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Irrigation and drainage of green roof for Leisure centre located in Hronov

Master Thesis

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I declare I completed this thesis on my own under supervision of doc. Ing. Václav Kuklík, CSc. and also that I cited all the literature sources that were used in accomplishing this thesis.

In Prague, date: 22.04. 2013 Bc. Milan Kubeček

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ABSTRACT

Thesis deals with an irrigation and drainage project design, suitable for leisure centre located in Dvorská 40, Hronov. The entire project starts with the selection of suitable plants for the roof and its substrate, followed by the distribution of water by micro sprinklers. In the drainage part it is crucial to divert all water from the roof surface and underneath the substrate and store it underneath the roof for irrigation. Every single part or component needed for the completion of the tasks are described in detail together with its appropriate placement.

Due to the occurrence of insufficient rain in the summer period and possibility of drying out or dying of the plants and shrubs, the complete irrigation and drainage system was designed.

The exact irrigation dose needed to cover the evapotranspiration rate of flowers is computed and also the calculation of hydraulic. Based on the calculation, it is possible to develop an irrigation network and subsequently a drainage system discharging the water where it is needed. Furthermore a fully automatic system with its single components is described.

Since there has been lack of outside sitting area in front of the leisure centre, other possibilities are suggested and resolved. The whole project is a subject to international standards and corresponds with latest norms and regulations.

Design of the whole project was properly discussed and approved by the owner and investor and performed under their specific wishes and conditions.

Key words: Green roof
Irrigation system
Drainage
Greening

Outlines

I. INTRODUCTION

A human being, regardless of their modern achievements and technology, is a creature of nature. Therefore, the sensation of being connected with nature to find a moment of peace, is sought after, particularly in the rush and stress of work.

The influence of green surrounding us has been undoubtedly confirmed medically to have a positive impact on our health.

Greenery around us influences us positively by releasing tension and calming our nervous system reviving our fatigue. No wonder more and more people are trying to bring at least piece of nature to their homes; whether it's the sound of trickling water, leaves rustling in the wind or flowers in a vase, the purpose is always the same; we are seeking the path to relaxation through the dulcification or domestication of the environment where we live where it might be a bit strange or unpleasant.

With this growing awareness, people are increasingly moving towards a natural way of developing and maintaining their landscape environment. Artificial elements of the landscape are being transformed; thereby these elements are approaching a natural form of being. Multi-functionality and effectiveness have become the motto of many industrial sectors.

Respectively, it is in the development of roof gardens. In addition to the main function, which is to divert water from the roof and thermal insulation feature, a green roof attaches importance in field of aesthetic and ecological value as well. Planting of a garden brings many benefits, and it is also more consistent with the nature around us.

A significant important element to green roofs is the irrigation system and drainage system. Proper irrigation supports plants during excessively hot periods, or times with lower rain fall, and properly designed drainage system protects plants and the roof against excessive flooding. Both are elemental in conventional roof gardens.

II. THESIS OBJECTIVES

1 Design a fully automatic irrigation system for the Leisure centre located in Dvorská 40, Hronov.

2 Maintain vital conditions of greenery throughout an entire year cycle its climatic fluctuations (rain and drought period).

3 Expand and increase the capacity of the outdoor tables at the expense of a lack of outdoor space.

4 Increase the attractiveness of the leisure center, i.e., the aesthetic and recreational function.

III. Literature review

3.1. Green roof

3.1.1. **Introduction and a brief backward look**

First known mentions of green roofs are from the Semiradin period, regarding the Hanging Gardens of ancient Babylon, dating around 600 BCE, although it is probable that these gardens were already known earlier in history. In ancient Rome the price of land grew so high that it forced people build their garden on their own villas. They would plant vegetables and fruits in pots, and and in some rich families, even fishponds were laid on the top of their roofs (Stifter, 1988).

There is proof that since the 900's there has been roof gardens in the upper north. The Scandinavian populations have brought a new meaning to putting a garden on the roof, they added roof gardens because of its great insulation features. They realized that in the cold winters the roof gardens offer protection as well as insulation, much like the igloos the Eskimos use. Thus, they are using the most temperature proof material that they can found in the nature (Stifter, 1988).

Later on in history, there is no evidence of intensive roof gardening. The more sensible usage of these gardens comes with the renaissance period. Pienza Villa Careggi in Florenz, the Palace of Earl Maffei and the palace of Piccolomini in Pienza, Italy are some the greatest examples of the bloom-extended gardens in Europe.

Since second half of the 20th century roof gardens have advanced in another sense also. In 1982, there was research completed by the Association of Landscape architects that give an inducement for the development in supporting of the expansion of green roofs.

After 1989, a great expansion of little companies and factories came to Europe with the standard procedure of redoing and reconstructing standard roofs and thereby making them more comfortable for its owners (Ahrendt, 2007).

3.2. Purpose of irrigation and drainage

3.2.1. Purpose of irrigation

Many designers and owners of gardens or other green space do not think about the required irrigation. Consequently, they come up with an idea that results in several evenings spent with hose in hand, watering, especially when the desired effect fails. Irrigation, in addition to its main function, has a number of other benefits. In addition to saving time, automatic irrigation surprisingly saves in the total amount of water consumed. In a properly programmed and designed irrigation system, the water can be dispensed in quantities that plants need, and not more. With a reliable and even distribution of water, owners can finally leave the premises with no worries. They can go on holidays because the automatic irrigation works, and of course, only when the plants need it, like when rainfall does not occur (Maroušek et al., 2008).

The very essence of irrigation is to create amelioration. That is, to carry out the development of: the soil, vegetation, and ground layer of air, thus creating an optimal system to obtain permanent high yields. In this case, the optimum condition of the plants and ornamental horticulture and in other special areas avoid serious consequences of drought (Slavík, 2001).

The primary purpose of irrigation has always served as a complement to natural processes, so that the plant has enough water throughout the growing season. Today, irrigation is secondarily used for fertilization, plant and soil protection against pests, and to modify the microclimate (Veverka, 2003). Important concept in the irrigation process is called evapotranspiration which is the sum of the evaporation of water from plants (transpiration) plus the surrounding soil (evaporation) (Kuklík, 1985).

If there is lack of moisture in the soil, the plant decreases all its living processes, in particular, processes relating to its organic matter. This decrease disrupts the biochemical processes that affect the quality of flowers, fruits and the entire plant's health. For the successful implementation of irrigation, it is necessary to know the demands of cultivated plants during their growth and development. Using the basis of such knowledge, it is then important to choose the appropriate method of implementation of irrigation and the appropriate technical equipment for its implementation. The total amount of water consumed during the plants growth, (with an adequate supply of soil moisture during the growing season) represents the water requirement for the plants. If there precipitation lower than the moisture needs, then it is necessary to irrigate. Each plant species needs different amount of water through the growing season, from the creation of the stalk and underground roots, to after the period of flowering and ripening of fruits. Each period has different requirements for the supply of moisture.

Therefore, it is important to assess the plants moisture needs at different developmental stages to see how much irrigation is needed to simulate natural rainfall. The need for irrigation is determined in millimeters of a water column. For the conversion of approximately 1 mm of valid precipitation = 1 liter of water per area of 1 m^2. For conversion the following applies: 1atm = 100 kPa = 1 bar = 10 m of water column (Veverka, 2003).

3.2.2. Purpose of drainage

The word *Drainage* is understood by the best way how to get rid of water (groundwater, precipitation) from the vicinity of the building through a system of drains and drainage structures. Draining to nearby drainages is suggested as a supplement to using to the main waterproof system (Balík, 2006).

Similarly as adding water for plants in periods of drought, there are periods when there is a surplus of water to the point where it is necessary to drain the roof. If the optimal balance between water and air is disturbed, we refer to this as *water logged*. The ideal ratio of water to air in the soil is: 60 – 80 % of the pores filled with water and 20 – 40 % pores filled with air. In the event that this ratio is unbalanced as a result of drying up the plant due to a lack of water, or as in the case of water logging, an excessive accumulation of CO_2 in the soil, subsequently plant will perish due to the deadly ratio.

A drainage system takes measures to reduce or eliminate adverse effects of waterlogged soil. Aerated soils also have a better thermal regime. They are more capable of warming themselves up and drying themselves out on the surface. Due to the extra drainage, this also increases the activity of micro-organisms in the soil (Tlapák Legate et al., 1992).

3.3. Roof irrigation system and its components

A roof irrigation system is the set of all elements and equipment (construction and technology) that is used for the abstraction of water from the source to the plants. This includes; pumping the water with the required quantity and pressure, and editing the properties to have the appropriate distribution and application of water to plants.

Because there are many different individual components of the irrigation systems on the market, only the components concerning green roof design were selected. Therefore, the appropriate types of components are described in the Attachments at the end of this thesis.

3.3.1. Source of irrigation water.

In the case of leisure centre in Hronov, the source of irrigation water will be rainfall. During its absence, water will be pumped up from an underground reservoir, in which its filling will be implemented using the excess water from the roof surface.

3.3.2. Artificial reservoirs water

Long-term experiments have shown that a flat roof of a house with the area of 160 m^2, (located in our climate zone in middle Europe with an average of 800 mm annual rainfall) captures nearly 100 m^3 of soft, slightly polluted water each year. Rainwater is free of lime; therefore plants are able to absorb it, rather than the hard water from a well or chlorinated tap water. It should be noted that, rainwater collected on your roof or land, everyone can collect and use without some kind of permeating process. However, additional built-in storage tanks and reservoirs for rain water to existing houses are just subject to a reporting requirement (Tůma, 2001).

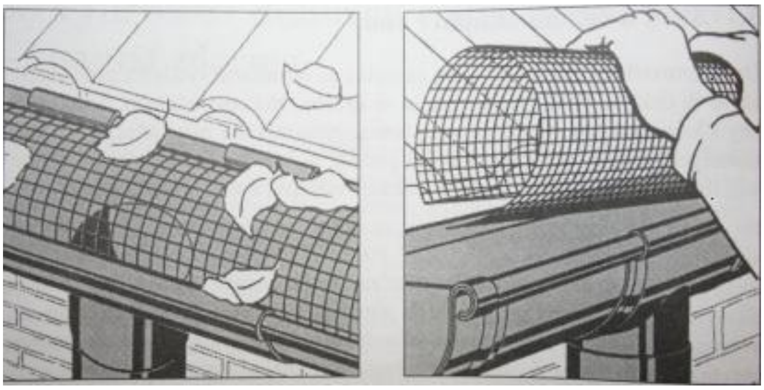
Properties of rainwater are similar to the properties of natural watercourses. Unless otherwise polluted, rainwater has good qualities. That is to say, it is supplied with nutrients and oxygen and favorable biological properties and temperature (Veverka, 2003).

3.3.2.1. Gutters water conducting and cleaning

Well executed gutter system captures and diverts up to 90% of rainwater that fell on the roof. Most downspouts feature as in addition a simple valve which can be open or closed as necessary by hand. Closing prevents overfilling of the tank.

Rainwater can be used exclusively for watering the roof garden, all that is necessary to get rid of coarse impurities (mainly leaves) using simple trap leaves, placed in the gutter at the orifice assembly. More effective are wire screens which are curled then placed in the gutter (see Figure 3.1). Leaves go not go into the gutter, they dry on a screen and wind it blows away. Such screens are offered in the form of 2 m long polyethylene mesh pipes, which can be adjusted to the required length (Tůma, 2001).

Figure 3.1: Polyethylen mesh



(Tůma, 2001)

3.3.2.2. Underground tanks

The underground tanks are wedge shaped cylinders or spherical. The tanks are placed in a pit lined with sand and are overlaid at least with 0.8 m of soil. The cylinder is mounted with a cylindrical shaft inspection and closed with cast iron or a plastic cover. The advantage to the burying is that it reduces the chance that the water in the tank will freeze, and throughout the year it will maintain practically the same temperature.

After running the container down at least 20 cm, a thick layer of sand must be filled in the pit and mounted with the inlet and outlet pipes. After the reservoir is filled with one-third of water, the pit is filled up to the same level with sand, which is evenly packed. Then the water is filled so that the level is always increased by 30-50 cm, and the amount of the toner is evenly placed from all sides and filled with sand. Finally is mounted on the revision shaft.

Manufacturers usually indicate that the surface of this cylinder shouldn´t be driven on by a heavy vehicle. Underground tanks should be provided with an access shaft (manhole) for cleaning and for access to the pump, filter and suction basket (Tůma, 2001).

3.3.3. Suction pipeline

An important part of the irrigation system is where the water flows from the source to the pump. This suction pipeline's job is to transport water from the source (sink) to the pump with minimal losses.

It consists of a suction strainer, suction pipe, and relevant fittings.

3.3.3.1. Strainer

Strainer is located at the start of the suction procedure. It must prevent the access of coarse dirt into the intake manifold, while also it also must not pose much resistance of the flowing liquid. The design is made as such with a metal or plastic body with plenty of perforations. It is often equipped with a switch check valve to ensure constant suction during irrigation filling (with this version, it is necessary for non-self priming pumps).

3.3.3.2. Suction piping

Its task is to ensure a smooth and easy flow to the pump. The pipe should be as short as possible, direct without sudden directional changes, and preferably in a consistent gentle climb to the pump (about 3% slope), in order to avoid air spaces. Being airtight is a necessary condition for its proper functioning. If air penetrates into the intake tube, it radically reduces the suction of the pump and proportionally decreases its effectiveness. In extreme cases, it can lead to breakage of the water column and cause serious damage or total destruction to the pump. Flow velocity inside the intake tube should be at least 0.8 $m.s^{-1}$ to avoid breakage of the water column during transient decreases in flow rate. For mobile and small pumps the suction pipe consists of a flexible tube called a *Sucker*. This must be fitted with steel or plastic fittings, to prevent its deformation and the effects of atmospheric pressure (the pressure within the tube is always lower than atmospheric pressure).

3.3.3.3. Armatures

In the order of arrangements, the intake should occur least. If its use is unavoidable, then it is necessary to use elements with a minimum displacement resistance (spool valve substitute, replace knee bends, etc.).

3.3.4. The pumping unit and its main parameters

For the purpose of a roof garden an electric pump serves well. It is intended for watering gardens and lawns, and in this case, it is stably installed.

Flow rate (flow) Q is given in $l\ s^{-1}$ for large pumps then $m^3\ s^{-1}$. Amount of water supplied should match the amount of irrigation system.

Specific energy pump Y expresses the value of energy transported by water. It is stated in $J.kg^{-1}$. In practice, often in the form indicates the transport height (m). As an indication, the following relation holds: 100 J.kg = 10 m water column. Pump energy (head) must cover all losses in the pipe fittings and must cover the requirements of application components, especially micro sprinklers.

Intake of specific energy indicates how deep the water pump can suck the suction head. In fact, the maximum fair value is around 8 m. For greater depths is necessary to use a submersible pump.

The Pump curve (diagram Q / Y) indicates the relationship between the amount of traffic and of specific pump energy, as well as the range of pressure and flow.

3.3.5. Discharge (transport) pipeline

Pumped water is usually pumped evenly. After the irrigated area, is the water distribution system, and then main and secondary distribution manifolds. The manifolds are connected lines with detailed distribution of flow irrigation pipe elements, ex: sprayers, drippers. Most of the distribution pipes are used in plastic piping systems that have a number of advantages to metal: low weight, relatively simple installation, small flow resistance, (low height), no corrosion, and flexibility. The disadvantage is somewhat lower strength and thus the possibility of mechanical damage.

3.4. Roof irrigation types assessment

There are several types of irrigation. The definition of irrigation is the method of distribution of water across the surface. This includes the operational and technical arrangements and the process of irrigation itself. As a result of assessing the purpose of irrigation for the roof in Hronov, only these types of irrigation systems were selected (Kuklík, 1985).

3.4.1. Sprinkler irrigation

Sprinkler irrigation is characterized by the fact that the water seeps into the ground from a point source, and it is sprayed in all directions. Soil moisture is highest in the immediate vicinity of the source of moisture and decreases with increasing distance to the sides (Kuklík, 1985). Due to unpredictable weather conditions, it is an essential means of irrigation for the preservation of green and increasing of agricultural crop yields. The essence of sprinkler irrigation is the distribution of water to plants by sprinklers or spray equipment. For the soil and the plants irrigated with artificial rain, the intensity and size of the droplets are a necessary control for irrigated crops. The intensity and droplet size affects the water pressure and the type of equipment used (Veverka, 2003).

In this type of irrigation, the main indicator of the need to irrigate is the moisture deficit. This is the difference between the total water required by plants in a given vegetation period, with the moisture given from rainfall and from deeper soil layers (groundwater). For this purpose, we need to calculate the irrigation ratio, which is the amount of water needed to reimburse and compensate the current water deficit. It is noted in either mm or l/m^2. The total ratio of irrigation during the growing period varies according to the type of plants and the climatic conditions (Grozman, 2006).

3.4.2. Micro irrigation system

3.4.2.1. Micro sprinkler irrigation

Micro spray irrigation can serve as an addition to the main function of irrigation. For instance, it can furthermore act as a conditioning irrigation, frost protection or supply fertilizers and disinfectants. To achieve the appropriate amount of micro sprinklers, the design is not too difficult can save considerable costs for water treatment. It is very important to ensure the water supply is free of impurities resulting from the mechanical processes, or small particles in general. Allowable particle size depends on the specific type of micro sprinklers.

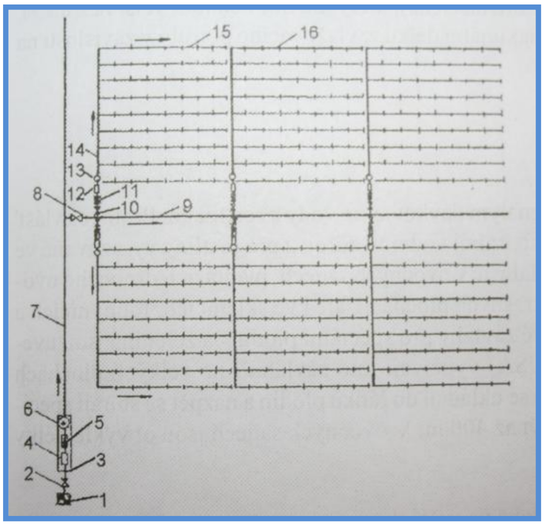
It consists of the input pipe (which branches off from the camshaft) and the surface of the pipe lines; which are directed using detailed timing and micro sprinklers irrigation pipes which are connected to the distribution manifold.

Micro sprinklers with a radius range of about 0.5 to 10 m are able to spray water uniformly in circular, rectangular or square shapes (vegetable gardens, lawns); or target areas of different shapes; ellipses, arcs, and points. As a result, they are mostly used in the immediate vicinity of the root system of cultivated plants (orchards, vineyards, fruit vegetables). It is a multipurpose system, operating with low intensity irrigation. Micro sprinkler irrigation causes minimum surface runoff, there is little to no soil structure damage, there is no risk of water erosion, and minimal leakage into the lower layers of the soil.

Micro-spray irrigation uses low flow rates and pressures, so it is recommended to install the inlet to the micro-spray irrigation, the low solenoid valve, and filter RBY with pressure regulation. The operating pressure is usually 1.4 to 10.3 bars. They are supplied with two extents, one with a flow rate from 0.01 to 0.32 l/s and the second variant with a flow rate from 0.19 to 0.95 l/s. The filter has a mesh size of 75 microns.

Other elements of micro-spray irrigation are powered through spaghetti pipes. It is made of flexible PVC connected to the PE solenoid valve. Furthermore it uses reducers, The Manifold EMT-6X, with six outputs on ¼ "tube and the inner ½" twist.

Figure 3.2: Scheme of micro irrigation



1 – Supply object with a pumping station
2 - Main shut
3 - Controller
4 - Water treatment equipment
5 - Main pressure regulator
6 - Equipment for mixing and dosing fertilizers
7 - Supply pipe
8 – Block valve
9 - Main distribution pipeline
10 - Control valve
11 - Pressure reducer
12 - Filtration equipment
13 - Meter
14 - Secondary distribution pipes (manifolds)
15 - Detailed distribution lines, perforated flow lines
16 - Outlet elements (drippers, micro-sprayers)

(Spitz et al.,1998)

A characteristic feature of micro irrigation is almost exclusively using plastic material in all system elements, expressly: pipes, pipes fittings, filtration equipment, etc. The advantages include: a particularly easy and quick assembly construction, high operating material durability, and a low hydraulic roughness of the pipe.

A micro irrigation system consists of:

- Water sources with a supply object
- The equipment for water pumping
- The equipment for water treatment
- Supply, transmission and distributive pipes
- Detailed distribution lines (irrigation pipes & lines) with outflow facility, and irrigation elements, i.e., drippers use of flow openings or sprayer.

3.4.3. Drip irrigation

Drip irrigation is characterized by a very slow dosage of water, literally by drops. Therefore it is especially advantageous in arid areas, areas with deficient water resources and areas where the plants are planted in larger clips. This type is used extensively in Israel and the U.S. over large areas of crops (Veverka, 2003). It is usually an important part of water treatment equipment.

Newly built drip irrigation systems provide water savings and the possibility of full automation of irrigation (Kuklík, 1987).

Namely the pros of drip irrigation:

- *Significantly saves water and energy*
- *Water drops in the shortest route to the roots of plants*
- *It does not endangers drinking water sources*
- *Nutrients do not leach into the lower layers of soil*
- *No soil erosion*
- *Does not interfere with the structure of the soil*
- *Water flowing through black piping is warmed, which is beneficial in plant development*
- *Drip irrigation can fertilize directly to plant roots*
- *The heated water in the pipe work in the evening as storage heaters*
- *It is inexpensive*
- *Irrigation computer ensures watering of plants even during the absence of owners*

Drip irrigation will keep the water content in the substrate balanced, and also bring the plants and shrubs fertilization. The second type, micro spray irrigation, will have a cooling effect during summer and a warming effect during spring or autumn frosts (Spitz et al., 1998).

Drip irrigation system

Drip irrigation is classified as a special type of irrigation also called *local* or *trickle* irrigation, it is categorized under *sprinkler* or *micro-spray irrigation* and is a very efficient way of irrigating. The water drips slowly to the roots of the plants; therefore it conserves water which, in the sprinkler method of irrigation, would have evaporated (Přidal, 2002). The demand on water resources for the same coverage is half the amount of spray irrigation (Marr, Rogers, 1993). The water goes through valves and different kinds of pipes and ending up at the drippers. The most important part of drip irrigation is dripper which is required to discharge the amount of water at a very low intensity. This is achieved by reducing the water pressure at the inlet of the irrigation pipes in drip mechanism so that there is a gradual decrease of discharge from dripper. This type of irrigation became very popular through its efficiency of water and fertilizers.

3.4.4. Irrigation types and its function

3.4.4.1. Air condition irrigation - Cooling effect

In the conditions of the specified study, this air condition irrigation is not commonly used; rather it is replaced by sufficient sprinkler irrigation. Generally, its purpose is to reduce the temperature of the plant and to aid in the creation of favorable microclimatic conditions during the period of summer with high temperatures. This heat significantly reduces the physiological processes of plants (Legat in Tlapak et al).

3.4.4.2. Warming effect

The warming of the irrigated land in the spring and autumn improves the microbial and chemical processes in the soil. This ensures a quick and early saturation with moisture and fertilizing nutrients; it also reduces the risk of spring frost and it accelerates the development of spring crops. (Limping, Limping, 2008).

In case of irrigating roof will secure the plant against spring frost or early autumn frost in the growing period. It is based on the physical phenomenon of release of latent heat in the conversion of water into ice. It is important to spray all the time at low temperatures to avoid damaging the flowers or fruits.

3.4.4.3. Irrigation fertilizers

For mixing with water, fertilizers are generally used in tanks of suitable capacity. The ratio for mixing fertilizer into irrigation water is carried out in several different ways: firstly, the suction pipes can be added through the pumping unit; or with the addition pump, it can directly go into the distribution; lastly, through the intake and distribution to irrigation pipes using an ejector (Veverka, 2003).

3.4.5. Organize irrigation

The main source of water for irrigation of the green roof will be rainfall, which will be accompanied by water from a tank located under the roof (Attachment 3).

Since the micro sprinklers will be used on the roof, which are very demanding on clean water, the water will be immediately edited, using fine screens and sieves (Spitz et al., 1998).

The water in the tank will be checked visually and chemically modified against the formation of algae, sludge and slimes. It is also appropriate to lead the water from the tank through the two-stage filtration. This filtering ensures removal of larger particles. The first stage consists of a sand filter and the second stage network or multiple discs filters. Flushing filter vessels can be performed manually or through an automatic process. The filters are dimensioned according to the water quality demand and the size of the area of interest. First stage of filters is usually located behind the pumping station. The second stage is treating together with pressure regulator placed in each irrigation sections (Veverka, 2003). In the case of fertilizers, the fertilizers must be completely soluble in water and meet all the requirements for drip irrigation.

3.5. Water treatment

Adequate clean water for a specific type and method of irrigation is the primary requirement for its proper function. Underestimation of this requirement may occur after a period of time. In the worst case scenario it can cause decommissioning of irrigation operation, because the outlet hole with a small flow area can be easily blocked by dirt penetrate in the pipeline. The purity of water is especially sensitive by drippers, where the outlet openings are small with DN of tenths of mm. The successful resolution of the purity of water in irrigation is necessary and water supply is assessed in terms of mechanical (suspended solids), chemical (precipitated substances) and biological parts (microbial bacteria, algae, slime). Device manufacturers should establish quality requirements for water or the products in order to ensure trouble-free operations irrigation. In addition to analyzing samples, or determining the physical, chemical and biological properties of water for irrigation, it is necessary to determine, whether it will lead to flocculation (formation of flakes) colloids and ingrown pipe algae or salts (chemical compounds).

3.5.1. Requirements for water treatment technology

Claims for irrigation water quality vary according to the type of irrigation, and therefore also different requirements for water treatment technology.

3.5.2. Requirements for micro sprinkler irrigation

Systems for micro irrigation, spraying the surface water generally requires especially high quality filtration. There are several filters mounted at pumping stations, supply or distribution pipeline or irrigation for individual sections. It is usually sufficient for cleaning of micro spraying to have fine mechanical cleaning filters on a network with a size 0.2 - 0.5 mm.

3.5.3. Requirements for drip irrigation

The governing surface waters are mostly rough cleaning devices described for spraying and two-stage filtration.

First level with sand filters or with filling plastic is refueling station. Either it is right next to it, or it is connected to the inlet pipe for drip irrigation.

The second stage of filtration (final treatment) is with a pressure regulator located in different sections of the irrigation. During treatment of surface water for drip irrigation it is necessary to remove the water-insoluble dispersion, which may be in the form of colloids, particles and coarse particles. Permissible size of solid particles suspended depends on the construction of dripper. Producers' permissible size is in microns (100μm) or is given a value of filter screen hole per unit on active area called "mesh".

In cases where it can close drip irrigation equipment creating mineral salts and fine particles of organic matter and sediments, which are mixed with bacterial slime, generated in the warm weather, chemical and biological water treatment is needed. Due to the complexity and high costs of chemical and biological water treatment in some cases it is better to choose a different drip irrigation method.

3.6. Individual micro irrigation elements

3.6.1. Pressure control

Stabilizes the pressure in the pipe at the desired value and protects it against increasing of the pressure above a specified value provided by regulatory pressure.

3.6.1.1. Piston Pressure Regulators

It is produced by a number of foreign manufacturers. It is used in micro irrigation systems and is easily placed on pipes of smaller diameter. The controller consists of a valve body, a piston with sealing gland, springs, in which the piston is attached, the guide rods and the lid. The pipes are connected with threaded connections. Pressure control is based on the water supply with an output value of instantaneous pressure above the piston, piston displacement or shortening and extension springs.

In the event that the value of the output pressure is higher than the set value, the piston is moved so that the reduced flow profile and flow rate, while a reduction in the output pressure to the set value. However, the piston displacement causes an extension spring, until all forces acting on it are in equilibrium.

3.6.2. Supply equipment for fertilizers to irrigation

Micro irrigation and spray systems are often used for the application of liquid fertilizers dosing of other additives, such as sodium chlorane to prevent the growth of microorganisms in pipe networks, herbicides, insecticides, acids to dissolve limescale etc. In the case of fertilizer, subsurface fertilization is available, where is the saving of fertilizer and increase of the effectiveness and efficiency of fertilizers. All fertilizers applied in irrigation water must be completely soluble in water (forming a right solution). This is particularly suitable for micro irrigation.

For mixing with water, fertilizers are generally provided by tanks of suitable capacity. Dosage fertilizers are in the irrigation water using the following methods.

- *Intake manifold to the pump unit*

- *By adding the pump directly into the distribution manifold*

- *Intake to distribution or irrigation pipe using ejector*

Most commonly used dosing pumps for micro irrigation (piston hydraulic motors and generators), for dispensing fertilizer can be placed directly on the irrigation pipeline, or a bypass.

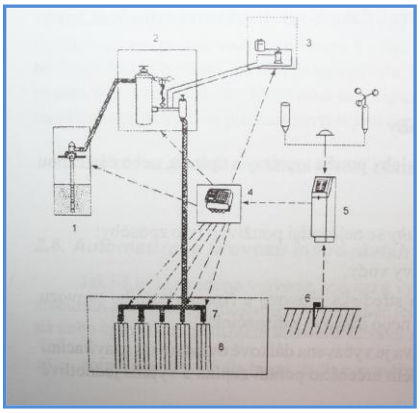
3.6.3. The system of control and regulation of irrigation

The advantage of micro irrigation system, as already mentioned, is the possibility of automation. Automation can be partial or total.

In the case of the roof project there will be a total automatic micro irrigation, which is equipped with weather station determining the need for irrigation doses, remotely controlled valve mounted on the supply, transmission and distribution network, and the control unit.

A schematic example of such automatic micro irrigation system is shown at Figure 1. The measured data are transmitted from the meteorological station (or satellite meteorological stations) or soil moisture sensors of the blocks irrigated areas to the control unit with a computer. The moisture deficit and irrigation dose size for individual plants at particular sites is continuously calculated and assessed. When exceeding water deficit, it is evaluated the order of the blocks and send both signals to be placed in service station with water treatment and also signal to open automatic valves for irrigation from the designated order. If there is a need of nutrients, the operation and control unit launches the fertilizer unit. During operation it manages and checks, if there are any troubles in the entire system, optimizes the operation basic procedures and records operational data. Eventually the increase in soil monture detected via a humidity sensor and reaching the value needed the control unit automatically turns off the irrigation (Spitz, 1998).

Figure 3.3 Fully automated micro irrigation scheme



1) pumping unit, 2) water treatment including filters, 3) fertilizer, 4) control unit, 5) weather station, 6) humidity sensor, 7) remote controlled valve, 8) water distribution

(Spitz, 1998)

3.6.4. Automatic Weather Station

Using an automated irrigation control method of calculation it is usually required setting irrigation on the computer or control unit, so that the automatic weather station was fitted with these sensors for monitoring meteorological elements:

- *Gauge for measuring precipitation*

- *A thermometer to measure air temperature*

- *Hygrograf for measuring relative humidity*

- *Anemometer to measure wind strength and direction*

- *A thermometer to measure the temperature of the soil*

- *Possibly other instruments measuring data for balancing the needs irrigation*

These weather stations are produced by many companies and are available on the Czech market.

3.6.5. Solenoid valve

Remote-controlled valves are being used for the distribution of the irrigation pipe network. Build in the beginning of each branch manifold, thus enabling to activate the irrigation lines connected to it. During the irrigation rest valves are automatically closed. If necessary, supply irrigation benefits of a certain section according to the instructions from the control unit opens the valves, which brings the flow of water into irrigation lines in this section.

At present, the automation uses almost exclusively two-ways closure solenoid valves, in which coil acts as an electromagnet, which governs the hydraulic opening and closing the valve.

3.6.6. Controller

Automatic controllers instruct the commissioning of the irrigation network, where was evaluated need to supply automatic irrigation dose. In micro irrigation regime apply two types of machines:

- *Time irrigation regime*

- *Making decisions on irrigation using the measured data*

For the roof would be chosen to control automatic determination of irrigation using the measured data.

3.6.6.1. Controllers with the determination of irrigation depending on the measured data

These devices are often soil moisture sensors or rain gauges with an evaluation unit which is used in combination with time-programmable solenoid valves. The advantage of this automatic control is that, if adequate soil moisture, it will not be executed even if irrigation was programmed on certain time period. Facility helps save irrigation water and the moisture regime ensures optimum crops (Spitz, 1998).

3.7. Substrate specification

Because of the quite extensive plant selection for the roof, choosing a correct substrate is crucial and requires special selection. With correct selection of plants suitable for certain substrates helps a company Optigrün (Germany) which gives a detailed selection of plants suitable for each substrate.

Table 3.4 Suitable substrate: One layer extensive substrate Optigrün Type M

One layer extensive substrate Optigrün Type M	
Suitable for:	Drainage and vegetation layer for green roofs
Material:	Lava, pumice, expanded shale, cinder, brick rubble composted bark, green compost
Features and parametetrs:	Total pore volume of air: 60-70 % of volume.
Weight at maximum water	Type "light" in the dry state by approx. 600 kg / m³
Capacity and compaction:	Water saturation to approx. 1150 kg / m³
Organic component:	1-3 % of total volume
PH value:	6,5 – 8,5
Soluble salts:	<3.5 g / l
Water permeability:	> 60 mm / min
Compaction factor:	1,15

(http://www.optigreen.co.uk)

3.8. Additional elements

For the purpose and completeness of the reconstruction of the roof, desired stairs, flooring and outdoor furniture by the owner were suggested.

These are essential elements important for the completeness of the project, however, its assignment will be given to specific companies according to the owners' wish and they are not included in this work, nor in the resulting price calculation. Therefore in terms of the project only elements related to irrigation and drainage are counted. All these elements serve only as a supplement for clarity and only as a recommendation for completion of the project.

3.8.1. Stairs, garden furniture, floor

Figure 3.5: Stairs type Spiral

- 

Description: Outdoor spiral staircase, space saving. Design spindle, metal stairs, suitable for outdoor use. The finish is hot dip galvanized.

http://www.swn.cz

For the purpose on the roof sitting area, two Monroe sets from the manufacturer V-Garden for the capacity of 60 persons were chosen. Six sets of V-Garden Monroe where each table has capacity of 6 people and another six sets V-Garden Monroe 4 where only 4 chairs by each table will be.

Figure 3.6: Table Monroe sets

Description: Garden set MONROE SET 6 Luxury table set of a massive 6-chairs, and a table of exotic, very durable and hard wood meranti. Designed for exteriors, interiors and pergolových space. Table dimensions: 150 x 90 x 74 cm. Size of chair: 59 x 63 x 86 cm.

www.elvaprofi.cz

Image 3.7: Type of flooring for roof terrase

Description: Outdoor floor from the company Woodplastic are resistant to frost, water, sunlight, and in any case no damages to the terrace of salt or chlorine from swimming pools.

www.woodplastic.cz

IV. Drainage

4.1. Drainage layers

Water loosely penetrating is filtered through filtration mat fabric underneath the substrate and drained to the main drainage sink. For the purpose of drainage layer components from the company Optigrün (Germany) were chosen.

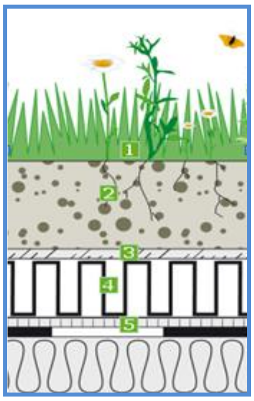
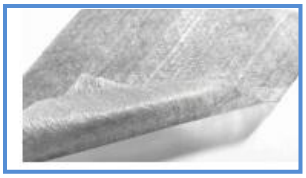


Figure 4.1: www.optigrun.de

Description of layers profile

1) perennials or lawn
2) substrate
3) filtration mat fabric
4) drainage mat foil
5) protective water storage fabric

Figure 4.2 Filter fabric Optigrün type 105

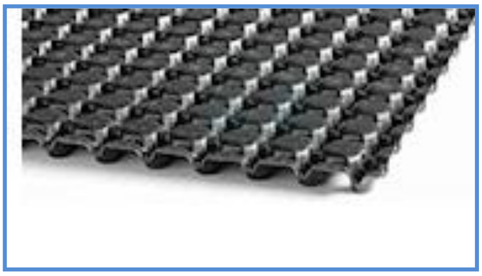


www.optigrun.de

Prevents floating material into the drainage system during high water permeability and also root penetration.

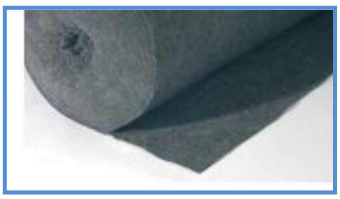
Fifure 4.3 Drainage mat foil Optigrün FKD 40

To preserve moisture after rain under the substrate so that the water can evaporate and on the other hand drain the surplus water to the sump when it rains heavilly, for this purpose will be placed right on the water storage fabric the drainage mat foil FKD 40 from the manufacturer Optigrün.



www.optigrun.de

Figure 4.4 Water storage fabric Optigrün RMS 300



www.optigrun.de

Protects the roof membrane against damage and stores water.

4.2. Roof area assembly

The entire greened area will copy the level of the terrace (20 cm lifted above the surface. There are altogether 4 secure boards. East and south sides are completely surrounded from the terrace pavement with 2 secure boards with dimensions (0,2 × 0,05 × 6,20) m. There are 4 holes made on the west side board through which the branches P1-P4 will go. First hole is made 0,05 m from the north side, the branches P2,P3,P4 with distance from the first branch of 4,25 m. All 4 boards are needed for keeping the substrate on its place firmly mounted. All side boards have an inside plastic fabric EKOPLAST 806 thickness 1mm to prevent leakage aside and damage of the construction. The entire encasement is also needed for not coming to a leakage aside of substrate or to its washing away. The side boards for encasement of the substrate with all other layers are mounted firmly to a terrace from east and south side. On the north side of the roof comes than all drained and filtered water heading towards main drain system and falling inside the water reservoir. All 4 boards are anchored into the roof surface with the anchor angle and firmly anchored with connection screws. There are 16 of anchor angles (40×160/60), 4 per each board, to secure better stability of the entire rectangular. All the components descriptions and specifications needed for assembly are in the attachments.

V. Methodics

5. 1. Project aims

The proposal for designing the project was risen by the current owner of the Leisure centre Hronov Ms. Žídková. Individual elements of the project were discussed in detail with the owner and her husband (investor). The project has two main objectives.

1) Selecting the appropriate greening of the roof, including a plan for the maintenance, designing a layout and attaching the list and price list of the flowers.

2) Appropriate economic irrigation system, based on planting design, management of which will be easy and not time-consuming for an already very busy operators and owner of the object.

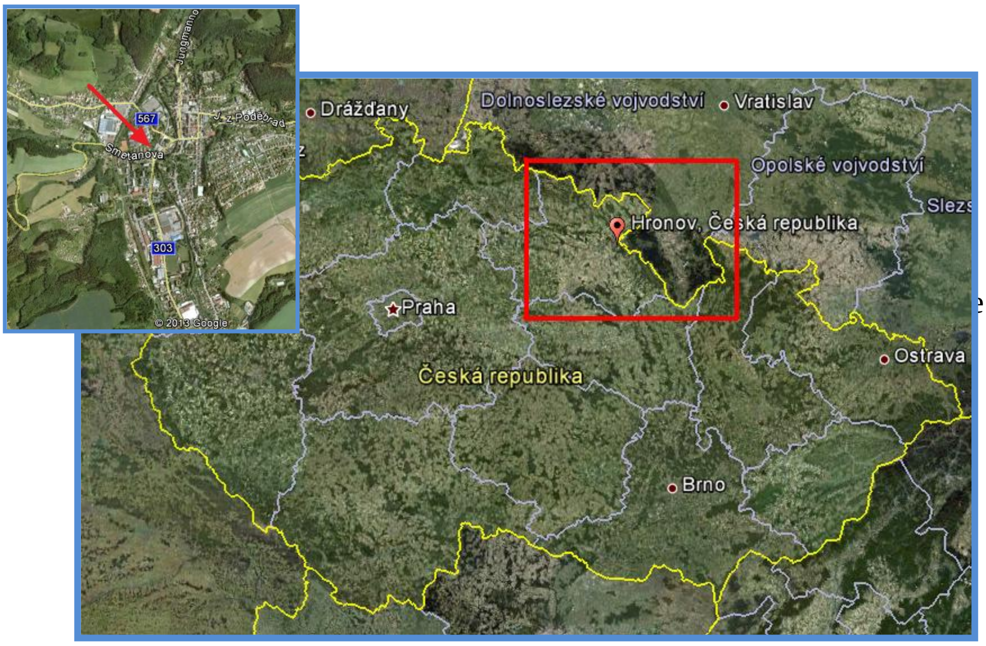
This thesis includes project documentation consisting of technical part, irrigation and drainage design and the supplemented main situation map and its single irrigation components. The work was approved by the investor and the owner and meets all water management standards.

The entire roof area will be accessible by public. It is therefore necessary to store the irrigation system safely to avoid possible damage of the whole system and its components. The concept of greening is based on 2 m wide and 4.5 m long rectangular strip lawn surrounded by an area 6 × 13 m planted with perennials. Other elements of the roof are irrigated shrubs in pots placed along the west side of the sitting area in the vicinity of the tables. Rectangular area with lawn and perennials is irrigated from extensible Rain Bird micro sprinklers. These micro sprinklerss are placed so that there is a uniform irrigation of the entire area. Watering of shrubs in pots ensure drip irrigation products from the same company. In each flower there are drippers inserted for better and economic irrigation of shrubs roots. Water is extracted from an underground sump located in the northern part of the roof (Attachment 9).

The system is controlled by an automatic control unit. It is also supported by atmospheric sensors based on the collected data, which triggers the irrigation process, if necessary. Integral part of work consists of the systems installation description and its recommended maintenance program.

5.2. Area description

The chosen object is located in the east of Bohemia (Figures 5.1, 5.2) in a beautiful town Hronov, Dvorská 40 (Figure 5.3). Project of greening concerns only a third of the entire roof, specifically the buffered green part of it.

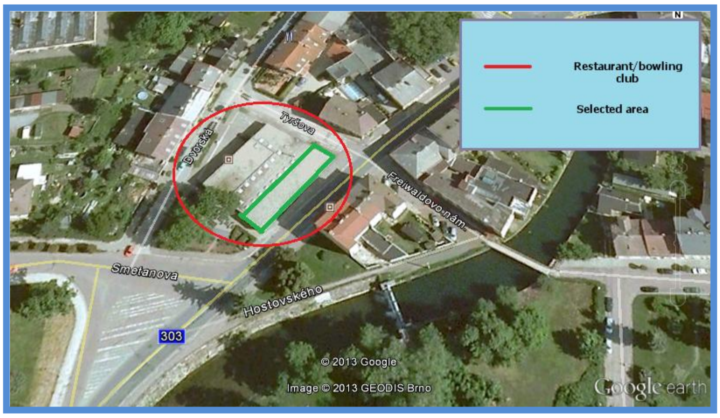


Parameters of the zone:

Entire area 248 m^2

Sitting area: 163,5 m^2

Green area 84,5 m^2



Figures 5.1 - 3: Google Earth satellite images

5.2.1. Roof description

The whole building was reconstructed during the year 2000 from the project and engineering company ASSPRO Ltd. with headquarters in Plhovská 1100, 54701 Náchod. Due to the complete reconstruction for sport and relax purposes (bowling, ricochet, fitness, table football, billiards and sauna) and at the request of its owner, the whole building was designed and built in a pattern of a ship. In a view of future an idea of a new restaurant building and possible roof garden formation was suggested. The roof was reinforced with iron plates and with that the entire load of the roof increased by 40 % and was brought up to 845 kg/m^2.

5.3. Climatic conditions of the location

There is no weather station in Hronov. The closest suitable meteorological station was chosen in the town of Náchod located 9 km in the south direction. This meteorological station provided average monthly precipitation rates and average monthly air temperature data.

Based on the growing season of plants, lasting from April to October,it was prepared a table of average monthly precipitation rates and average monthly temperatures for 25 years period monitored in Náchod (Table 5.1).

The climate atlas of the Czech Republic shows for the given location average monthly precipitation from April to October ranging from 450 to 500 mm (Fig. 5.4). The average total rate of evapotranspiration for the same period is 500 - 550 mm (Fig. 5.5).

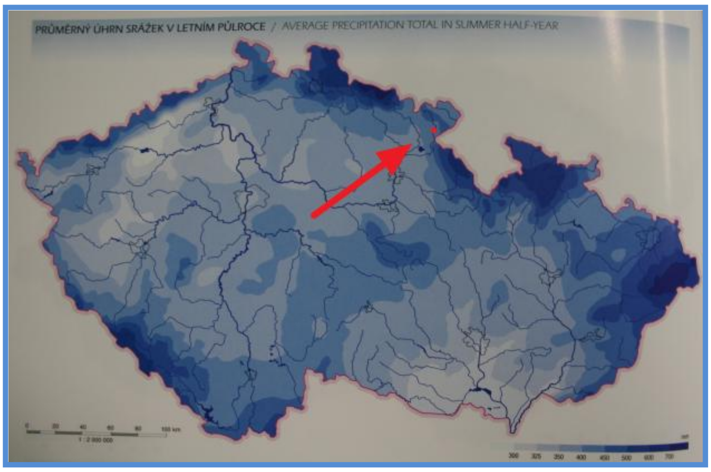
Table 5.1. Average temperatures [° C] and precipitation rate [mm] - Náchod.

Month	April	May	June	July	August	September	October
mm	52,3	74,7	81,7	89,5	86,4	62,2	51,3
°C	6,5	11,4	14,7	15,4	15,8	11,9	7,6

(Data - Czech Hydrometeorological Institute,2013)

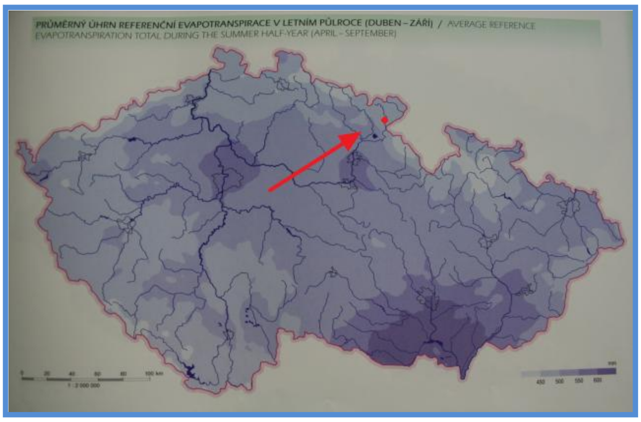
Long-term average rainfall in vegetation period reaches 498.1 mm and average temperature from April to October, 11.9 ° C. Overall, southwest wind flow prevails in the area (Czech Hydrometeorological Institute).

Figure 5.4 Sum of rainfall (Hronov)



(Climate Atlas of the Czech Republic, 2003)

Figure 5.5 Evapotranspiration rate (Hronov)



(Climate Atlas of the Czech Republic, 2003)

5. 4. Documents

All maps of the roof and necessary data were provided by the owner and had been processed during the reconstruction of the building in 2000. Based on these maps a detailed layout representing future planting shrubs and perennials and detailed layout of sprinklers and pipe networks was drawn (Attachment 1, 2 Main situation).

5.4.1. Current status

The current gravel surface of the roof is becoming penetrated by weed and roots from neighboring trees. Since the roof is not protected against root penetration, the growing trees cause damages of the protective foil. Water is leaking into the building due to infiltration and trees root system damages the entire state and causes failure of its function.

5.4.2. Concept solution

The area will be deployed with a total of 6 micro sprinklers with adjustable height control (Attachment 11). It will be an interconnected network of PVC and PE pipes that will be connected to a water supply bringing the water from the tank up the north-east side of the building. Pipes are deposited on the west side of the roof just behind the ending substrate and pots (section $P_{0,}$ $P_{D)}$.

The operation will be controlled by an automatic irrigation control unit, which will be connected to the sensor of precipitation and solenoid valves. A valve will supply the water for the 6 micro sprinklers and the Drip irrigation section. There will be a double filtration system of both sections. First filtration starts directly after a pumping unit, beyond the fertilizer. The second filtration is secured in the Control Zone Kit starting with P_0 section to prevent stoppage of the micro sprinklers and drippers (Attachment 11, 12). The pumping unit will be in standby mode under set pressure and wenn needed, the solenoid valve opens, which causes a decrease of pressure in pipes which launches the pumping.

VI. Technical Part

6.1. Accompanying report

8

To ensure constant freshness and vitality of plants, the owner and investor plan to carry out the irrigation in the marked rectangular zone of the size of 78 m^2 and 6.5 m^2 area of shrubs in the pots. In total 84.5 m^2. Using two Irrigation types Micro drip irrigation and for lawn with perennials micro sprinklers (Attachment 10). The water source will be only rainfall ducted into the tank from the roof surface, including the remaining two-thirds of the roof west of the section marked for planting.

As it is a supplementary irrigation of a small area, an appropriately large underground tank was chosen (Attachment 9) to cover the water demand of the plants even in extremely dry months. The selected drainage and irrigated area is located on the northeastern part of the roof. The difference of heights between the ground surface and the roof surface is 3,150 m and the roof has a tendency to fall toward north by 3.79 %. A 20 meters long terrace starts at the southern part and continues toward north, marking the end of the greening part. The terrace has a capacity of 60 seats. It was designed due to the lack of outdoor seating. The southern part of the roof will be used during the warm days from spring to autumn (April - October). Design and construction of the rooftop terrace with tables is not involved in the project (owner contracts another entity). However, for clarity and overall appearance of the roof, the tables with terrace are also displayed in the main situation. Components of the complete pressure pipe system are described below.

6.1.1. Irrigation system

Operating mechanism of the irrigation unit (system) of the roof is made up of a suction strainer, suction pipe, armatures, pumping unit, fertilizer injector, filter, discharge pipeline, inlet pipe network (P), Control zone Kit (made of second filter and solenoid valve), atmospheric control unit, sectional pipeline P_O and to it connected irrigation detail, micro spray irrigation pipes P1 - P4 and drip irrigation section PD. Specifications of individual components are described below:

6.1.1.2. Suction line

Due to the low volume of flow, a simple suction line was chosen for the irrigation. It consists of a suction strainer, polyethylene pipe and armatures.

6.1.1.3. Strainer

The strainer is located at the start of the suction procedure (Attachment 18.). It is fitted to a polyethylene pipe DN 1"connecting the second end of the tube with armature bend PE 1” 90° followed by another PE pipe heading to a pumps suction throat D 1”.

6.1.1.4. Pumping unit

For the project was chosen pumping unit KOPRO JET 100 A(a), with a pressure tank of 60 l, connected to 230 V from the Kopro manufacturer. It will be placed between the north eastern wall and the underground tank on the ground surface beyond the wooden fence. The exact location is described in Attachment 3.

6.1.1.5. Discharge pipe

Once the pumping station is placed at the location, a discharge pipe with three stainless securing sleeves will also be attached to the north wall to ensure stabilization of the entire system. The discharge pipe is made of black polyethylene. During manipulation it is necessary to follow the instructions of the manufacturer. After reduction beyond the pump from DN 1” to DN ¾” the black PE tube ¾” will be used.

6.1.1.6. Main pipe (P)

Starts by bringing water from the discharge port of the pumping unit and ending on the end of section P_D. Pipe P divides the irrigation detail into two parts. The first part of the series P (section P1-P4) consists of micro sprinklers spraying the lawn with perennials in the vicinity of the atmospheric station. Second part P_D is bringing the water towards 13 pots section.

According to Attachment 2 (Layout of micro sprinklers) the P line starts with lPE DN ¾” and leading the water through the Control Zone Kit and its filtration system with solenoid valve is proceeding till the first turn P1 to the place of sectional pipeline $P_{0.}$ Between the sections P1 - P4 proceeds the pipe with the same DN ¾”. Right beyond the turn P2 pipe is reduced to PVC DN 16 fading towards the turn P3 and later on with DN 12 to P4. Behind P4 turn the pipe is reduced again to PVC DN 6 and the water going through the Control Zone Kit and is filtration system is proceeding in the PVC DN ¼“ till the end to P_0 watering the pots. The entire pipeline leads and follows the western part of the wall.

The slope of the pipeline follows the slope of the roof 3.79 %. For the irrigation pipes branches P1 - P4 this tendency will be artificially created in the substrate (Attachment 7). It will ensure that the water can be easily drained from the higher levels (by the micro sprinklers) to the lower level towards the sectional pipe P_0 and the main pipe P.

6.1.1.7. Irrigation pipes

They are used for water supply towards the micro sprinklers/drippers. The term “irrigation pipes” considers pipes branching from the main pressure pipe P and its sectional pipes P_0 namely P1, P2, P3, P4. The second part of the irrigation pipe is a part of the sector P_D. (Attachment 2).

For the design of the roof the black polyethylene was selected, together with PVC pipes suitable for outdoor irrigation distribution systems and carrying a number of advantages. It is worth mentioning, that they are extremely durable, non-corrosive and with no formation of encrustations (scale) on the inner walls of pipes with high chemical resistance. In addition, this material is eco-friendly, fully recyclable, economical and having very low hydraulic losses and very easy connecting and re-dismountable joints.

Suitable PE pipes from company ThermoLux were chosen. The selected single components for the irrigation systems are then described in detail in the parts list of items and price list at the end (Attachment 19). For the compilation there are needed DN 1”, ¾”, 16, 12, and 6 (1/4”).

6.1.2. Connecting the system

Connection of the network starts with placing the discharge pipe with strainer in catchment MIROSEP 6000, continues through connection with 90° bend lPE DN 1” and another 1” lPE pipe heading towards pumping unit Kopro Jet 100 A(a), 230V fitted to the suction port with armature reducer DN ¾”. From the pumping unit with reducing port on lPE DN 3/4” towards gate valve ¾” and fertilizer injector with filter AFI 5016-HV ¾“ proceeding upwards through polyethylene pipes with same DN fixed to the wall with 3 fixation stainless sleeves going over the roof wall with 90° bend lPE DN ¾”. After this bend followed by 0,25 m long lPE DN ¾” followed by another 90° bend lPE DN ¾” is connected to lPE DN ¾” 0,25 m long heading to the roof surface over another 90° bend lPE DN ¾”.

In place of the proposed branches P1 - P4 are reducing T profiles armatures. After P1 T armature line continues on P_0 section with lPE ¾” DN heading to the second branch P2 and another T profile armature. On section P_0 between P2 and P3 comes to a transition to PVC DN 16 crossing another T armature reducing after P3 branch the line to PVC DN 1/2”.

On the ends of T profiles heading towards micro sprinklers are on P1 and P4 reductions to PVC DN ¼" and on P2 and P4 transitions to PVC tubes DN ½" and after its first micro sprinkler then reduction to PVC DN ¼".

Behind P4 turn continues tube over the gate valve with PVC DN ¼" supplying the water till to the pots with shrubs. Pipes are beyond the Control Zone Kit loosely laid on the ground.

The total length of drip tube is 20 m. There are 4,3 cm long distances among the branches P1 – P4. The PVC tube DN ¼" on P1 and P4 branches are 3 m long in the greened area and by P2 and P3 there are 6 m long distances. Total length from the P_0 for P1 and P4 is 3,5 m and for P2 and P3 6,5 m.

6.1.3. Operation and use of the system

Watering is carried out during the growing season of plants, from 1st of April to 30th of October. Supplementary irrigation dose will be determined during the growing season by controller (Annex 16), depending on climate conditions and hydraulic calculations.

6.1.4. System check

The correct functionality of the system is determined by the periodic inspection of individual elements of the irrigation network and its maintenance. Every single element of the entire system has to be checked and protected, particularly its filters, pumping unit and micro sprinklers and drippers. It is also necessary to clean the whole system from settled sludge from time to time. This can be achieved by opening gate valves and draining it into the main drain divert to the local drainage system of the town in the vicinity of the catchment.

6.2. Water management concept

For the purpose of calculating the irrigation batch of all plants, it is at first required to find out the water demand of all plants Vc. There are not great differences in water demand for every single plant and the irrigation should be more additional than substantial. It is therefore possible to use the average water demand for all plants used on the roof Vc´. The average used for perennial plants in growing season is Vc = 4500 m^3/ha. The average value for the irrigation of lawns is Vc = 5000 m^3/ha. To find an equilibrium among all plants and the lawn, the value of Vc = 4750 m^3/ha is used.

Watering of the plants and the lawn will be designed in a way that even in drier periods the evapotranspiration of plants will be covered. For this purpose it is necessary to calculate the total amount of irrigation Mz. It determines the amount of water that must be supplied to the plants during the growing season to supplement natural moisture.

For this purpose we use an equation:

M_z= kz (Vc – αSv)

k_z – loss coefficient
Vc – water demand [m^3/ha]
α – coefficient of utilization of precipitation according to soil type
Sv – the sum of all precipitation during the growing season [m^3/ha]

The coefficient of losses of sprinkler irrigation is set at 1.25%. Consumptive water use of plants and grass is considered 4750 m^3/ha. Utilization coefficient α precipitation was set at 0.75, with regard to the 3% slope roofs and according to ON 83 06 35 for medium heavy soils in flat areas. According to the data provided by the Czech Hydrometeorological Institute, the Czech Republic rainfall during the growing season (April to October) for the site Hronov (Náchodsko) is 497 mm. Conversion to m^3 is necessary to obtain the information needed for the equation. (Kuklík, Bushman, 1988)

$M_z = k_z (Vc - \alpha S_v)$
M_z = 1,25 (4 750 – 0,75* 4980)
$\underline{M_z = 1015{,}0\ m^3/ha}$

Irrigation dose Mz converted to selected roof with an area of 84.5 m^2 = 8.58 m^2 per growing season.

Table 6.1. Usable precipitation in months

α	0,6	IV.	V.	VI.	VII.	VIII.	IX.	X.
Sn	498	52,3	74,7	81,7	89,5	86,4	62,2	51,3
Sn*α	373.5	39,23	56	61,3	67.13	64,8	46,7	38,48

The total growing season is from 1st of April to 30th of October and lasts 214 days. Assuming the data for the lawn and field crops to meet the agro technical condition the total amount must be between 30-40 mm 5-7 days, it means, it will be irrigated 40 days throughout the growing period for a maximum of 12 hours.

Consequently, it is necessary to determine what portion of the total amount of irrigation Mz is needed to be supplied during these months. From the total amount of irrigation Mz = 1015 m^3/ha for the given area of 0.00845 hectares, the resulting value is 8.58 m^3. This figure is divided by the number of hours irrigated throughout the growing season to 320 (total hours of irrigation) = 0.02681 m^3. After conversion to liters, one hour watering time has to be converted to the roof surface = 26.81 l/hour. The number of micro sprinklers and the total flow rate (Q) has to be sufficient in order to cover the value of 0.32172 m^3 = 321.72 l of water for irrigation for 12 hours.

Table 6.2. Indicative daily evapotranspiration rate dependent on temperature and indicative irrigation dose (Kuklik, 1985).

směrodatná závlahová dávka Mds (m^3/ha)	Průměrná červencová teplota, C°						
	16	17	18	19	20	21	22
	Ed (m^3 /ha)						
100	**45,7**	**48,9**	53,7	60,2	65,6	73,0	81,0
200	40,7	43,5	47,8	53,6	58,3	65,2	72,0
300	37,5	40,1	44,1	49,5	53,8	60,1	66,0
400	35,4	37,9	41,7	46,6	50,8	56,7	62,5
500	33,8	36,2	39,7	44,5	48,5	54,1	59,7
600	32,6	34,8	38,4	43,0	46,6	52,2	57,6
800	30,9	33,0	36,3	40,6	44,4	49,5	54,4

(Kuklík,1985)

The irrigation system will be based on the average July temperature of 16.3 ° C for the locality of Náchod, where the daily evapotranspiration rate of lawn of Ed 46.3 m^3/ha was detected computed from the baldfaced numbers in the table 3. This value Ed is converted (46.3 × 1000/10, 000) to express the evapotranspiration rate l/m^2. With computation will be found, that at 16.3°C is the value of evapotranspiration rate of 4.63 kg/m^2 = 4.63 mm/m^2. To ensure adequate watering of the lawn and the plants, the irrigation system must meet the daily evapotranspiration rate of the plants. In this case, the expected total roof area is 84.5 m^2. It means, that by the July temperature of 16.3 ° C for total area of 84,5 m^2 it is needed to deliver to plants an irrigation dose of total amount of water 0.391 m^3 = 391 l.

Time of irrigation: Irrigation should be performed mainly at night or evening hours to minimize evaporation. For cooling the plants and lawn the irrigation will be launched also by hot summer days for 5 minutes followed by 15 minutes interruption of irrigation procedure.

6.2.1. Types of sprinklers

According to main situation (Attachment 2) there will be altogether 6 micro sprinklers, two working in a semicircular sector type Rain Bird series U10 – Half Circle Sprayer and 4 working in a semicircular sector Rain Bird Rotary Nozzles R13-18H. One micro sprinkler of the type Rain Bird Rotary Nozzles R13-18H will irrigate with r = 4.3 m. The second type RAIN BIRD series U10 - Half Circle Sprayer with r = 3 m (Attachment 2). Flow (Q) RAIN BIRD series U10 - Half Circle Sprayer is 0.18 m3/Hr and flow rate (Q) Rain Bird Rotary Nozzles R13-18H is 0.16 m3/Hr. Within one hour of irrigation is therefore supplied to an area of 78 m2 is 0.998 1m3 $\doteq$1 m3.

Flow rate (Q) of 6 sprinklers working simultaneously is 16.64 l / min. Considering watering of shrubs in pots by amount of 4l/Hr per one pot, the total amount of water needed for 84.5 m2 is 1050 l/Hr. Irrigation dose 0.391 m3.in this case will take approximately 22.5 minutes.

The impact of last drops from the micro sprinklers is 4.3 m, but in relation to the radius, the effective width of irrigation can be calculated.

Effective irrigation width:

2r - 10%

2 × 4.3 - 10% = 7.74 m

Because micro sprinklers work in a semicircular sector, the results have to be divided by two, to obtain effective strip width r = 3.87 m for one micro sprinkler.

By two micro sprinklers located on the north and south side of the roof will be radius of 3 m. Considered the effective width of the two micro sprinklers, the resulting radius is at half-circle 2.7 m. By micro sprinkling comes however to overlapping of radiuses for more complex irrigation of the entire area.

For each of the six micro sprinklers, the total period of irrigation time is double as long than if the micro sprinklers were working in a circle. The given time of irrigation from micro sprinklers provided by RAIN BIRD company already counts with this fact in parameters table.

6.2.2. The distribution of water on the area.

Based on dimensions of the rectangular area were chosen micro sprinklers and according to theirs radius properly deployed, so that they would not overspray the bounded area. Four 180° sector micro sprinklers of radius 4.3 m, designed by the RAIN BIRD Company, were deployed on the west and eastern side of the roof. The northern and southern side is covered by two 180° sector micro sprinklers with radius of 3 m.

6.2.3. Layout of pipes

Rows of pipes were designed to carry water in the shortest possible distance from the pump and without excessive pressure loss caused by frequent use of fittings, armatures, bends or reductions. Main P was therefore designed to distribute the water directly from the pump around the west side. At the same time drip irrigation for shrubs in pots was established. There are altogether 4 branches from P line (P1 - P4). The ranks of P1 and P4 water supply water to micro sprinklers on the southern and northern part, while each one from the lines P2 and P3 has two sectional micro sprinklers. Beyond the turn of pipe branch P4 is the pipe PD with gate valve, heading to pots in the south direction (Attachment 2). Into the pots are installed 26 drippers. In each pot two drippers are installed for better irrigation of a whole area of the substrate and better growth the main mass of the roots. For drip irrigation of the pots two RAIN BIRD dripper sets were selected (Attachment12).

6.2.4. Maintenance instruction

The system requires treatment for each component. The instructions should be followed and kept together with maintenance diary to be kept up-to-date. Maintenance is essential for proper working of the entire system and should not be neglected.

Sump – Removing weeds, branches and silt-deposits from suction pipe. During irrigation season trying to avoid growth of algae in clear water. Primary and secondary filtration system is also checked.

Pumping unit – Before start-up it is important to make sure the shaft is not stuck and all check valve open. Every 3-5 weeks whenever pumps are stopped, replace oil and lubricate pump bearings. At the end of the season, pump efficiency should be tested and Compaq it with manufacturer´s pump curves. Check for vibrations and unusual notes, also check transmission between pump and motor. At the end of the irrigation season replace stuffing-box seal and grease where necessary.

Irrigation control heads – Visually check its performance or calibrate.

Check valve – Check performance, lubricate moving parts check seals and sealing.

Irrigation controller – Check batteries, power source, electric and hydraulic connections.

Filters – Visually check for abrasion and cleanliness of settling tank, check pressure differential when filters are clean and compare with requirements.

Fertilization system – Check performance, check are air release valves and check valve.

Micro-sprinkler – Has a swivel instead of the static spreader, producing a rotary movement and trajectory. It converts water into a small sprinkler.

6.3. Hydraulic management

The purpose of the hydraulic pressure pipes solution is to determine the profile pipe, flow conditions and the calculation of pressure loss and to ensure, at each site of the designed system is allowed the right pressure and flow. Flow in the irrigation network is determined by the ON 83 06 35. To figure the pressure to overcome the loss of hydraulic resistance $h_{z,}$ it is usually divided into pressure losses along the flow Z_t (losses to overcome the frictional resistance) and local losses (losses caused by a change in direction, or a flow pipe DN).

To calculate pressure losses along the flow can be used Blasin formula, which is valid for the hydraulically smooth pipes, in which friction depends on the roughness of pipe:

$$\lambda = 0.316 / RE^{0,25}$$

Re - dimensionless Reynold number

λ - coefficient of hydraulic friction in pipes of circular cross-section

Friction loss in the pipe is usually stated by the tube manufacturer. In the case of pipeline system for the roof, a black PE and PVC pipes were chosen, so that their loss to overcome the frictional resistance is minimal.

Local losses must be estimated, so that, based on the total pressure loss, the most suitable pump unit could be selected, or possibly change the network diameters or its fittings.

Local losses arise mainly from changes in the direction of flow or cross-section flow, by cutting and assembly of current, when it flows around obstacles, etc. They are caused by fittings, valves and other devices of piping network. Pressure loss due to local resistance can be determined by the Weisbach expression:

$$z_m = \xi \, v2/2g$$

v - mean flow velocity in the flow area, located in a given resistance

ξ - coefficient of local resistance

Resistance figures of coefficients ξ are listed in the specialist hydraulic literature. In practical calculations it is often replaced by local pressure losses so called, replacement of straight pipe length **Le**, which is determined in the following way:

$$Le = \xi \, d / \lambda$$

d - internal diameter of the pipe (m)

λ - coefficient of hydraulic friction circular cross-section

For the calculation determining the equivalent length of straight pipe, table providing the equivalent length of straight pipe for various fittings and valves in the exercise of irrigation was used (Kuklík, 1985) on page 258 or the equivalent length of straight pipe provided by the manufacturer of the valve.

To calculate pressure drops in the plastic pipe a Nomo gram for the design of plastic pipe according Ševelev, the exercise of irrigation on page 262 was used (Kuklík, 1985).

The selected profile pipe tented middle flow rate, preferably between 0.8 to 1.2 l / s need to draft profile and follow-up assessment in terms of economy as nomograms for the design of PVC pipe on page 265 and lPE on page 266 Cvičení ze závlah (Kuklík 1985).

Hydraulic calculation of the pipe network is based on its complete solution. Pipes of the highest order P is connected directly to the pumping station. The pipes of the highest order P pipe turns lower order (P1, P2, P3, P4).

Hydraulic calculation of the network is based on the flow distribution in the individual pipelines. In its own hydraulic calculation of the irrigation network is divided into separate sections of pipe lengths *Li*, pipe diameters *Di* and the constant flow of *Qi*. The calculation is performed tabular and its solution is recommended gradually in the direction from the outermost branches of a petrol station. The flow that occurs in each section of pipe network is then tented slope line of pressure loss and height according to the formula:

$h_{zi} = Li \times J/1000$ where J is in promiles

h_{zi} - height loss (pressure drop) in a specific section of pipe Li, m

L_i - length of section, m

J - pressure gradient line, in °%

By summing up the individual partial pressure losses h_{zi} each section is calculated as the total pressure loss h_z of the pipe branches L_i.

Based on the calculated values according to Table calculation of pressure losses is constructed arranged longitudinal profile pressure conditions (Attachment 5).

Axis of the pumping. St.	354.70
Water level	353.50
Surface altitude	354.00
Slope	90 degrees

PIPE LINE FROM PUMPING UNIT - First turn																	
	Strainer 1"	IPE 25	IPE 90° Bend	IPE 25	IPE 90° Bend	IPE 25	Reduction 3/4"	GV	DIH	IPE 90° Bend	IPE 25	IPE 90° Bend	IPE 25	IPE 90° Bend	CZK	IPE 25	Sum of losses
Length (L)	0.2	1.7	0.1	0.2	0.05	3.15	0.2	0.1	0.3	0.1	2.45	0.1	0.31	0.05	0.3	1	Le = 40,1
(Le)	6	1.7	2	0.2	2	3.15	0.5	6	4	2	2.25	2	0.31	3	4	1	

Branch	Section	Stationing of section (m)	Length (m)	DN (mm)	Pipes Material	flow rate (l/s)	Average speed	Flow pressure line slope	Height loss	hzs	hgs	h	45	Terrain	Overpressure
P	Pump. St. - P1	0,0 - 5,80	5.88	3/4"	IPE	0.32	1.02	8.070525944	0.047454693	0.052200162	0.50	0.55	396.61	353	43.61
	P.1 - P.2	6,38 - 10,71	4.33	3/4"	IPE	0.27	0.86	5.892321995	0.025513754	0.084704081	0.50	0.58	396.03	353	43.03
	Transition DN 3/4" IPE / DN 16 PVC														
	P.2 - P3	10,71 - 15,04	4.33	16	PVC	0.17	1.25	7.455801362	0.03228362	0.120216063	0.50	0.620216063	395.99	353	42.99
	Transition IPE DN 16/ PVC DN 1/2"														
	P.3 - P.4	15,04 - 19,37	4.33	1/2"	PVC	0.07	1.62	5.907225037	0.025578284	0.148352175	0.50	0.648352175	395.96	353	42.96
	Transition PVC 1/2" / DN 1/4"														
	P.4 Turn - Gate valve	19,37 - 19,58	0.21	1/4"	PVC	0.02	0.71	17.2342638	0.003619195	0.15233329	0.50	0.65233329	395.95	353	42.95

Branch	Section stationing (m)	Length	Pipes DN	Material	Flow rate	Average flow speed	Flow pressure line slope	T - armature	Reduction 1/2"	Reduction 1/4	Gate valve	Sum of losses	Hydraulic head	Terrain	Overpressure
P1	0,00 - 3,50	3.5	1/4"	PVC	0.05	1.77	9.45873999	0.391747998		0.4364685		0.8282	395.93	353.58	42.35
P2	0,00 - 0,50	0.5	1/2"	PVC	0.1	0.88	11.4049775	0.450909505	0.2124			0.6633	395.86	353.6	42.26
	0,50 - 6,50	6	1/4"	PVC	0.05	1.77	7.45873999			0.3364685		0.3365	395.83	353.63	42.20
P3	0,00 - 0,50	0.5	1/2"	PVC	0.1	0.88	11.8049775	0.450909505	0.2124			0.6633	395.78	353.64	42.14
	0,50 - 6,50	6	1/4"	PVC	0.05	1.67	7.95873999			0.3364685		0.3365	395.75	353.68	42.07
P4	0,00 - 3,50	3.5	1/4"	PVC	0.05	1.27	9.787399898	0.29322094	0.2867			0.5799	395.67	353.72	41.95
PD	0,00 - 20,00	20	1/4"	PVC	0.02	0.32	16.4873999	0.69322094			0.263	0.9562	395.33	353.62	41.71

VII. Results

As requested by the Leisure center in Hronov, the fully automatic system of irrigation was designed which helps an easy maintenance and will not require more work. For the roof, undemanding plants, perennials were chosen. Perennials were chosen according to their bloom period from April till October. Plants will revel with colors (yellow, pink, blue, red) throughout the whole spring till autumn. Every month, at least three kinds of perennials will bloom. There are also shrubs in pots and for them suitably designed drip irrigation. For the perennials and lawn on the roof area, 6 pop ups micro sprinklers RAIN BIRD XP 400 X were chosen, which will irrigate in semicircular sector with sets of exchangeable heads (sprayers or rotors). For pot irrigation two sets of RAIN BIRD drip irrigation kits were chosen.

Both (lawn and the shrubs in pots) will be checked by the controller WP2. WP2 launches the irrigation dose based on data from meteorological station RSD-BEX. Controller is set so that it covers the water deficit of the rain falls. Controller is connected to solenoid valve which by opening decrease the set pressure and automatically launches the pumping unit in standby mode and triggers the irrigation. Water is filtered firstly from the strainer, than goes to the filter behind the fertilizer on the suction pipe and finally to the Control Zone Kit and its filter. All filter steps are needed to ensure there are no small particles of impurities or unsolved fertilizers which could get stuck in the micro irrigation system, especially in the drip irrigation area.

Drainage of the roof will be built on current drainage system, which so far diverts all water to urban sewerage system. By blockage of the outflow to urban sewerage system in the concrete block of drainage and connecting it with catchment according attachment 3, all water will be diverted into the catchment. The surplus water will be drained according the Attachment 8 back to the urban sanitation. Drainage underneath the substrate is solved with drainage layers that will divert water to the main drainage sink and simultaneously protect the concrete surface against rooting.

Entire system is also accompanied by maintenance instruction, list of material used, price list.

VIII. Discussion

Greening is very likeable by public in general and although it has more positive than negative aspects, such as extra expenses, it is not taken into account very often. Economical situation of many restaurateurs does not allow to even let the roof greened, although in many cases it could distinguish their restaurant from the conventional ones and bring profit in return.

Greening of leisure centre in Hronov surely brings new admirers from the visitors and guests. Sitting up there brings surely a lovely view on the north, east and south direction, on the west side however it still remains not very pleasant view on the other two parts of the roof, remaining unchanged. Greening of these parts would be expensive and would not offer such a nice view on the river and the park area in the southern direction. Most of it is hidden from the tall full grown trees growing in front of the entrance in south direction.

The unpleasant view was attempted to be hidden with the high shrubs in pots on sitting area west from the tables, however this still does cover only a little part of the unpleasant view. Better option would be greening of the middle part at least with high trees or shrubs in the line completely avoiding the view in the west direction. Other possibility is to plant full grown shrubs and trees on the area with perennials on the western side along the entire wall.

Other element disturbing times of sitting and relaxing by the glass of beer is the busy traffic. There are plenty of trucks going on the street right below the roof on the eastern side. This traffic can be really annoying and sitting on the terrace in heavy traffic can discourage many guests which would rather prefer some quiet place and with not so much noise.

Concerning irrigation system, it would help if the whole pump unit were covered and completely hidden from bypassing walkers, who could eventually damage or steel its single components.

IX. Conclusion

Realization of the project is a solution how to differentiate the leisure centre from other conventional restaurants and public places. Greening is being considered as very likable and appears almost in every nation. It is very innovative and recently fast developing trend of tops of factories, commercial buildings and also families and their houses. Enthusiasm of newly planted roof can however soon change into weeping eyes on account dying out from water shortage or inadequate fertilizers. Irrigation or fertilization is in many cases ignored and a greening without it can eventually cost a lot of money.

By a fully automatic system will no drought jeopardize our lawn, plants and flowers, wherever it might be. It is surely so far the best way how to enjoy absence of home with no worries. It also helps to give our greenery the best care, to keep the water balance of plants and keep them always fresh and vital.

Development of irrigation project takes a proper selection of every single component. Many manufactures with new innovations are coming on the market and offer a variety of selection from components. Economic and water saving systems are preferred and still prevails.

Entire project fulfilling brought up the solving many related tasks and is not easy at all. With well done concept solution can be a gardener rewarded with never ending freshness and multi-colored looks.

X. Used standards list

CSN 75 5301 for water pumping station

EN ISO 15494 Plastics piping systems for industrial applications - Polyethylene (PE) and polypropylene (PP)

CSN 75 5401 (75 5401) Designing a water pipe

CSN 75 5911 (75 5911) Pressure tests on water and irrigation pipe

CSN EN 12201-1 Plastics piping systems for water supply - Polyethylene (PE)

IEC EN12201-2 This European Standard specifies the characteristics of pipes made of polyethylene (PE), designated for drinking water, including transportation of untreated water. It also specifies the test parameters for the test methods referred to this standard.

CSN EN 12201-3 This European Standard specifies the characteristics of fittings made of polyethylene (PE)

CSN EN 13244-1 EN13244 This standard specifies the general requirements for piping systems made of polyethylene (PE) pressure systems for water for general purposes, drainage and sewerage buried under a ground.

CSN EN 13 244-4 Plastics piping systems buried and for water for general purposes, drainage and sewerage - Polyethylene (PE).

CSN EN 1171 - Industrial valves - Cast iron gate valves

CSN EN 13 8768 - Transition connection IPE

CSN EN 13 1356 This document has been prepared according to the latest requirements for the production and quality of supply piping systems with oval flange joints for PN 16

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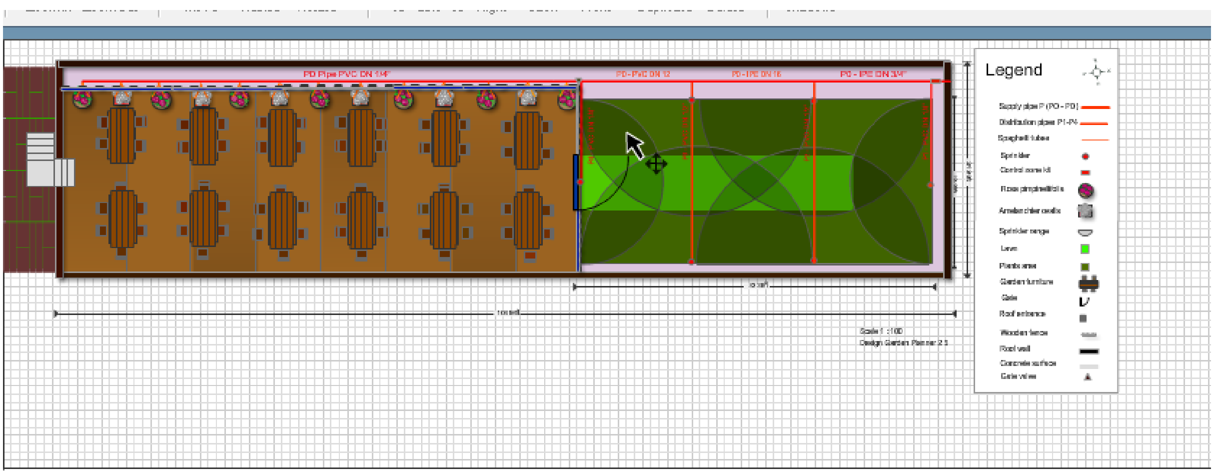
XII. Attachments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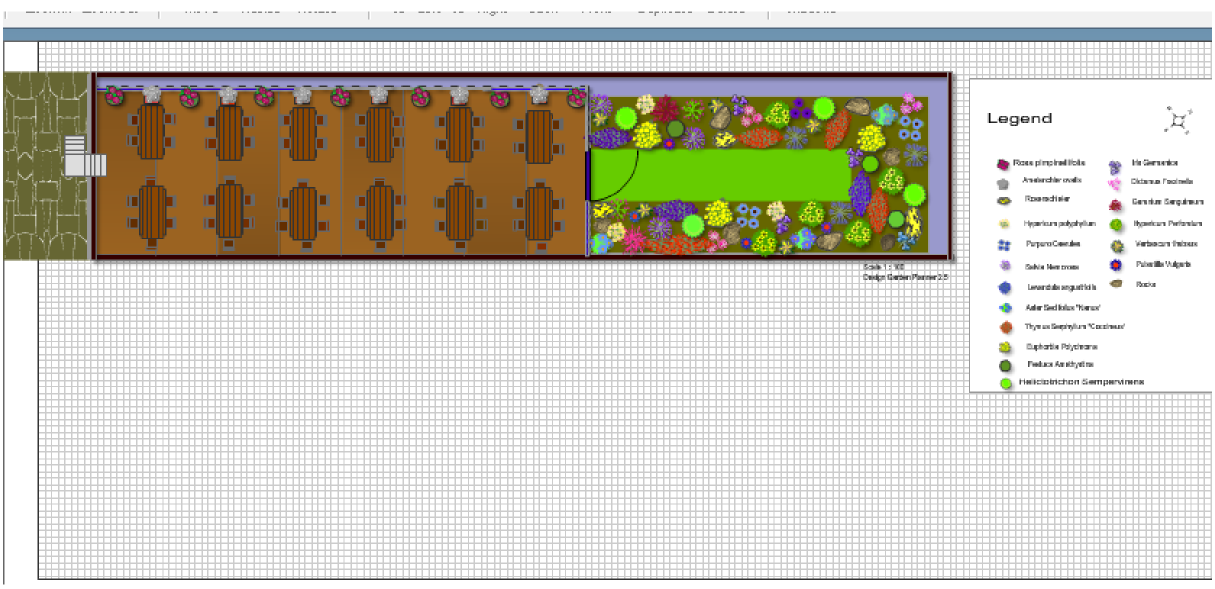
Sprinkler
Lawn
Garden furniture
Gate
Wooden fence
Concrete surface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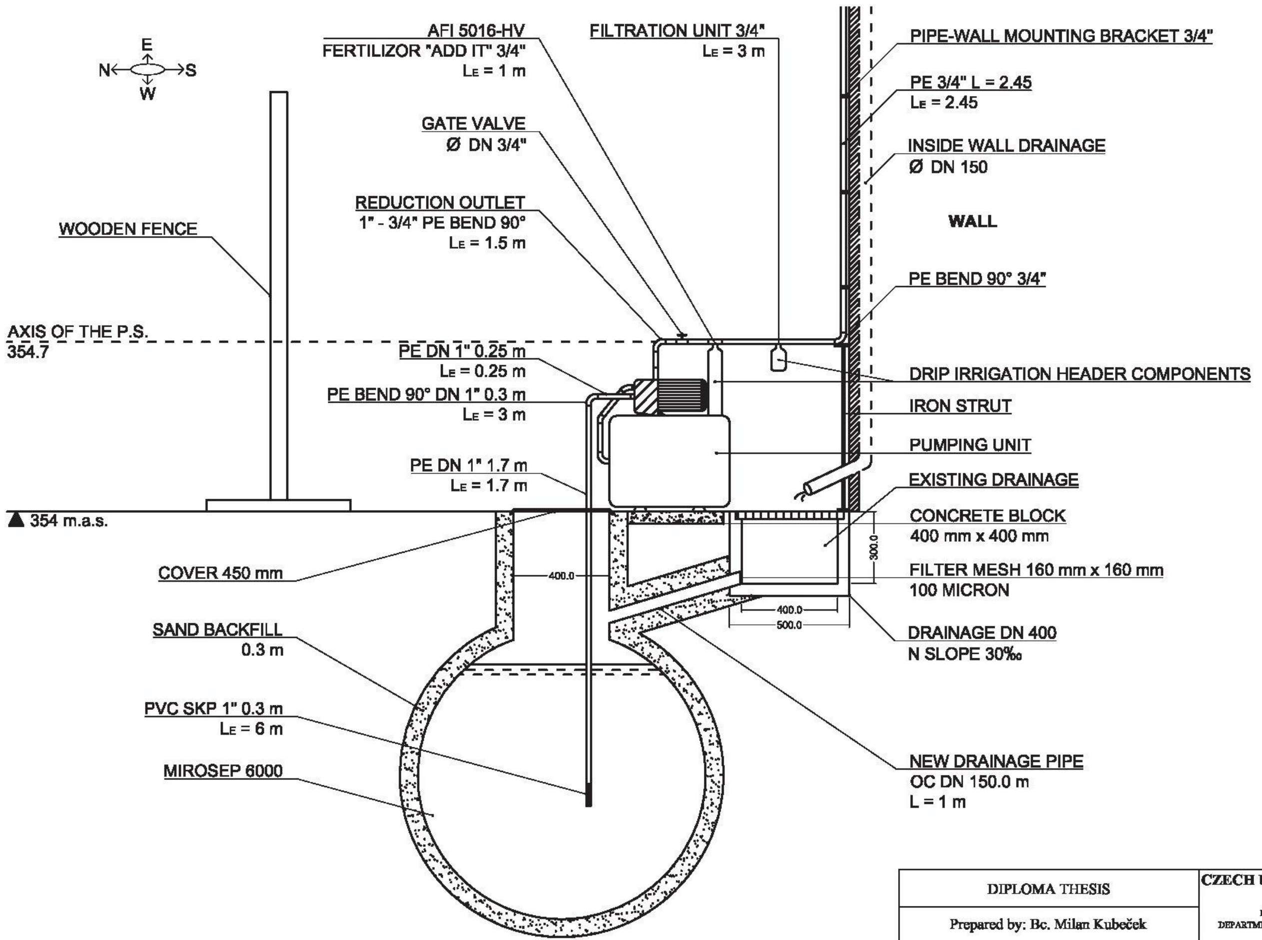
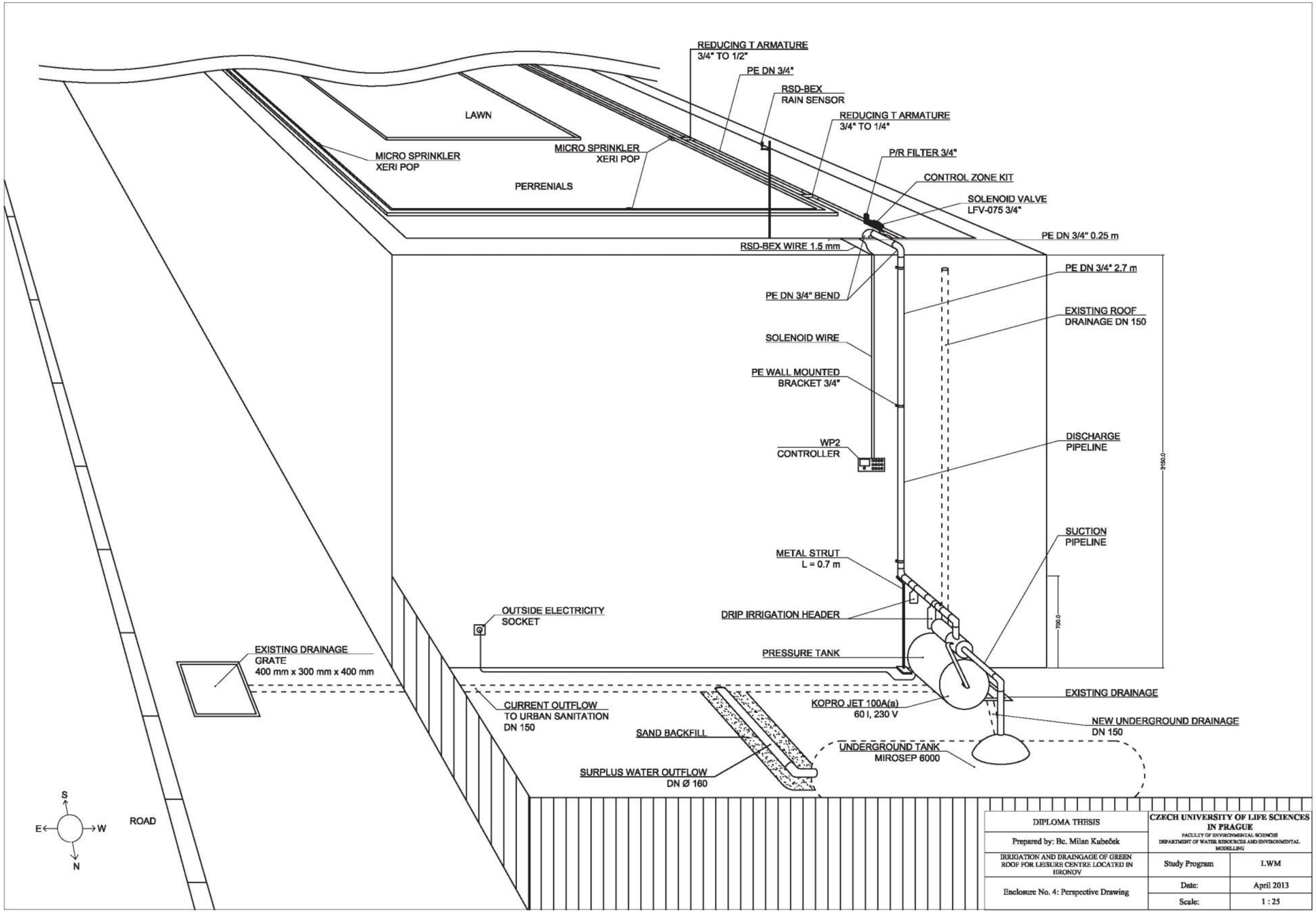
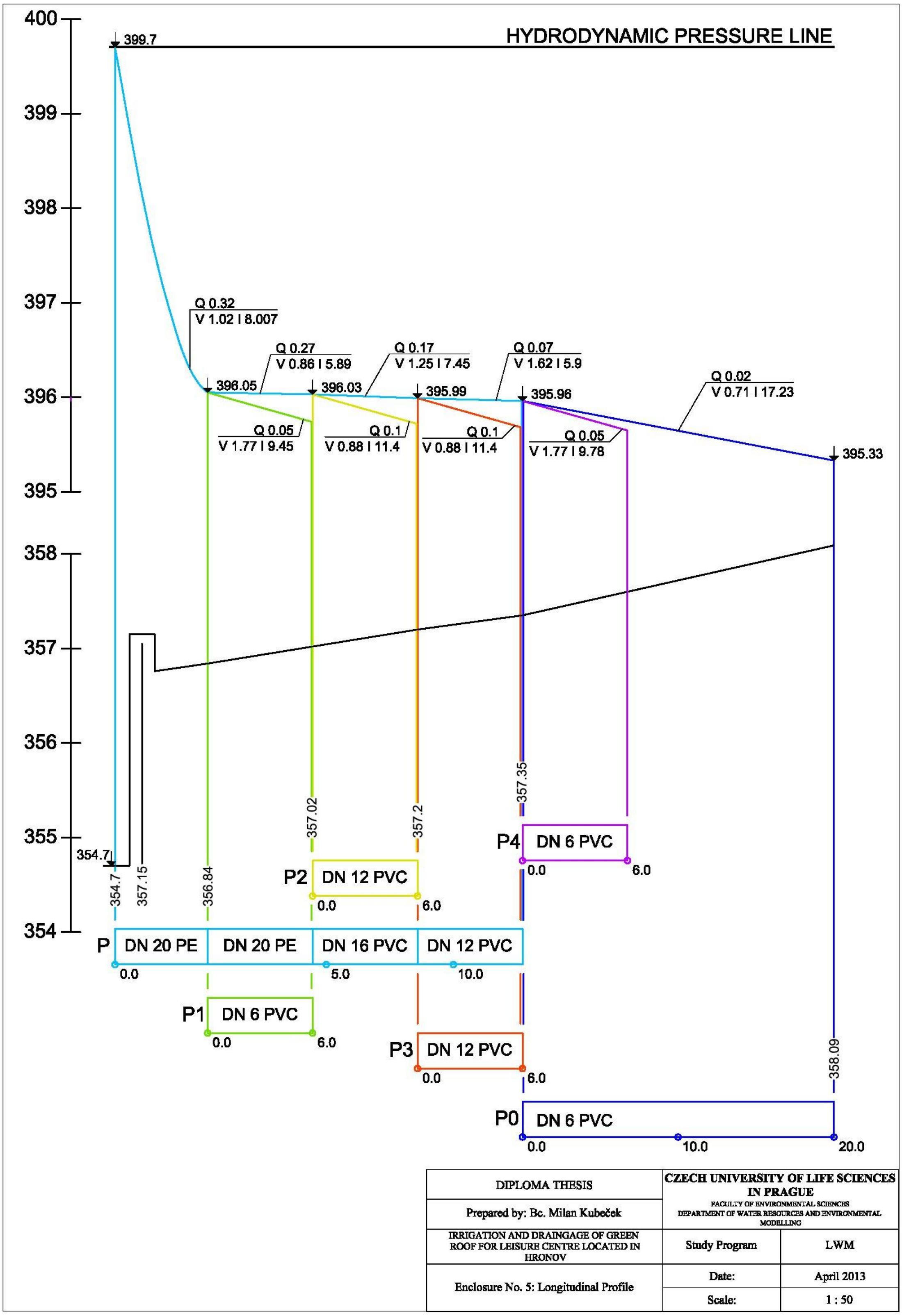
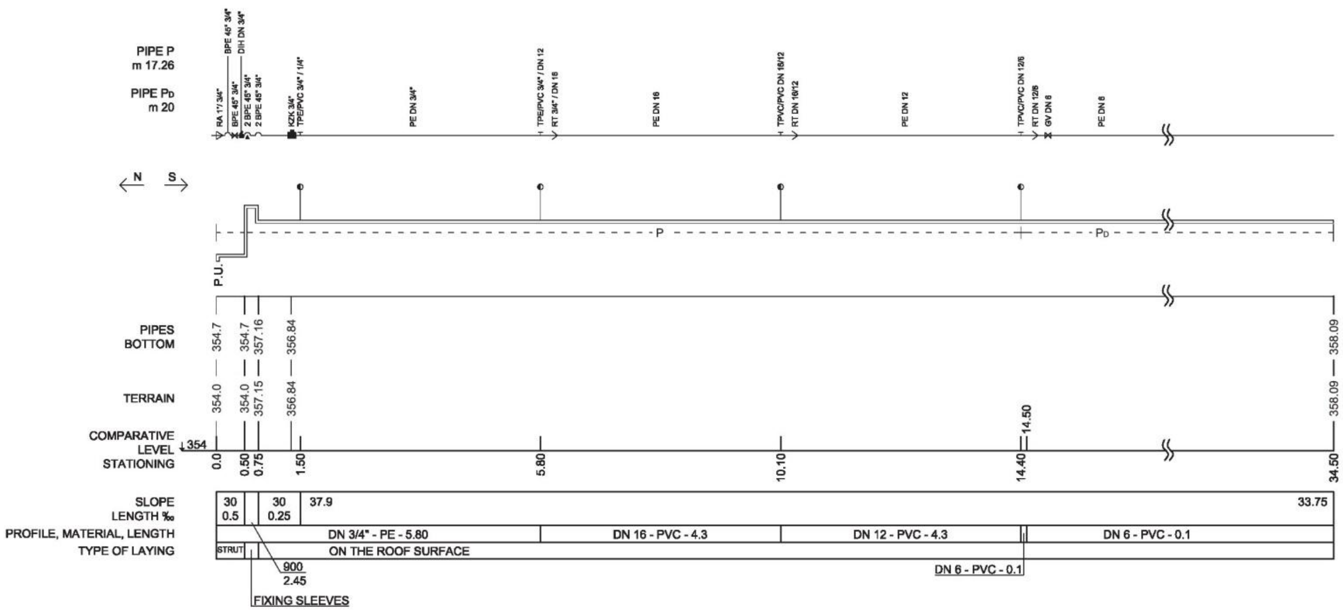
Euphorbia Polychroma
Helictotrichon Sempervirens



DIPLOMA THESIS	CZECH UNIVERSITY OF LIFE SCIENCES IN PRAGUE		
Prepared by: Bc. Milan Kubeček	FACULTY OF ENVIRONMENTAL SCIENCES DEPARTMENT OF WATER RESOURCES AND ENVIRONMENTAL MODELLING		
IRRIGATION AND DRAINGAGE OF GREEN ROOF FOR LEISURE CENTRE LOCATED IN HRONOV	Study Program	LWM	
Enclosure No. 3: Pumping unit and drainage of the roof	Date:	April 2013	
	Scale:	1 : 25	

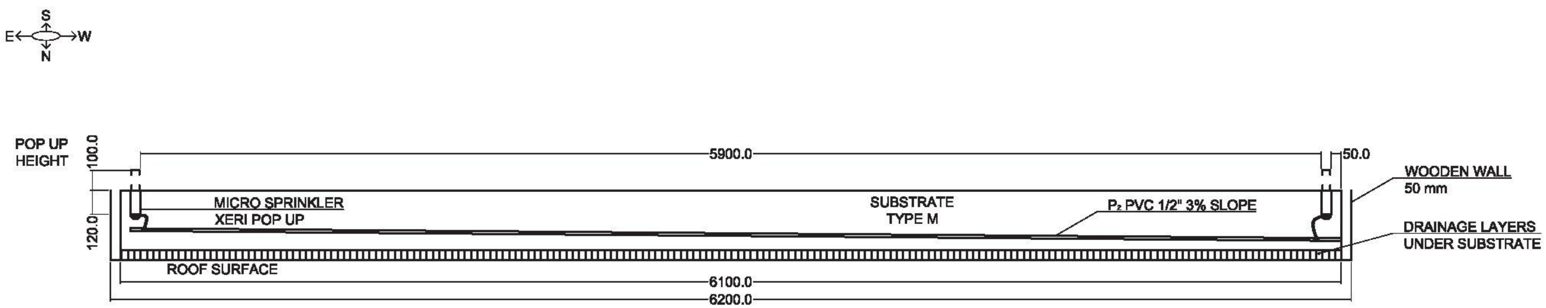

REDUCING T ARMATURE
3/4" TO 1/2"
PE DN 3/4"
RSD-BEX
RAIN SENSOR
REDUCING T ARMATURE
3/4" TO 1/4"
P/R FILTER 3/4"
CONTROL ZONE KIT
SOLENOID VALVE
LFV-075 3/4"
PE DN 3/4" 0.25 m
LAWN
MICRO SPRINKLER
XERI POP
MICRO SPRINKLER
XERI POP
PERRENIALS
RSD-BEX WIRE 1.5 mm
PE DN 3/4" 2.7 m
PE DN 3/4" BEND
EXISTING ROOF
DRAINAGE DN 150
SOLENOID WIRE
PE WALL MOUNTED
BRACKET 3/4"
WP2
CONTROLLER
DISCHARGE
PIPELINE
3150.0
SUCTION
PIPELINE
METAL STRUT
L = 0.7 m
OUTSIDE ELECTRICITY
SOCKET
DRIP IRRIGATION HEADER
700.0
EXISTING DRAINAGE
GRATE
400 mm x 300 mm x 400 mm
PRESSURE TANK
EXISTING DRAINAGE
CURRENT OUTFLOW
TO URBAN SANITATION
DN 150
KOPRO JET 100A(a)
60 l, 230 V
NEW UNDERGROUND DRAINAGE
DN 150
SAND BACKFILL
UNDERGROUND TANK
MIROSEP 6000
SURPLUS WATER OUTFLOW
DN Ø 160
S
E
W
N
ROAD
DIPLOMA THESIS
Prepared by: Bc. Milan Kubeček
IRRIGATION AND DRAINGAGE OF GREEN ROOF FOR LEISURE CENTRE LOCATED IN HRONOV
Enclosure No. 4: Perspective Drawing
CZECH UNIVERSITY OF LIFE SCIENCES IN PRAGUE
FACULTY OF ENVIRONMENTAL SCIENCES
DEPARTMENT OF WATER RESOURCES AND ENVIRONMENTAL MODELLING
Study Program
LWM
Date:
April 2013
Scale:
1 : 25


HYDRODYNAMIC PRESSURE LINE
400
399
398
397
396
395
358
357
356
355
354
399.7
Q 0.32
V 1.02 I 8.007
Q 0.27
V 0.86 I 5.89
Q 0.17
V 1.25 I 7.45
Q 0.07
V 1.62 I 5.9
Q 0.02
V 0.71 I 17.23
396.05
396.03
395.99
395.96
395.33
Q 0.05
V 1.77 I 9.45
Q 0.1
V 0.88 I 11.4
Q 0.1
V 0.88 I 11.4
Q 0.05
V 1.77 I 9.78
357.35
357.02
357.2
354.7
354.7
357.15
356.84
358.09
P4 DN 6 PVC
0.0
6.0
P2 DN 12 PVC
0.0
6.0
P DN 20 PE
DN 20 PE
DN 16 PVC
DN 12 PVC
0.0
5.0
10.0
P1 DN 6 PVC
0.0
6.0
P3 DN 12 PVC
0.0
6.0
P0 DN 6 PVC
0.0
10.0
20.0
DIPLOMA THESIS
Prepared by: Bc. Milan Kubeček
CZECH UNIVERSITY OF LIFE SCIENCES IN PRAGUE
FACULTY OF ENVIRONMENTAL SCIENCES
DEPARTMENT OF WATER RESOURCES AND ENVIRONMENTAL MODELLING
IRRIGATION AND DRAINGAGE OF GREEN ROOF FOR LEISURE CENTRE LOCATED IN HRONOV
Study Program
LWM
Enclosure No. 5: Longitudinal Profile
Date:
April 2013
Scale:
1 : 50

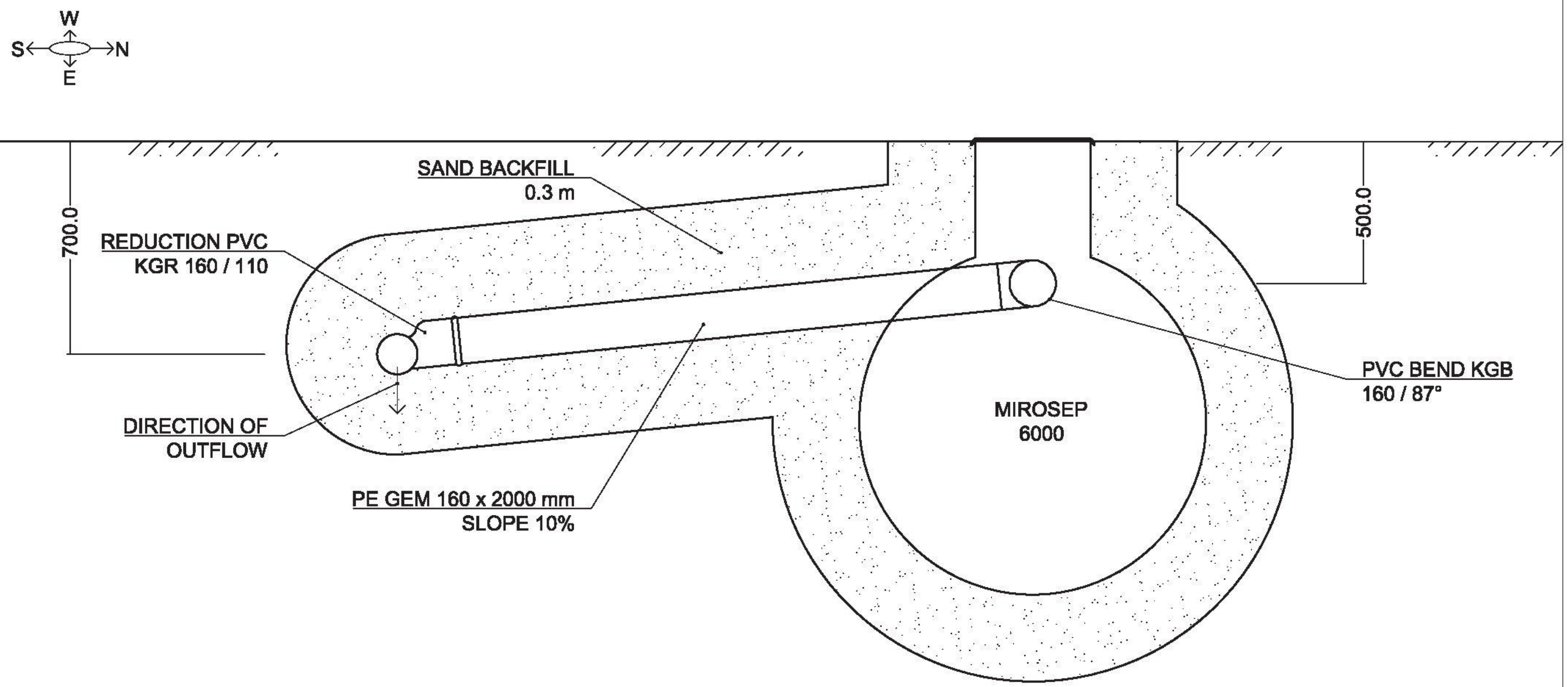


LAYING SCHEME AND PIPES BEDDING P, PD	
CADASTRE	HRONOV
ESTATE KIND	BUILDING - ROOF
PLOT NUMBER	220/2

DIPLOMA THESIS	CZECH UNIVERSITY OF LIFE SCIENCES IN PRAGUE FACULTY OF ENVIRONMENTAL SCIENCES DEPARTMENT OF WATER RESOURCES AND ENVIRONMENTAL MODELLING	
Prepared by: Bc. Milan Kubeček		
IRRIGATION AND DRAINGAGE OF GREEN ROOF FOR LEISURE CENTRE LOCATED IN HRONOV	Study Program	LWM
Enclosure No. 6: Laying Scheme	Date:	April 2013
	Scale:	1 : 75



DIPLOMA THESIS	CZECH UNIVERSITY OF LIFE SCIENCES IN PRAGUE FACULTY OF ENVIRONMENTAL SCIENCES DEPARTMENT OF WATER RESOURCES AND ENVIRONMENTAL MODELLING	
Prepared by: Bc. Milan Kubeček		
IRRIGATION AND DRAINGAGE OF GREEN ROOF FOR LEISURE CENTRE LOCATED IN HRONOV	Study Program	LWM
Enclosure No. 7: Micro Sprinkler Detail	Date:	April 2013
	Scale:	1 : 30



DIPLOMA THESIS	CZECH UNIVERSITY OF LIFE SCIENCES IN PRAGUE FACULTY OF ENVIRONMENTAL SCIENCES DEPARTMENT OF WATER RESOURCES AND ENVIRONMENTAL MODELLING	
Prepared by: Bc. Milan Kubeček		
IRRIGATION AND DRAINGAGE OF GREEN ROOF FOR LEISURE CENTRE LOCATED IN HRONOV	Study Program	LWM
Enclosure No. 8: Surplus Water Flow to the Urban Sewage System	Date:	April 2013
	Scale:	1 : 20

Attachment 9: MIROSEP 6000

Figure 1:

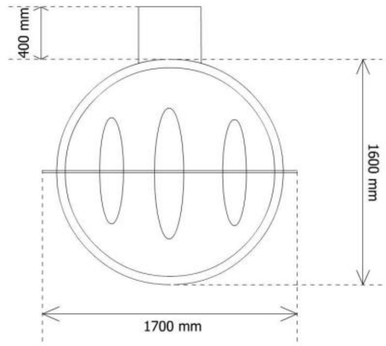
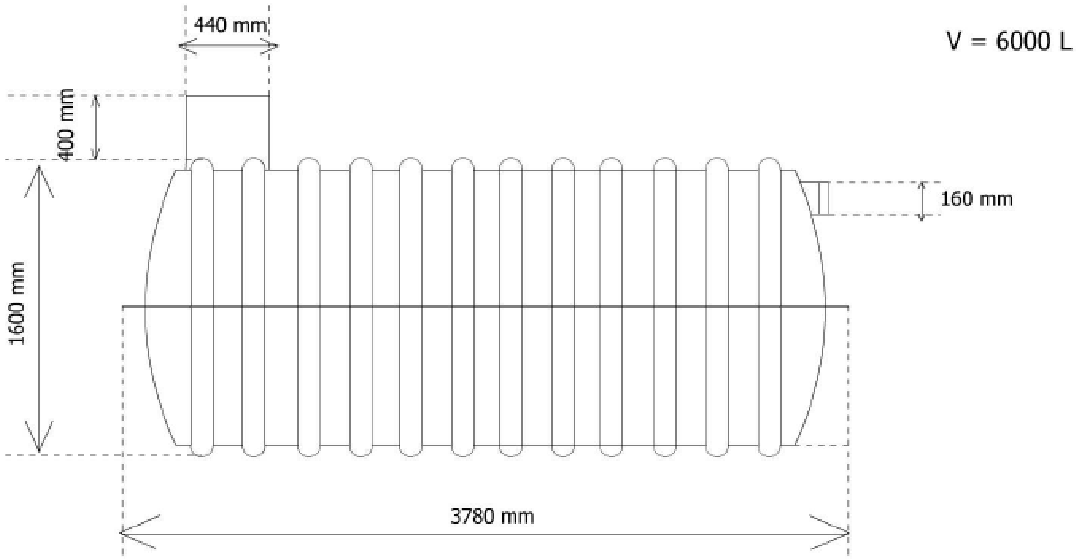


Figure 2:



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FACULTY OF ENVIRONMENTAL SCIENCES
DEPARTMENT OF WATER RESOURCES AND ENVIRONMENTAL MODELLING</td></tr>
<tr><td>Prepared by: Bc. Milan Kubeček</td></tr>
<tr><td>IRRIGATION AND DRAINAGE OF GREEN ROOF FOR LEISURE CENTRE LOCATED IN HRONOV</td><td>Study Program</td><td>LWM</td></tr>
<tr><td rowspan="2">Attachment 9: MIROSEP TANK</td><td>Date: 22.4.2013</td><td>April 2013</td></tr>
<tr><td>Scale:</td><td>1 : 50</td></tr>
</table>

Attachment 10

Figure 10.1 KOPRO JET 100A(a), 60 l, 230 V

Max. manometric head 45m

Min -max. flow rate (Q)=0 - 3,2m3/h = 53 l/min

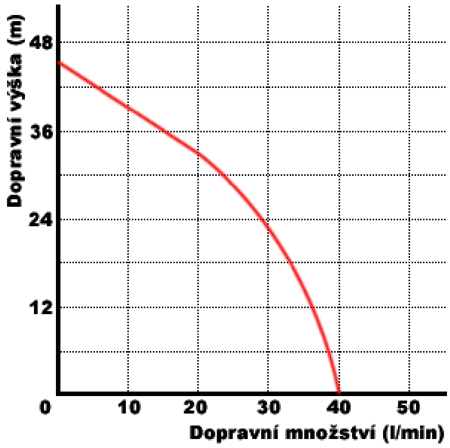
Engine power 0,75kW

(KOPROJET;2013)

Parameters:

- Dimensions: 373 x 182 x 199 mm
- Weigth: 33 kg
- Suction/ discharge port: 1" / 1"
- Voltage/ Frequency: 230V / 50Hz
- Delivery head: max. 45 m
- Delivery: 3,2 m3/h = max. 53 l/min
- Suction head: max. 8 m
- Performance/ electricity: 750W / 3,4A
- Pressure standby mode for control unit
- Length of cable: 1,5m
- Suction port DN 1“
- Volume of the pressure tank: 60l
- Regulation of flow rate: Pressure switch

Figure 10.2 Manometric head



(KOPROJET;2013)

http://www.sos-shop.cz/sos/eshop/14-1-CERPADLA/0/5/1853-povrchove-cerpadlo-JET-100-A-a-230V-cerpadlo-horizontalni

Attachment 11a

For the roof was chosen Xeri pop micro sprinkler from the manufacturer Rain Bird. This micro sprinklers will be placed 0.12 m under the substrate surface and by turning on the head with nozzle will pop up over the surface. On the head of the micro sprinkler can be placed a variety of nozzles (description in Attachment 11b,c).

Figures 11a 1-4**:** RAIN BIRD XERI POP XP 400 X

Xeri-Pop Micro-Spray

Micro Spray Pop-Ups

The Xeri-Pop micro-spray makes it easy to integrate a durable micro-spray into a low-volume drip irrigation design.

The only pop-up spray that works in low-volume low-pressure application, and this is the perfect solution to vandal-prone areas.

Xeri-Pops can be installed and located in nearly any location and are ideal for small, odd-shaped planting beds; the 12" version is perfect for annual flower beds.

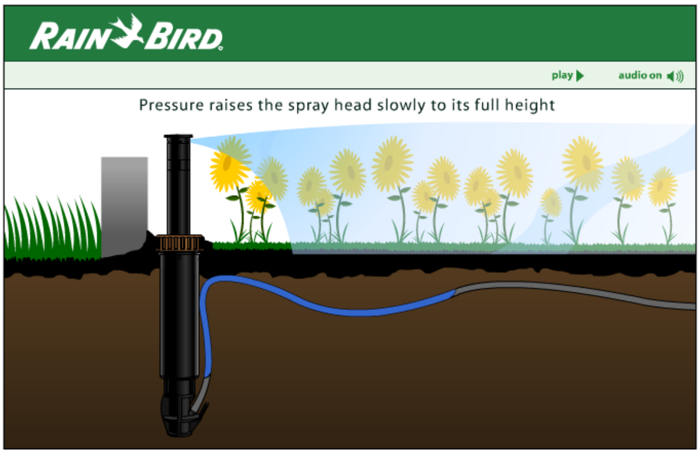
The Xeri-Pop can operate with 20 to 50 psi base pressure when water is supplied via 1/4" Distribution Tubing (XQ).

The flexibility of 1/4" tubing allows the Xeri-Pop to be easily located and relocated as planting conditions dictate.

A durable, plastic snap-collar (on 4" and 6" models) secures the 1/4" tubing to the outside of the Xeri-Pop case.

The Xeri-Pop's 1/4" Distribution Tubing can readily connect to 1/2" or 3/4" polyethylene tubing or to a multi-outlet manifold (EMT-6XERI). Connections to polyethylene tubing are accomplished with either an SPB-025 1/4" Self-piercing barb Connector or an XBF1CONN 1/4" barb Connector.

External parts are UV-resistant and available in 4", 6" and 12" pop up heights.

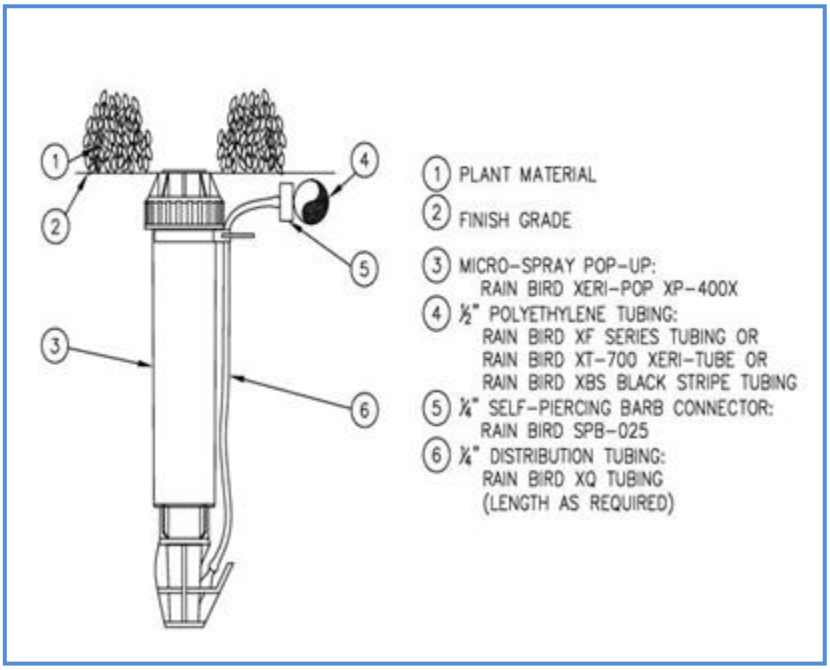


(Rainbird; 2013)

http://www.rainbird.com/landscape/products/dripEmission/XeriPopMicroSpray.htm

Enclosure 11b

Figure. 11b.1 Rain Bird Pop Up XP 400 X



http://www.rainbird.com/support/XeriPop/xeripop_demo.htm

Selected Rotary Nozzles

Figure 11b.2 Rain Bird Rotary Nozzles R13-18H

Description: 0.60 in/hr precipitation rate from 13 to 24 feet. Rotary Nozzles provide unsurpassed design flexibility and highly efficient water distribution from 13 to 24 feet. Rain Bird Rotary Nozzles help reduce water waste and make it easier to design systems. The Rotary Nozzle is a truly remarkable innovation with a low precipitation rate, highly uniform distribution, and increased radius range, all in a nozzle which fits on a Rain Bird spray head.

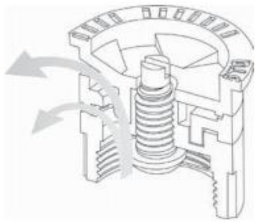
	1,4	4,0	0,2	19	22
	1,7	4,3	0,22	18	21
	2,1	4,8	0,24	15	18
	2,4	5	0,26	15	18
	2,8	5,2	0,28	15	18
	3,1	5,4	0,29	15	18
	3,4	5,5	0,31	15	18
	3,8	5,6	0,33	15	18
	1,4	4,0	0,15	19	22
	1,7	4,3	0,16	18	21
	2,1	4,8	0,18	15	18
	2,4	5	0,19	15	18
	2,8	5,2	0,21	15	18
	3,1	5,4	0,22	15	18
	3,4	5,5	0,23	15	18
	3,8	5,6	0,24	15	18
	1,4	4,0	0,1	19	22
	1,7	4,3	0,11	18	21
	2,1	4,8	0,12	15	18
	2,4	5	0,13	15	18
	2,8	5,2	0,14	15	18
	3,1	5,4	0,15	15	18
	3,4	5,5	0,16	15	18
	3,8	5,6	0,24	15	18

http://www.rainbird.com/landscape/products/sprayNozzles/rotaryNozzles.htm

Enclosure 11c:

Figures 11c. 1-4 U-10 Series Spray Nozzles

Description: U-Series Nozzles are uniquely designed to provide even coverage throughout the spray pattern, ensuring uniform watering, leaving you with a beautiful lawn and garden. U-Series Nozzles are designed to be used with all Rain Bird® spray head sprinklers. U-Series Nozzles are available in a variety of spray patterns to meet your lawn's diverse watering needs.



U-Series Nozzles deliver a second stream of water close-in around the sprinkler head significantly reducing brown spots close to the spray head. They efficiently provide even coverage throughout the spray pattern, which reduces watering times, saving you water and money.

Tryska	bar	m	m³/h	■ mm/h	▲ mm/h
U-10F	1,0	2,1	0,24	52	60
	1,5	2,4	0,30	47	55
	2,0	3,0	0,31	41	48
	2,1	3,1	0,37	40	46
U-10H	1,0	2,1	0,12	52	60
	1,5	2,4	0,15	47	55
	2,0	3,0	0,15	41	48
	2,1	3,1	0,19	40	46
U-10Q	1,0	2,1	0,06	52	60
	1,5	2,4	0,07	47	55
	2,0	3,0	0,08	41	48
	2,1	3,1	0,09	40	46

(Rain Bird;2013)

Image 1-4:http://www.rainbird.com/homeowner/products/sprays/USeriesnozzles.htm#.UVry2Rd9CJQ

Attachment 12: Drip Irrigation Kit

Figures 12.1-2 Patio Plant Watering Kit

Drip Irrigation System

Rain Bird's Patio Plant Watering Kit is an easy and convenient way to get your plants watered and keep them looking healthy.

Rain Bird's Patio Plant Watering Kit helps to produce longer lasting blooms, greener leaves, and a healthier plant life. It eliminates watering by hand to make it easier for you to get your plants watered. It gives direct watering for up to 10 planters. Easy to assemble kit allows you to just cut and connect to your outdoor faucet.

Each Kit Contains:

- (1) Pressure Regulator with 1/4" Tubing Adaptor
- 25 feet of 1/4" Tubing
- (10) 1/4" Stakes with Bug Caps
- (2) 1/4" Barbed couplings
- (10) Tubing mounting clips
- (5) Spot watering emitters 2 GPH
- (8) 1/4" barbed tees
- (5) Spot watering emitters 1GPH
-

Table 12.1 Irrigation of shrubs: Rosa pimpinellifolia and Amelanchier ovalis

Plant	Time		
	Cool Climate	Warm/Humid Climate	Hot/Arid
Small Pots	10 min./week	15 min./week	30 min./week
Large Pots	15 min./week	30 min./week	45 min./week
Small Shrub (3 ft.)	15 min./week	30 min./week	1 hour/week
Large Shrub (6 ft.)	45 min./week	1.5 hours/week	2 hours/week
Small Trees (10 ft.)	3 hours/week	5.5 hours/week	8 hours/week
Large Trees (20 ft.)	11 hours/week	22 hours/week	32 hours/week

(Rain Bird;2013)

Images 1-3: http://www.rainbird.com/homeowner/products/drip/PatioPlantWateringKit.htm#.UVsVfhd9CJR

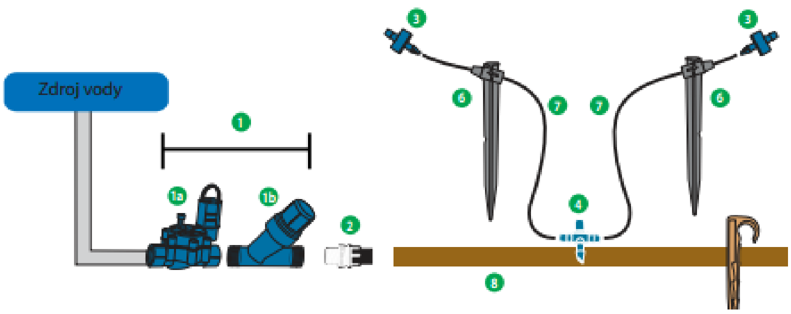
Attachment 13

DRIP IRRIGATION

In each pot two drippers will be placed to ensure proper irrigation of the whole pot area. This scheme helps by the completing of the entire drip system.

The entire drip system starts with gate valve beyond P4 pipe. We start placing BF-3 T pieces in the closest vicinity of pots with shrubs. Later on spaghetti tubes are connected to BF3 T pieces and placed into pots with spikes stuck into the soil. On the end of spaghetti tubes drippers are placed.

Figure 13.1 **Drip irrigation structure and connection process**



1 - Control Zone Kit
1a: Low flow-valve
1b: Pressure Compensation Filter
2 – Lock Fitting 16 mm Union Coupling
3 – Xeri-Bug Emitter
4 - BF3 T-piece Tubing Stake 4-6 mm
6 - Spike TS-025 for 6 mm Tubing Stake
pipeline
7 – DT -4 – 6 mm Distribution Tubing
8 - PX pipe without drippers

Figure 2: Making holes on P_D tube

Figure 3: Connection with no BF-3 T

Images 1 - 3: http://www.rainbird.com/homeowner/support/catalog.htm

Attachment 14: Control Zone Kit

Figure 14.1 Control zone kit

LOW FLOW VALVE

Control Zone Components

- The only valves in the industry made specifically for drip irrigation systems, making these the only valves that can effectively handle particles at low flow rates (45,4 to 1136 liters/hour).
- These valves contain all of the features of Rain Bird's reliable DV valve, coupled with a unique diaphragm design that allows particles to pass through at extremely low flow rates, thereby preventing weeping of the valve
- Allows the filter to be safely placed downstream of the valve since these valves handle all sizes of particles


LFV-075

SPECIFICATIONS

Flow : 45,42 to 1136 liters/hour
Pressure : 1,0 to 10,3 bars

ELECTRICAL SPECIFICATIONS

24 VAC 50/60 Hz (cycles/sec) solenoid
Inrush current : 0.30 (7.2 VA) at 60 Hz
Holding current : 0.19 A (4.56 VA)

Friction Loss Characteristics

Flow, l/hr	Flow, l/s	LFV-075, bars
45,42	0,01	0,19
227	0,06	0,19
454	0,13	0,24
908	0,25	0,26
1362	0,38	0,30
1817	0,50	0,36

PRESURE-REGULATING FILTERS

- The Pressure-Regulating (P/R) Filter reduces the number of components in a control zone, making it smaller and easier to install. More control zones can fit in one valve box !
- Combination unit reduces the number of connections, making installation easier and saving time.
- The P/R Filter provides increased reliability--fewer parts and fewer threaded connections mean less chance of a leak both at installation and also over the life of the system.

SPECIFICATIONS

Pressure: 1,4 to 10,3 bars
Flow:
3/4" units: 114 to 1136 liters/hour
1" units: 681 to 3407 liters/hour
Filtration: 75 microns

Friction Loss Characteristics

Flow l/hr	PRF-075-RBY bar	PRF-100-RBY bar
45	0,21	N/A
227	0,28	N/A
681	0,42	0,06
1136	0,69	0,14
1817	N/A	0,26
2271	N/A	0,36
3407	N/A	0,83

http://www.pipelife.si/media/si/pdf/Rainbird/arrosage_en.pdf

Attachment 15:

Figure 15.1 Tube

BLANK TUBING
16 mm Distribution Tubing

APPLICATIONS
- 16 mm flexible pipe used in drip irrigation system to attach emitters or 16 mm tubing or Dripline.
- High UV resistance and 100% Crack-resistant
- Resists kinks and damage caused by routine landscape maintenance activities
- Important: Do not use any lubricant (grease, soap, oil, etc)

BLANK BLACK TUBING

SPECIFICATIONS
- UV-resistant low-density polyethylene material
- One layer
- Black color
- Operating water pressure rating: up to 4 bar
- 100% crack-resistant
- UVA-resistant. Black carbon = 2%
- Accepts any Rain Bird 16 mm barb insert fitting and universal fittings and lock type fittings

MODELS
DBL025: Blank Drip Tubing Black 25 m coil
DBL050: Blank Drip Tubing Black 50 m coil
DBL100: Blank Drip Tubing Black 100 m coil
XFD1600: brown blank tubing, 100 m coil
XFD160050: brown blank tubing, 50 m coil
XFD160025: brown blank tubing, 25 m coil

DIMENSIONS
External diameter: 16 mm
Internal diameter 13,7 mm
Wall thickness: 1,15 mm

http://www.pipelife.si/media/si/pdf/Rainbird/arrosage_en.pdf

Figure 15.2 Tools

XM-TOOL
Installation Tool

APPLICATIONS
Used to install Rain Bird low volume irrigation components such as self-piercing emitters with or without 4-6 mm distribution tubing and goof plugs into drip tubing. Also used to easily remove installed emitters.

MODEL
XM-TOOL: Installation tool

T135SS
Tubing Cutter

APPLICATIONS
Designed for easy and clean cutting of all distribution tubing used in low volume irrigation installations.

SPECIFICATIONS
Length: 21,5 cm

MODEL
T135SS : tubing cutter

EMA-GPX
Tubing Goof Plug

APPLICATIONS
Used to plug any unwanted holes made while inserting self-piercing emission devices into 13-16 mm tubing.

MODEL
EMA-GPX plug

http://www.pipelife.si/media/si/pdf/Rainbird/arrosage_en.pdf

Attachment 16

Figure 16.1 Controller and rain sensor

WP SERIES: WP 2, WP 4,

Electronic Battery-Powered Controller
Multi-station Battery-operated Line

- Battery-powered : operates with 2 top-grade 9V alkaline batteries such as Varta type 6AM6 (international standard) or 6LR6I (European standard). Batteries not included.
- Resists humid and harsh environments, Rated IP68: 100% waterproof and fully submersible.
- Outdoor / indoor wall mount or directly in a valve box.

FEATURES

- **Easy to install and to program**
  - Compact size.
  - Easy-to-understand LCD display with iconbased design.
  - Ergonomic 5-touch keypad.
  - Manual station or cycle start capacity.
  - Three independent programs provide versatile irrigation control.

  Operating temperature: -20° to 70° C

ELECTRICAL SPECIFICATIONS

Operates with 2 9V alkaline batteries.
Compatible with all Rain Bird valves equipped with a Rain Bird latching solenoid.
Station capacity: 1 Rain Bird latching solenoid per station plus a latching solenoid equipped master valve.
Maximum distance between the controller and a latching solenoid using wire sized 1,5mm²: 30 m
Can be directly connected to the RSD-BEx Rain Sensor.

RSD-BEX

Rain Sensor

APPLICATIONS

The RSD Series Rain Sensor is a rain sensor device suitable residential and commercial applications. It saves water and extends irrigation system life by automatically measuring precipitation and keeping irrigation systems from watering in rainy conditions.

FEATURES

- Works with all 24 VAC controllers and TBOS™ products equipped with the TBOS™ Rain sensor interface
- Multiple rainfall settings from 3.2 to 20 mm are quick and easy with just the twist of a dial
- Adjustable vent ring helps control drying time
- High-grade, UV resistant polymer body resists the elements
- Rugged aluminum bracket and arm extend a full 15.2 cm
- 7.6 m of UV resistant extension wire offer an easy connection to irrigation controllers

SPECIFICATIONS

Not recommended for use with high voltage circuits or devices.
Switch electrical rating: 3A @ 125/250 VAC
Capacity: Electrical rating suitable for use with up to three 24 VAC, 7 VA solenoid valves per station, plus one master valve
Includes 7.6 m conductor extension wire (2 x 0.5mm²)

DIMENSIONS

Length: 16.5 cm
Height: 13.7 cm

MODEL

RSD-BEx

http://www.pipelife.si/media/si/pdf/Rainbird/arrosage_en.pdf

Attachment 17: Armatures, fittings and other components

PE ¾“ BEND 90°

Mounting bracket for PE tube D 3/4“

Reduction inlet 1“- ¾“

Extension inlet ¾“ – 1“

Gate valve DN 6

Bend 90° Reduction 1“ - 3/4“

BL – T Reducing 3/4“×2/4“×3/4“

BL-T 3/4“×1/4“×3/4“

www.zavlahy-pokorny.cz

Attachment 18:

Figure 18.1 Strainer

http://obchod.pumpa.cz/

Strainer is coupled with the suction switch valve for installation in vertical suction pipe. It is designed for pumping of drinking water or utility water without impurities to a maximum temperature of 60 ° C. Strainer is made of plastic parts with high mechanical strength and durability. Connection with tube DN 1“.

Drip irrigation system header

Fertilizer injector Model AFI 5016-HV ¾“

It has pint capacity, with ¾” female x male hose threads. It can be easily attached to a hose bib or garden valve.

Includes:

Vacuum Breaker (backflow preventer)
Fertilizer Injector (pint capacity)
Filter (stainless steel element)
Pressure Regulator (preset at 19 PSI)
¾” PVC Adaptor Fittings

Figure 18.2 Drip irrigation system header

www.greenroofs.com

Attachment 19: Components

Fig. 19.1 Montage bracket FGRS Plus   Fig.19.2 Anchor angle 40×160/60

(Samontec; 2013]

www.obchodprodilnu

Fig.19.3-5 PVC Bend KGB 160/87° GEM 160x1500mm   Reduction KGR 160/110

http://www.eshop-koupelny-topeni.cz/koleno-kgb-160-87st/

Attachment 20: Material and Price list

TYPE	MODEL DESCRIPTION	PRICE PER UNIT/PIECE	NUMBER OF PIECES/UNITS	TOTAL PRICE
WP9-2	Rain Bird Controller WP-2, 2 * 9V	3550,00,-	1	3550,-
R13-18H	Rain Bird Rotary Nozzles	225,00,-	3	675,-
U10-H	Rain Bird U-Series Nozzles	62,00,-	3	186,-
Rain Bird's Patio Plant Watering Kit	Rain Bird's Patio Plant Watering Kit	459,00,-	2	918,-
LFV-075	Rain Bird Low flow valve	1185,00,-	1	1185,-
PRF-075-RBY 3/4" RBY	Rain Bird Pressure regulating filter	345,00,-	1	345,-
DBL025 6 mm	Rain Bird Blank Drip Tubing Black 25 m	295,-	1	295,-
BF 82-50	Rain Bird Lock type Fittings	9,80,-	1	9,80,-
BF 12 Plug	Rain Bird Quick Union Coupling	6,70,-	1	6,70,-
PE 25 Black	TB P/m	16,55,-	2	33,1,-
PE 20 Black	TB P/m	13,22,-	11	145,42,-
PVC 16 Black	TB P/m	11,60,-	5	58,-
PVC 12 Black	TB P/m	10,32,-	5	51,6,-
PVC 6 Black	TB P/m	9,46,-	12	113,52,-
BL - T	3/4" - 1/4"	32,52	2	65,04
BL - T	3/4" - 1/2"	34,9	2	69,8
GT 6	Gate valve 1/4"	26,14,-	1	26,14,-
XM-Tool	RB Drip I. Installation Tool	56,-	1	56,-
T135SS	RB Drip I. Tubbing Cutter	29,-	1	29,-
EMA-GPX	Tubing Goof Plug	6,7	3	20,1
Filter mesh 170*170	100 Micron	569,-	6	3414,-
Varta Industrial Alkaline	Alkaline Battery 9V	39,-	4	39,-

RSD-BEX	Rain Sensor	1199,-	1	1199,-
KOPRO JET 100A(a), 60 l, 230 V	Pumping unit	5 145,-	1	5 145,-
MIROSEP 6000	MIROSEP jímka na dešťovou vodu	22 700,-	1	22 700,-
Drip irrigation system header	Drip rite irrigation	682,5.-	1	682,5,-
SKP 1 - PVC, fittings	Indutrial Strainer and fittings	138,-	1	138,-
BF 685	Rain Bird Valve 16 x 16	31,-	1	31,-
Pop up XP 400 X	Rain Bird Pop up micro sprinkler	569,-	6	3414,-
Optigrun M Type	Substrate	399,-	22	8778,-
Armatur Bend 45°	PE 20 Bend 90°	31,20,-	5	156,-
Armatur Bend 45° reducer	PE 25 -20 Bend 90°	34,5	1	34,5,-
Anchored Angle	Anchored angle 40*160/60	17,17	17	291,89
Screws	Screw with countersunk head 5,0x020	0,32	200	64,-
Dowel	Dowel Type 5	0,26	200	52,-
FFGRS Plus 3/4"	Two screw braket 3/4"	6,5	3	19,5
Ekoplast 806	Folie - grey	154,-	5	770,-
PVC Bend KGB 160/87°	Drainage Bend	68,-	1	68,-
Pipe GEM 160x1500mm	Drainage tube	341,-	1	341,-
AFI 5016-HV ¾“	DI header	541,-	1	541,-
Optigrun FKD 40	Drainage layer P/m2	23,73,-	78	1851,-
Optigrun RMS 300	Drainage layer	3,45,-	78	269,1,-
Optigrun 105	Drainage layer	6,42,-	78	500,8,-
Reduction KGR 160/110	Drainage reducer	58,-	1	58,-
OC 159,0/4,5, 1m Thermoquell	Drainage tube	727,-	1	727,-
Amelanchier ovalis	50 cm high	45,-	7	315,-
Euphorbia Polychroma	30 cm high	25,-	3	75,-
Hypericum Perforatum	30 cm high	15,-	3	45,-
Pulsatilla Vulgaris	55 cm high	25,-	3	75,-

Rosa pimpinellifolia	30 cm high	56,-	6	336,-
Rosenschleier	30 cm high	35,-	3	105,-
Aster Sedifolius "Nanus"	30 cm high	15,-	3	45,-
Dictamus Fraxinella	30 cm high	15,-	3	45,-
Geranium Sanguineum	30 cm high	19,-	3	57,-
Hypericum polyphyllum	30 cm high	15,-	3	45,-
Iris Germanica	30 cm high	25,-	3	75,-
Levandula angustifolia	30 cm high	25,-	3	75,-
Purpuro Caerulea	30 cm high	23,-	3	69,-
Salvia Nemorosa	30 cm high	19,-	3	57,-
Thymus Serphyllum "Coccineus"	30 cm high	15,-	3	45,-
Verbascum thabsus	30 cm high	25,-	3	75,-
Helictotrichon Sempervirens	30 cm high	23,-	3	69,-
Festuca Amethystina	30 cm high	25,-	3	75,-
		SUM TOTAL CZK:		60.805,52,-

Attachment 21 Photodocumentation

Southern side (foto: Author)

View from the roof top (foto: Author)

Northern side (foto: Author)