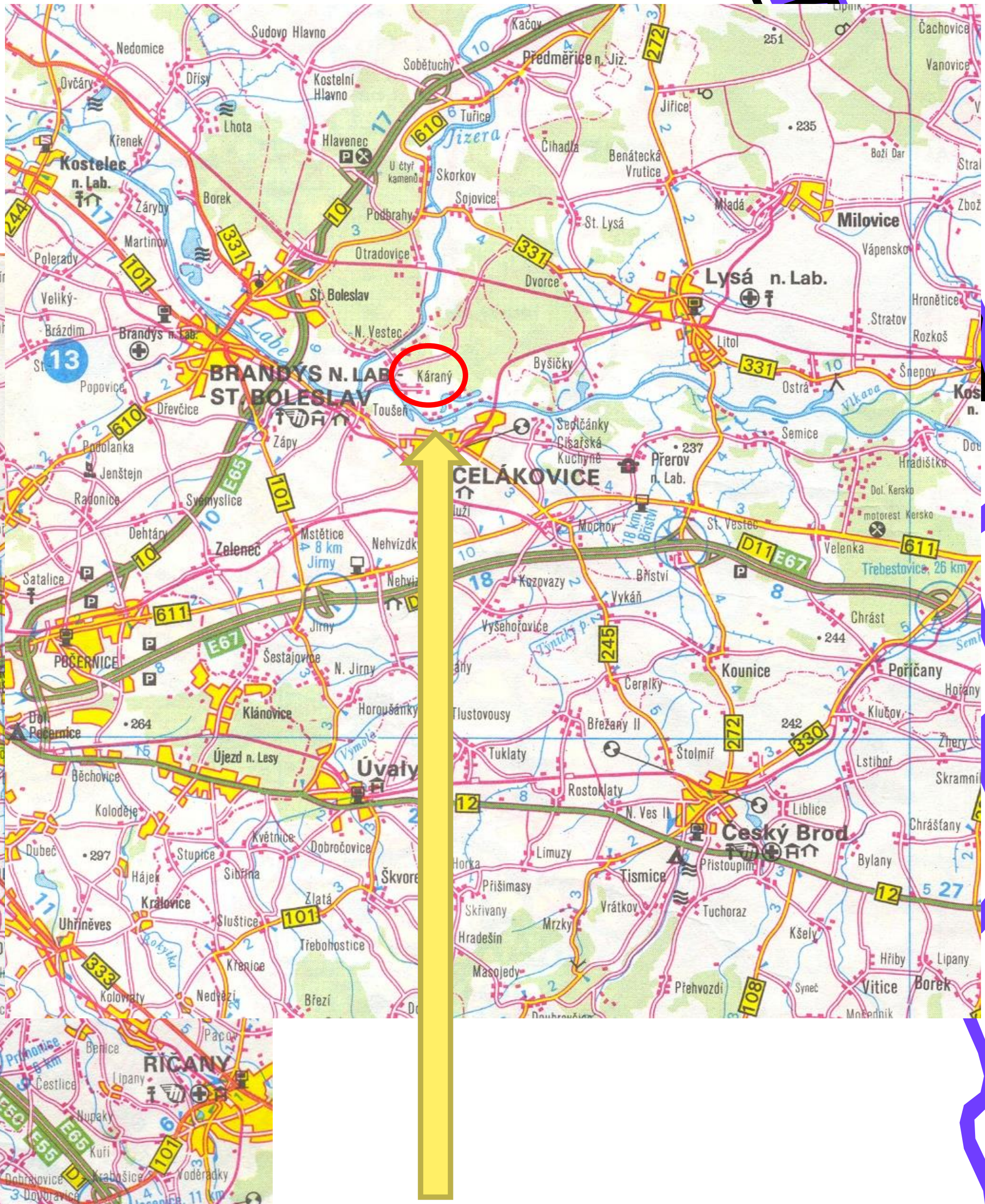
18.6.2013

18.8.2013

Location Káraný

- Káraný is located northeast of Prague, direction to Brandýs nad Labem .
- The distance is around 35 km, however the major part of the road is motorway
- For the location see the map 1: 200 000

Prague and surroundings
Map 1:200 000



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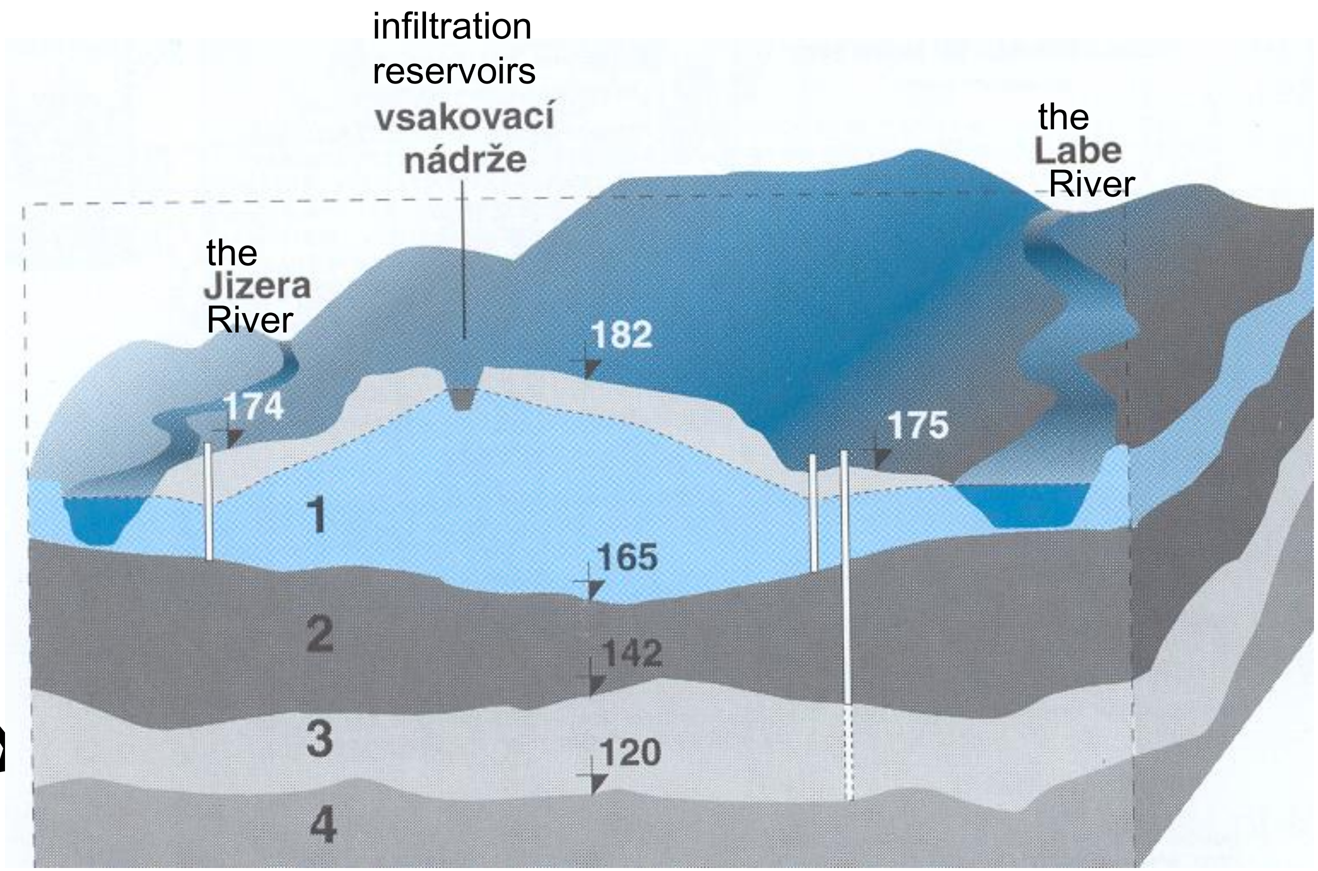
Hydrogeology of the location Káraný

1. Quoternary sand and gravel
2. Lower Turonian marlstones
3. Cenomanian sandstones
4. Clayey shales



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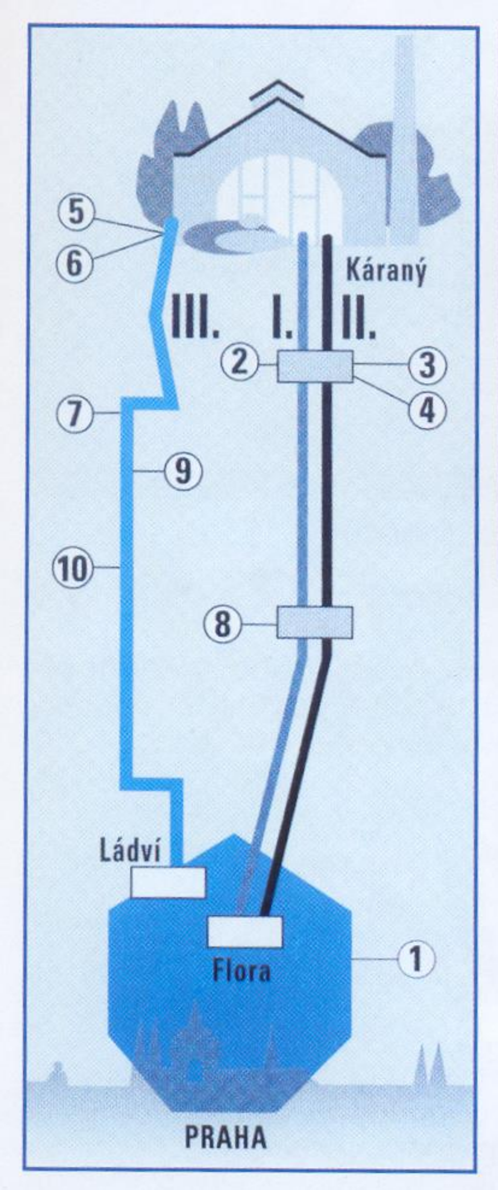
- Transport of potable water into the City of Prague (Three lines of tubes,2 of 1.1 and one 1.6 m in diameter



Basic Information

Kárany waterworks

The main activity of the subsidiary is treatment of drinking water and its supply to the distribution network of the Prague Capital City in the required amount and quality. It is one of few large European waterworks treating groundwater, which has retained the original capacity and water quality of its water resources since its establishment.

The plant at Kárany is the first supplier of drinking water to Prague, operating since 1914. The selection of the Kárany site at a confluence of the Elbe and Jizera Rivers was based on a very suitable hydrogeological structure of the region, rich in quaternary gravel sand deposits.

For a long time, the Kárany plant was the most important source of drinking water for Prague. In relation to development of the city and to increase of its population, additional plants were gradually constructed and proportion of water from Kárany on the total water supply of the city dropped to the current 25 per cent. The average capacity of the waterworks is 1750 l/s.

Drinking water treatment technology

Kárany ground drinking water is acquired through three systems:

1. Natural infiltration

Water from the Jizera River infiltrates through the river bed and banks into the surrounding gravel sand deposits, where it is collected together with natural groundwater at a distance of 250 m from the river. A number of bore holes linked by a siphon are used for the purpose. Water is then transported using pumping stations and gravitational conduct pipeline into the main pumping station in Kárany.

2. Artificial infiltration

Raw water from the Jizera River is transported to the treatment plant where it is filtered through sorted sand on high-rate filters and then pumped into infiltration reservoirs with natural sand bed in the gravel sand deposits. The water infiltrated through this natural filter enriches intensively natural groundwater resources and it gains characteristics of groundwater by contact with the geological layers. The infiltrated water is collected as very good drinking water at a distance of 200 m from the infiltration reservoirs after 40 to 50 days of retention at ground and it is pumped into the main pumping station. After ensuring the necessary hygienic measures by chlorine dosing, water is transported to the Prague water distribution reservoirs.

3. Artesian water

It is a source of water of exceptional quality, flowing into the region in deep ground from the northern part of the geological structure known as „Bohemian Cretaceous (Česká křída)". It is collected by seven artesian bore holes; its age is estimated to be 16 000 years. Its composition, after simple treatment (iron removal), corresponds to requirements on water for preparation of infant food. A small part of this water is used for bottling and for sale as potable water using distribution containers.

Water quality

The selection of the site for supply of Prague with drinking water proved to be a good choice. A mixture of groundwater and infiltrated water supplied by the Kárany Waterworks has definitely the best composition in comparison with other two sources supplying water to Prague. In 1986, the water resources at Kárany were incorporated into a zone of hygienic water protection. The decision on the zone sets the appropriate water use rules, control of construction activities, limits for discharge of waste water and handling of waste etc.

Grundangaben

Das Wasserwerk Kárany

Die Hauptaufgabe des Wasserwerks Kárany besteht in der Aufbereitung von Trinkwasser und der Belieferung des Prager Trinkwassernetzes in erforderlicher Qualität und Menge. Dabei handelt es sich um eine der wenigen europäischen Grundwasserwerke, wobei das Wasserwerk Kárany seit dessen Entstehung sowohl ursprüngliche Leistung, als auch Beschaffenheit der Ressourcen aufrecht erhalten konnte.

Das Wasserwerk Kárany stellt die erste Trinkwasseraufbereitungsanlage dar, die seit 1914 Prag versorgt. Die Wahl zugunsten des Trinkwassergewinnungsgebietes am Zusammenfluss von Elbe und Jizera fiel aufgrund der äußerst günstigen hydrogeologischen Gestaltung dieser Region, die reich an quartärer Kiessandaufschemmung ist.

Über eine Zeit lang war die Aufbereitungsanlage Kárany als entscheidender Trinkwasserversorger Prags tätig. Im Zuge der städtischen Weiterentwicklung und dem Anstieg der Einwohnerzahl mussten in Prag weitere Wasserwerke gebaut werden, womit der Anteil des Trinkwassers aus Kárany schrittweise bis auf die heutigen 25 % gesunken ist.

Technologie der Trinkwasserproduktion

Das Trinkwasser wird in Kárany aus Grundwasser durch folgende drei Systeme produziert:

1. Natürliches Uferfiltrat

Das Wasser der Jizera infiltriert sowohl durch den Boden, als auch das Ufer in die umliegenden Kiessandaufschwemmungen, wo es anschließend in rund 250 Meter Entfernung vom Fluss in einer Mischung mit Naturgrundwasser gespeichert wird. Dies geschieht mit Hilfe einer Reihe von durch ein Heberohr miteinander verbundenen Bohrbrunnen. Von dieser Anlage aus gelangt das auf diese Weise aufbereitete Wasser durch Pumpwerke und eine Rohrleitung mit Selbstgefälle in das Hauptpumpwerk in Kárany.

2. Künstliches Uferfiltrat

Das in die Aufbereitungsanlage geförderte Rohwasser aus der Jizera wird über Schnellsandfilter gefiltert und anschließend in Versickerungsbecken mit natürlichen Sandböden in Kiessandaufschmemmungen gepumpt. Das durch diesen natürlichen Filter versickernde Wasser reichert intensiv die natürlichen Ressourcen an Grundwasser an und durch den Kontakt mit geologischen Schichten erhält es die Eigenschaften von Grundwasser. In einer Entfernung von 200 Metern von den Versickerungsbecken wird das auf diese Weise infiltrierte Wasser nach einem Aufenthalt von 40 bis 50 Tagen als Trinkwasser bester Qualität in das Hauptpumpwerk gefördert. Von hier aus tritt es dann nach vorgeschriebener Chlorierung den Weg in die Prager Hochbehälter an.

3. Artesisches Wasser

Hierbei handelt es sich um eine Ressource besonderer Qualität, die in tiefstem Untergrund aus dem Nordteil des geologischen Gebildes „Tschechische Kreide" zufließt. Das schätzungsweise 16 000 Jahre alte Wasser wird durch sieben artesische Bohrungen gefördert. Dessen Zusammensetzung entspricht nach geringer Nachbehandlung (Enteisenung) den Anforderungen auf Säuglingsnahrung. Ein geringer Anteil dieser Produktion wird zum einen für die Kunden in Flaschen abgefüllt und zum anderen als Tafelwasser vertrieben.

Wasserqualität

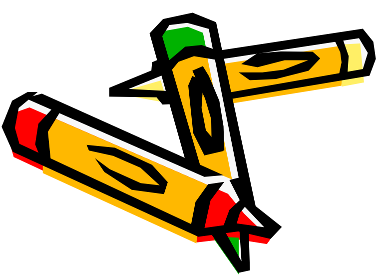
Die Wahl der vorstehend genannten Lokalität zugunsten der Trinkwasserversorgung Prags hat sich langfristig als richtig erwiesen. Im Wettbewerb mit den übrigen zwei Aufbereitungsanlagen, die ebenfalls die Hauptstadt mit Trinkwasser beliefern, weist die Mischung von Grund - u. Uferfiltratwasser die unzweideutig bessere Zusammensetzung auf. 1986 wurden die Kárany-Ressourcen unter die Hygienischen Schutzzonen - PHO aufgenommen. Diese Entscheidung setzt die Art und Weise sämtlicher wirtschaftlicher Maßnahmen, u.a. Bebauung, Abwasser - u. Müllentsorgung, u.s.w. fest.

Figures about Káraný Waterworks

-natural infiltration

- artificial infiltration

- artesian water



THE MAIN INFORMATIONS – WATERWORK KÁRANÝ
DIE WICHTIGSTEN INFROMATIONEN – WASSERWERKE KÁRANÝ
ГЛАВНЫЕ ДАННЫЕ О ВОДОПРОВОДНОЙ СТАНЦИИ КАРАНЫ

Jizera – the surface of riverbasin
die Fläche des Sammelgebietes 2.200 km^2
поверхность басейна

the lenght of stream
die Länge des Wasserlaufes 163,7 km
длина реки

average discharge of a year
zentraler Jahresdurchfluss 25,5 m^3/s
средний годовой расход воды

Q_{355} 5,1 m^3/s

Total production groundwater
Gesamte Erzeugung 1.600 - 1.980 l/s Grundwasser
продукция в целом

from that: riversides infiltration
davon: Ufersickerung 900 - 1.000 l/s
из этого береговая инфильтрация

artificial infiltration
artifizielle Infiltration 700 - 900 l/s
искусственая инфильтрация

artesian supplies
artesische Quellen 60 - 80 l/s
артезианские ресурсы

Total required electric power
Gesamter Kraftbedarf der elektrischen Energie 5,2 MW
потребляемая эл. энергия в целом

Lenght of the water intake wings of deep wells
die Länge der Fassungsflugel von Bohrbrunnen 26 km
длина сборных флигелей с буровыми колодцами

Quantity of deep wells
die Zahl der Bohrbrunnen 750
количество буровых колоцев

Crude water diversion
die Rohwasserentnahme 1.100 l/s - max 1.500 l/s
отбор сырой воды

Area of rapid sand filtration
die Fläche der Sandschnellfilter 1.440 m^2
поверхность быстродействующих песчаных фильтров

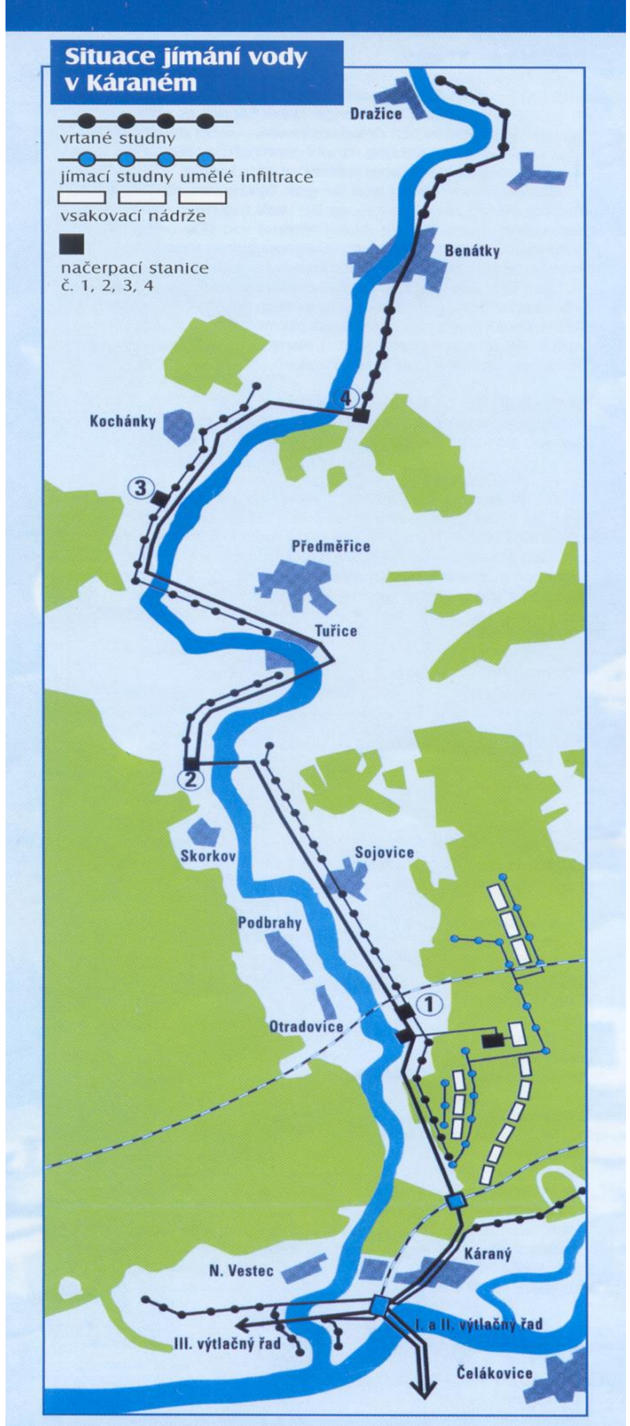
Area of infiltration reservoirs
die Fläche der Einsickerungsreservoire 68.000 m^2
поверхность инфильтрационых басейнов

Quantity of drop caissons
die Zahl der Senkbrunnen 24
количество опускных колодцев

Lenght of water pipes
die Länge des Wasserleitungsnetzes 115 km
длина водоводных колодцев

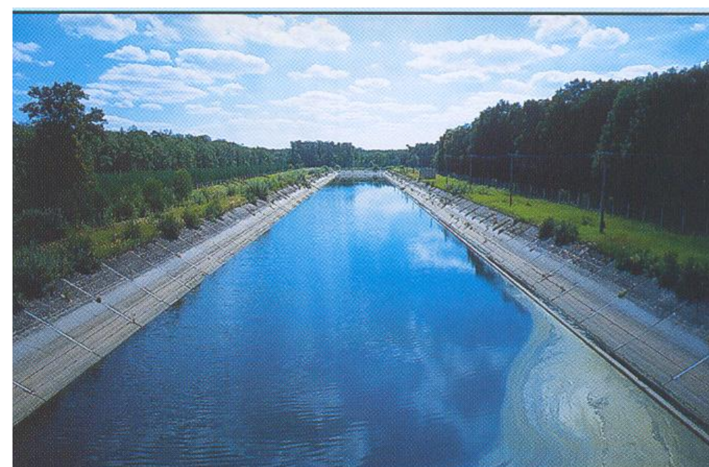
Saturated hydraulic conductivity „K“
/of gravel sand fluvial deposits/
Koefizient der Wasserdurchlässigkeit "K"
/der Schottensandschwämmänder/ $4 . 10^{-4}$
коэффициент пропускания "K"
/наносов песчаных гравий/

Water intake wings, black dots represent the wells of riverside infiltration connecting together, blue dots are the wells of the artificial infiltration, rectangles are the infiltration reservoirs, black rectangles are pumping stations (no 1, 2, 3 and 4)



The drilled wells

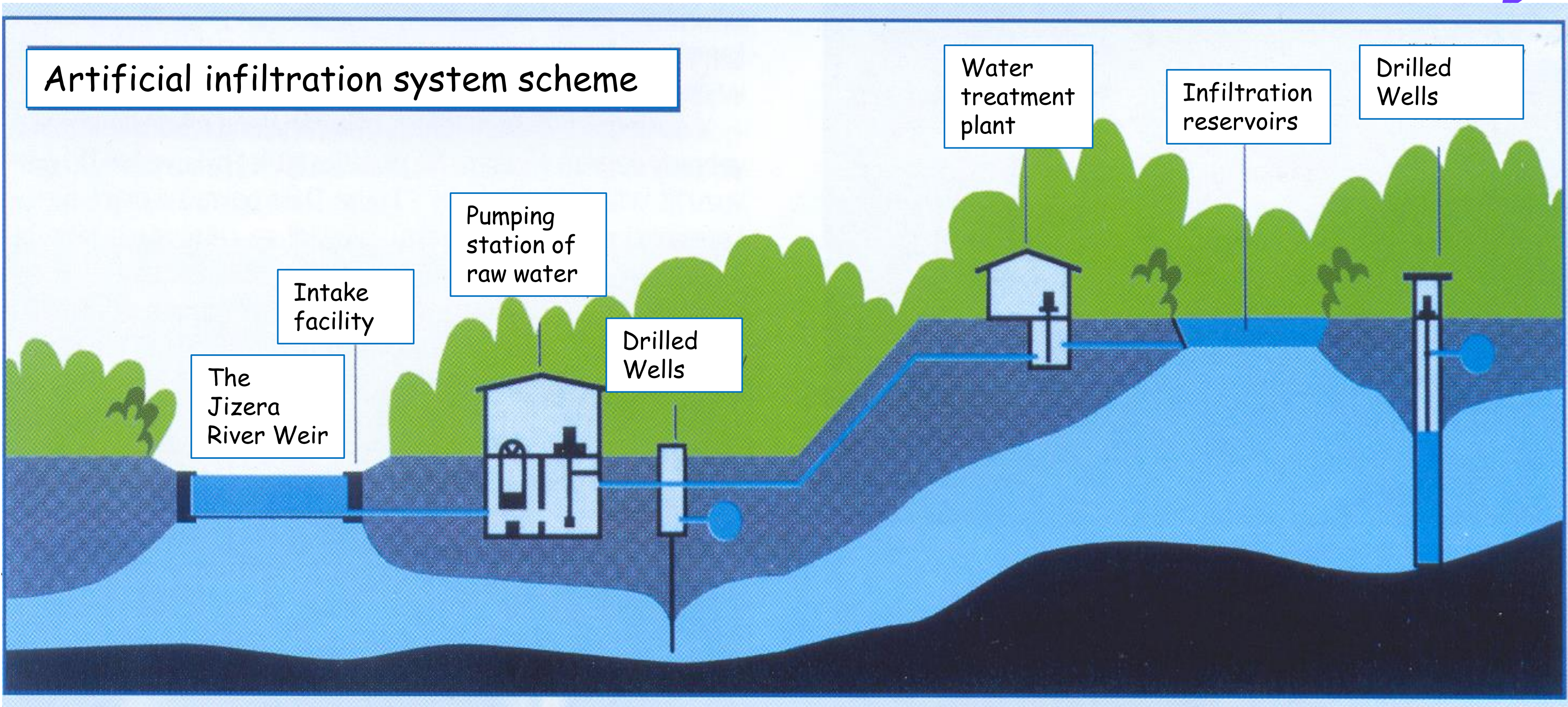
Artesian well in 1909



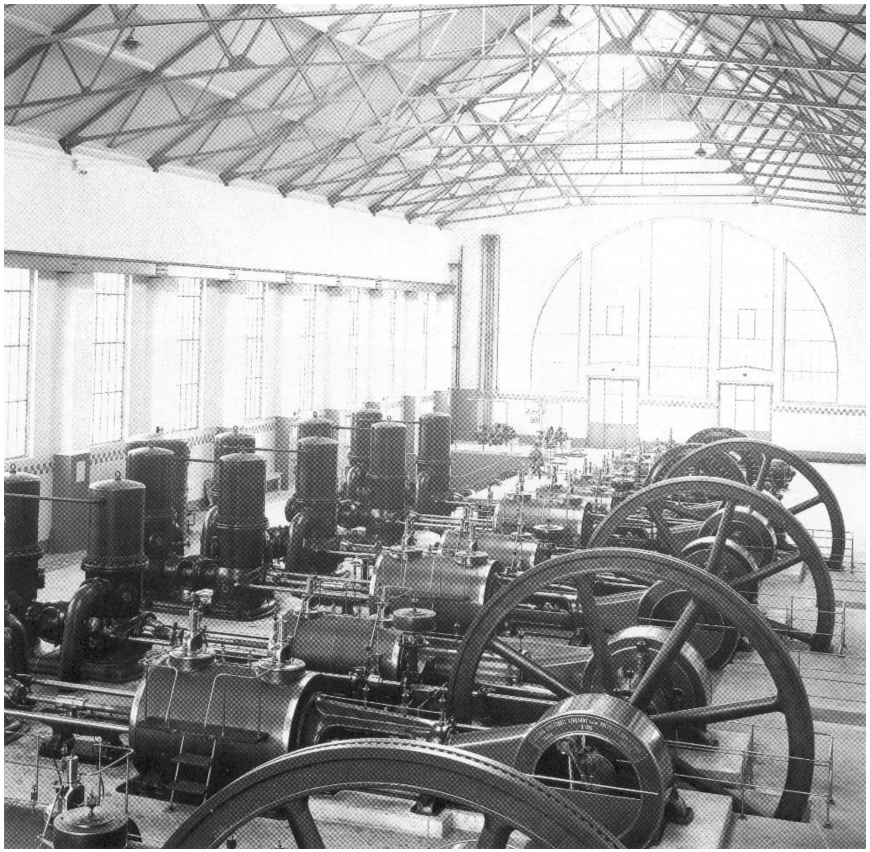
Infiltration reservoir

Artificial infitration system scheme

From the left to the right it consists of: The Jizera River weir, water taking object, pumping station of raw water, drilled wells, water purification station - filtration, infiltration reservoirs and system of wells for pumping clean potable water



Old hall of pumps in 1912 and Karaný in the nineties

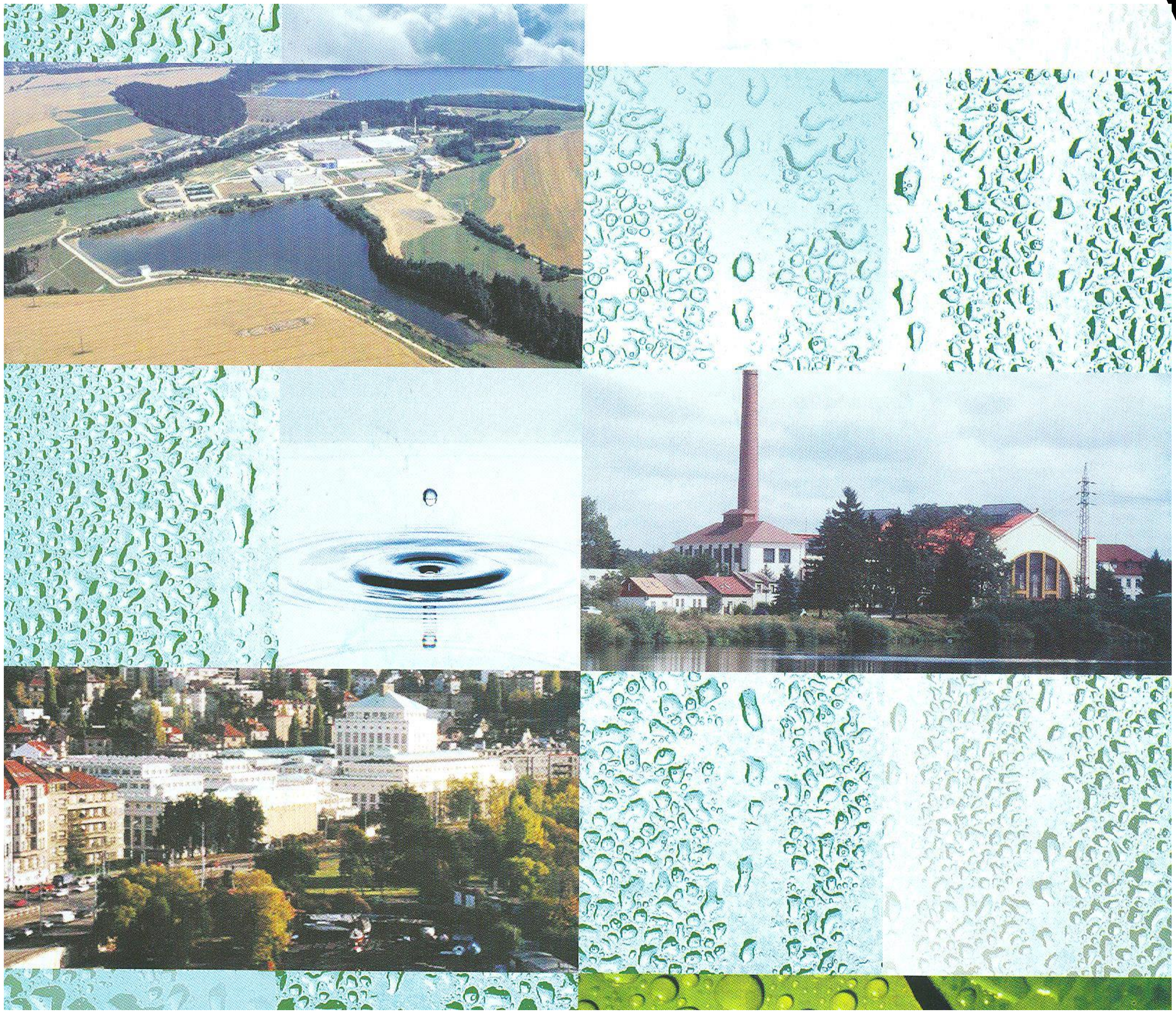


Three waterworks

Želivka
surface water

Káraný
ground water

Podolí
river water



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Želivka Waterworks

Želivka Waterworks

The Želivka Waterworks provide the most advanced and the biggest water supply for the Prague Capital. In addition, they provide drinking water for the Central Bohemian and Jihlava Regions. The share of the Želivka Waterworks on the total supply of drinking water to Prague reaches 62 %. By its maximum capacity of 7 000 l/s of drinking water and the current average output of 3 400 l/s, the Želivka plant ranks among the major waterworks in Europe and it is the biggest plant in the Czech Republic.

Hydrotechnical Complex The dam is located 4.4 km above the confluence of the Želivka and Sázava Rivers. The earth dam has an upstream loam sealing. The volume of the water supply reservoir is 266.56 mill. m^3 at the maximum water level of 377 m a. s. l. (backwater reaches 38 km upstream from the dam, the maximum depth is 49.5 m and the average depth is 18 m).

Water Treatment Complex Raw water is abstracted from the Švihov water supply reservoir at the combined dam structure by two intake towers. Each of them has five water inlets at varying depths. The intake system allows to abstract water of the best quality in view of the effectiveness of the treatment technology. Transport of water to the treatment plant is provided by a pumping station. The delivery conduits bring water to a distributor and from here to three separate technological processes. The first water treatment process uses coagulation and filtration using 32 open high-speed filters (surface of 99 m^2, filtration velocity 3.8 to 4.4 m/hour), the other two processes use rapid stirring before delivering water to 24 high speed sand filters (surface of 99 m^2, filtration velocity 6 to 8 m/hour). As the principal coagulant aluminium sulphate is used. Filtration material consists of siliceous sand with grain size of 1.1 to 1.6 mm. In cases of unsatisfactory quality of raw water it is possible to use charcoal dosing and for removal of manganese potassium permanganate, pH value is corrected by adding sulphuric acid. After filtration, water is brought from each process to ozonization. By ozonization the water sensorial characteristics are improved. Supplementary alkalisation by lime hydrate serves for correction of pH value, chlorination ensures drinking water hygienic requirements.

Water Conduit Treated water is transported to two distribution reservoirs with volume of 17 000m^3 and then to the water conduit. The length of water conduit is 52 km and it reaches the closing chamber prior the water tank in the Jesenice locality amounting 200 000 m^3.

Podolí Waterworks

Podolí Waterworks

History of the waterworks The beginning of modern water treatment dates from 1929 when a new plant treating the Vltava River water for drinking water supply was put into operation in Prague - Podolí. The new waterworks was built at the site of the old Prague waterworks. The project was completed by an architect Antonín Engel. The new technology consisted of multi-stage filtration of the Puech-Chaball system. Water was aerated, filtered three times and finally purified using slow-rate biological filters. After this treatment the output of the waterworks was approx. 400 l/sec.

Reconstruction of the waterworks Prague, as a growing city, was forced to continually increase the capacity of its waterworks. In the next period, it was achieved by both the extending the waterworks and improving the water treatment technology:
1932 - capacity of 640 l/sec (fitting out the waterworks by equipment for dosing of aluminium sulphate into raw water with subsequent filtration of impurities bound by floccules on the existing slow-rate filters)
1942 - capacity of 890 l/sec (three-stage filtration was replaced by high-rate filters)
fifties and sixties - capacity of 2 200 l/sec (extension of the waterworks by a new part equipped by clarifiers)
seventies (plans for discontinuing the Podolí Waterworks operation in connection with construction of the Želivka Waterworks)
1992 - 1999 - capacity of 2 200 l/sec (reconstruction aimed at improvement of quality of drinking water produced and at elimination of impacts of the plant operation on surrounding area).

Drinking water treatment technology The current system of water treatment consists of pre-treatment of raw water in clarifiers where liquid ferric sulphate is injected as a flocculant. By this, floccules are formed in water binding impurities from raw water which after maturation gravitate as sediment to the bottom of the clarifier. The clarifiers eliminate up to 95% of impurities from raw water and the pre-treated water is brought to sand filters. In filters, water passes through a layer of quartz sand approx. 1,3 m thick by velocity of 3,2 m per hour. The sand bed retains the remaining mpurities and water is brought to reservoirs of treated water. Since sulphate is a highly acid substance, it is necessary to modify water pH after filters to a neutral value of about pH 8. The final step of water treatment so far is its hygienic processing from bacteriological point of view. It is carried out by chorine injection and water processed is pumped into water reservoirs of the Prague distribution network. Plans are being considered for completing the whole cycle by injection of either ozone or chlorine dioxide for further improvement of hygienic condition of water with additional filtration through granulated charcoal. This would improve also taste qualities of the treated water.

Perspectives of the Podolí Waterworks
Completion of the reconstruction will result in upgrading the level of the Podolí Waterworks adequate to the end of 20th century. It could be even farther if ozonization or possibly chlorine dioxide injection into treated water with subsequent filtration through granulated charcoal were applied. Inclusion of this technological stage that would significantly improve drinking water quality is prevented by, among other reasons, insufficient financial resources. In spite of the current low output of the Podolí waterworks linked to low water consumption in Prague, the waterworks represents an important reserve of drinking water in cases of disruption of water supply from the Karaný or Želivka Waterworks or in a case of ecological accidents on the Jizera or Želivka Rivers. A Muzeum of the Prague Waterworks Engineering showing its history and development is a part of the Podolí Waterworks.

END OF THE EXCURSION GUIDE