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WATER SUPPLY NETWORK EXPANSION IN THE COMMUNE OF MŚCIWOJÓW AS RELATES TO THE PILOT PROJECT VITAL LANDSCAPES

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Summary

This article presents the analysis of the water supply system expandability in the commune of Mściwojów. Such necessity of the expansion resulted from the locations of the new investments covered by the pilot program VITAL LANDSCAPES. Hydraulic calculations, covering two possible solutions, have proven that the existing water supply network is sufficient now and will be sufficient in the near future (after expansion), in supplying all the consumers with water.

Keywords

rural water supply • expansion • concept

1. Introduction

In the design process for a water supply network, one has to keep in mind that it has to be able to deliver water to all the consumers at all times, with proper pressure, quantity and quality. On the other hand, a properly designed network should be simple to expand, in the future. This is not easy, in terms of a rural water supply systems which are quite different from urban solutions. Rural solutions are unique because of basic rural and small-town spatial management practices. These differences include the extent of the water supply network in rural areas, which are uniquely different from the urban configuration. The fact that the system is branchy is a result of the scatter of buildings. The water supply usage is also different. A typical village uses water for the purposes of:

- living needs of the people,
- keeping the households,
- livestock,
- watering crops and green spaces,
- washing cars, agricultural vehicles and machinery,

- diluting chemical plant protection products (fertilizers),
- other, e.g. construction works.

The diversity of needs and the fact of well water use after connecting the households to the water supply system make it difficult to assume a proper value of a required water unit in the water supply design process. This is especially difficult, as the values in the literature range from 50 to 260 $dm^3 \cdot M^{-1} \cdot d^{-1}$ [Pawełek and Bergel 2004]. Based on the research on water demand, in 426 water supply systems in various rural areas, it has been proven that the demand is about 81 $dm^3 \cdot M^{-1} \cdot d^{-1}$ [Bergel 2013]. The similarity of this value to the one given by the Regulation of Minister of Infrastructure [Rozporządzenie... 2002b] means that in the absence of design guidelines administering the current standards of water consumption, the Regulation should be used for the design purposes of water supply systems in the analyzed communes.

The problem of assuming the proper value of water usage in a given area is very serious. If an incorrect value is assumed, the investors and the future users will have to cope with many inconveniences, such as:

- higher construction and usage costs,
- unsatisfactory work of the water supply devices,
- too low flow rate, resulting in recontamination of water.

The aim of the study is the analysis of expandability of water supply system in the rural commune of Mściwojów. This has been planned in part due to the investments connected with the realization of the pilot project VITAL LANDSCAPES [Project no. 2CE164P3]. These investments include future construction of: an orangery, a hotel with a restaurant, a stud farm with a recreational area, a vineyard with a restaurant and a housing estate on the left side of the water reservoir.

2. Material and methods

The commune of Mściwojów is located in the Lower Silesia and is part of the Jawor district consisting of six communes. It comprises of 12 villages, inhabited by 4170 people. All of these villages are supplied by three collective water supply systems, two of which are located in the commune. The water supply "Grzegorzów" covers the villages of: Grzegorzów, Mściwojów, Niedaszów, Zimnik, Siekierzyce, Snowidza and Barycz. The water supply "Targoszyn" covers the villages of: Targoszyn, Luboradz, Marcinowice and Drzymałowice. The third system, supplying the village of Godziszowa is located outside of the commune, in the city of Jawor. All of these water supplies use underground waters.

Based on the data provided by the Zakład Gospodarki Komunalnej (ZGK, Department of Public Utilities) in Mściwojów, it has been stated, that the water supply system, whose net length is 44 677km (made of PVC pipes), supplies 100% of the inhabitants of the commune. The average water usage per person is 90 $dm^3 \cdot PM^{-1} \cdot d^1$

and the same value was assumed for later calculations of the supply network. Due to the specifics of the planned investments, it was necessary to calculate all the demands that can result from them. The calculations used the average normal water usage given in the Regulation issued by the Minister of Infrastructure [Rozporządzenie... 2002b]. The number of units was assumed based on the information given by the design team of the investment mentioned above, which is an integral part of the project VITAL LANDSCAPES [Project no. 2CE164P3].

The concept of water supply system expansion is scheduled for the perspective of the year 2030. The existing network was hydraulically tested, based on the data acquired from the municipal office in Mściwojów and the investment requirements, existing networks of individual sub-systems of water supply and developed in conjunction with planned investments Grzegorzów water supply system were tested hydraulically (variant 1). To increase the reliability of the water supply and to ensure the fire safety of the hotel, the restaurant as well as the stud farm, it was suggested that the Grzegorzów system be connected with the Targoszyn system (variant 2). Special calculations were made for this newly expanded system, using the software developed by the Department of Sanitary Engineering and Water Management in the University of Agriculture in Krakow, based on a well-known and widely used in the calculation of water supply – Cross method.

3. Analysis of study results

In the concept of development of the water supply system expansion, the future demographic changes have to be taken into account. This is the reason why the individual demographic growth indexes were calculated for particular villages in the commune, based on the population of the last 10 years. With this information, the characteristic water usage indexes were calculated for particular water supplies and villages (Table 1). For villages with a negative population growth index, the populations of the year 2011 were assumed.

According to the legal documentation for water intake for the Targoszyn water supply, the maximal hourly demand should not exceed 12.22 $dm^3 \cdot s^{-1}$ and the average daily intake should not exceed 290 $m^3 \cdot d^{-1}$. According to Table 1, the water demand for the location in question is respectively 9.36 $dm^3 \cdot s^{-1}$ and 268.58 $m^3 \cdot d^{-1}$. After comparing the hourly demands, it can be stated that the Targoszyn water supply has a surplus of 2.86 $dm^3 \cdot s^{-1}$.

In case of Grzegorzów water supply, we have the following values: maximal hourly demand of 11.11 $dm^3 \cdot s^{-1}$ (for the perspective: 9.09 $dm^3 \cdot s^{-1}$) and the average daily demand of 290 $m^3 \cdot s^{-1}$ (for the perspective: 272.84 $m^3 \cdot d^{-1}$). This means that this water supply also has a surplus, which is equal to 2.02 $dm^3 \cdot s^{-1}$.

The investments that are a part of the VITAL LANDSCAPES project, will be located in the area supplied by the Grzegorzów water supply. Comparison of the surplus of maximal hourly demand (2.02 $dm^3 \cdot s^{-1}$) with the calculated water demand of the investment (1.96 $dm^3 \cdot s^{-1}$) shows that this water supply is sufficient to fulfill

the needs presented in Table 2 (variant 1). The proximity to balance zero, of the calculated reserve equal 0.06 dm $^3 \cdot s^{-1}$ is completely accidental. The calculations of water demand for the whole water supply system in Mściwojów (Table 1) takes into account the losses which are relatively large for a water supply systems, more than 17% on average. Even a slight reduction of losses for example, by renovation of the most subject to failure sections of the water supply system, will lead to a greater guarantee of fulfilling the water demand.

Table 1. The characteristic indicators of water consumption in the Mściwojów community (year 2030 perspective)

ID	Village	Population	Water demand			
			Average daily [$m^3 \cdot d^{-1}$]	Maximal daily [$m^3 \cdot d^{-1}$]	Maximal hourly	
					[$m^3 \cdot h^{-1}$]	[$dm^3 \cdot s^{-1}$]
Water Supply "Grzegorzów"						
1	Snowidza	1093	116.80	157.66	12.59	3.50
2	Barycz	65	6.93	9.35	1.35	0.38
3	Mściwojów	413	56.83	73.44	6.60	1.83
4	Grzegorzów	172	18.32	24.69	2.51	0.70
5	Niedaszów	306	32.40	43.75	3.94	1.09
6	Zimnik	204	27.44	35.58	3.65	1.01
7	Siekierzyce	132	14.13	19.03	2.09	0.58
Total		**2385**	**272.84**	**363.50**	**32.73**	**9.09**
Water Supply "Godziszowa"						
8	Godziszowa	314	33.40	45.05	4.05	1.12
Total		**314**	**33.40**	**45.05**	**4.05**	**1.12**
Water Supply "Targoszyn"						
9	Targoszyn	975	200.45	245.19	24.73	6.87
10	Marcinowice	247	28.58	37.98	3.64	1.01
11	Drzymałowice	129	13.81	18.60	2.06	0.57
12	Luboradz	242	25.74	34.72	3.27	0.91
Total		**1593**	**268.58**	**336.49**	**33.70**	**9.36**
TOTAL		**4292**	**574.82**	**745.04**	**70.48**	**19.57**

Table 2. Water demand calculations of the planned investments

ID	Specification	Number of units	Water demand				
			Standard unit [$dm^3 \cdot j^{-1} \cdot d^{-1}$]	Average daily [$m^3 \cdot d^{-1}$]	Maximal daily [$m^3 \cdot d^{-1}$]	Maximal hourly	
						[$m^3 \cdot h^{-1}$]	[$dm^3 \cdot s^{-1}$]
1	Three star hotels	200	100.0	20.00	22.00	2.75	0.764
2	Restaurants, cafes	300	25.0	7.50	8.25	0.86	0.239
3	Bussines (1 or 2 employees)	62	25.0	1.55	1.71	0.21	0.059
4	Orangery	100	4.0	0.40	0.40	0.02	0.005
5	Flowers	200	3.0	0.60	0.60	0.03	0.007
6	Horses	50	55.0	2.75	4.13	0.52	0.143
7	Sheep and goats	10	9.0	0.09	0,12	0.01	0.004
8	Agricultural machinery	5	10.0	0.05	0.06	0.00	0.001
9	Vineyard	18 665	1.5	28.00	30.80	2.57	0.713
10	Cars	3	25.0	0.08	0.08	0.01	0.002
11	Trucks	3	25.0	0.08	0.08	0.01	0.002
Total				**61.09**	**68.21**	**6.98**	**1.94**
Losses			1%	0.61	0.68	0.07	0.02
Own needs			0%	0.00	0.00	0.00	0.00
TOTAL				**61.70**	**68.90**	**7.05**	**1.96**

Due to the special fire safety regulations of the hotel with a restaurant [Rozporządzenie... 2002a, Rozporządzenie... 2009, Rozporządzenie... 2010], for the computing node (node 40) fire protection equal to 10.0 $dm^3 \cdot s^{-1}$ and the pressure of 2.0 bar (20 m water column) was adopted. These values were used later on to calculate the subsystem of the Grzegorzów and the connected systems of the Grzegorzów and Targoszyn (variant 2).

In the calculations of variant 1, the existing infrastructure was taken into account, including the pumps by the tanks and in the network in Niedaszów, and the reducer in Luboradz. All the hydraulic calculations along with the schemes are published in another study [Pawełek et al. 2012]. The water supply calculations print containing the values of the hydraulic water supply network is shown on Figure 1, while the longitudinal profile of a part of the water supply network along with the pressure line diagram is shown on Figure 2.

WATER SUPPLY CALCULATIONS M S C I W O J O W Commune
QMAX-HOURLY – year 2030 – water supply GRZEGORZÓW
Well supply at node –18 – 9.09 l/s

we press at a pressure of 4.0 at – water supply after expansion (hotel)

NUMBER OF LOOPS = 2
HYDRAULIC CHARACTERISTICS

ODC NR	DIAMETER D MM	ROUGH K MM	LENGTH L M	FLOW RATE Q L/SEK	VELOCITY V M/SEK	LOSS H M	FROM NODE	TO NODE
7	210	0.040	1400.0	2.24	0.06	0.04	[7	8]
8	83	0.040	210.0	0.13	0.02	0.00	[8	9]
9	149	0.040	602.0	0.73	0.04	0.01	[10	11]
10	102	0.040	266.0	0.13	0.02	0.00	[11	12]
11	83	0.040	140.0	0.33	0.06	0.01	[16	17]
12	149	0.040	168.0	1.98	0.11	0.02	[8	16]
13	149	0.040	980.0	–1.42	–0.08	–0.07	[10	16]
14	102	0.040	2408.0	0.37	0.05	0.10	[11	13]
15	149	0.040	182.0	0.46	0.03	0.00	[10	14]
16	102	0.040	560.0	0.23	0.03	0.01	[14	15]
17	210	0.040	50.0	–8.86	–0.26	–0.02	[7	18]
19	210	0.040	770.0	6.62	0.19	0.16	[7	19]
20	102	0.040	1040.0	0.23	0.03	0.02	[19	20]
21	210	0.040	450.0	6.16	0.18	0.08	[19	21]
22	210	0.040	530.0	5.93	0.17	0.09	[21	22]
23	102	0.040	360.0	0.13	0.02	0.00	[22	23]
24	200	0.040	2140.0	5.59	0.18	0.42	[22	24]
25	149	0.040	630.0	3.03	0.17	0.17	[24	35]
26	102	0.040	980.0	0.30	0.04	0.03	[35	36]
27	149	0.040	1540.0	–2.50	–0.14	–0.30	[25	35]
28	149	0.040	110.0	1.72	0.10	0.01	[25	26]
29	149	0.040	1360.0	0.59	0.03	0.02	[26	27]
30	102	0.040	210.0	0.36	0.04	0.01	[27	28]
31	83	0.040	460.0	0.13	0.02	0.01	[28	29]
32	102	0.040	840.0	0.90	0.11	0.16	[26	30]
33	102	0.040	1220.0	1.09	0.13	0.33	[30	31]
34	102	0.040	1160.0	0.23	0.03	0.02	[31	32]
35	102	0.040	350.0	0.59	0.07	0.03	[31	33]
36	83	0.040	310.0	–0.42	–0.08	–0.04	[30	34]
37	102	0.040	1190.0	0.65	0.08	0.13	[25	34]
38	149	0.040	700.0	0.80	0.05	0.02	[24	37]
39	102	0.040	480.0	0.57	0.07	0.04	[37	38]
40	102	0.040	920.0	0.33	0.04	0.03	[38	39]

Caution!!! The (–) sign in hydraulic characteristics means that the water flows from a node with a higher number to a node with a lower number

Fig. 1. Part of hydraulic calculations for water supply "Grzegorzów" (variant 1)

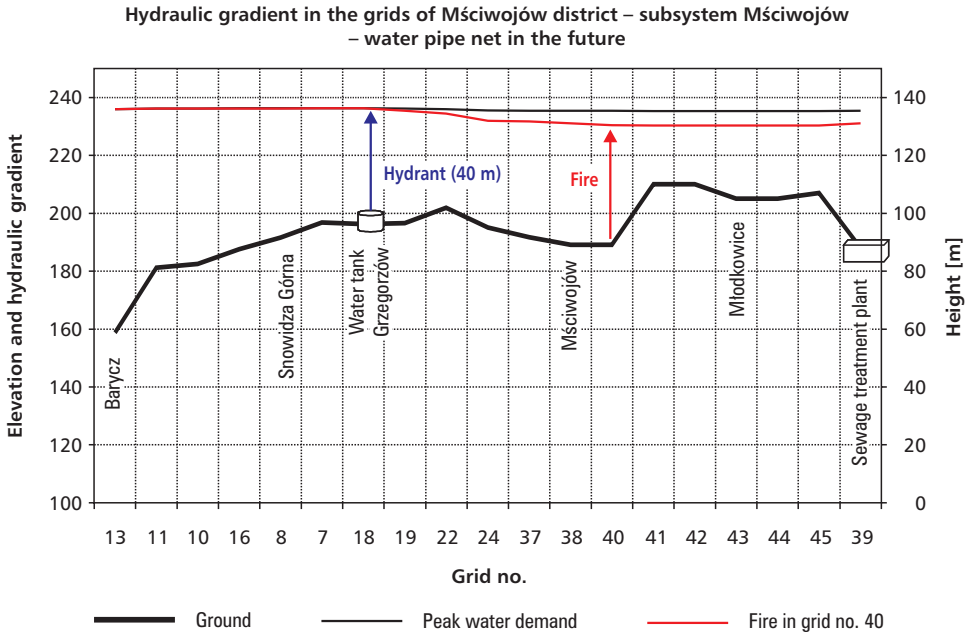
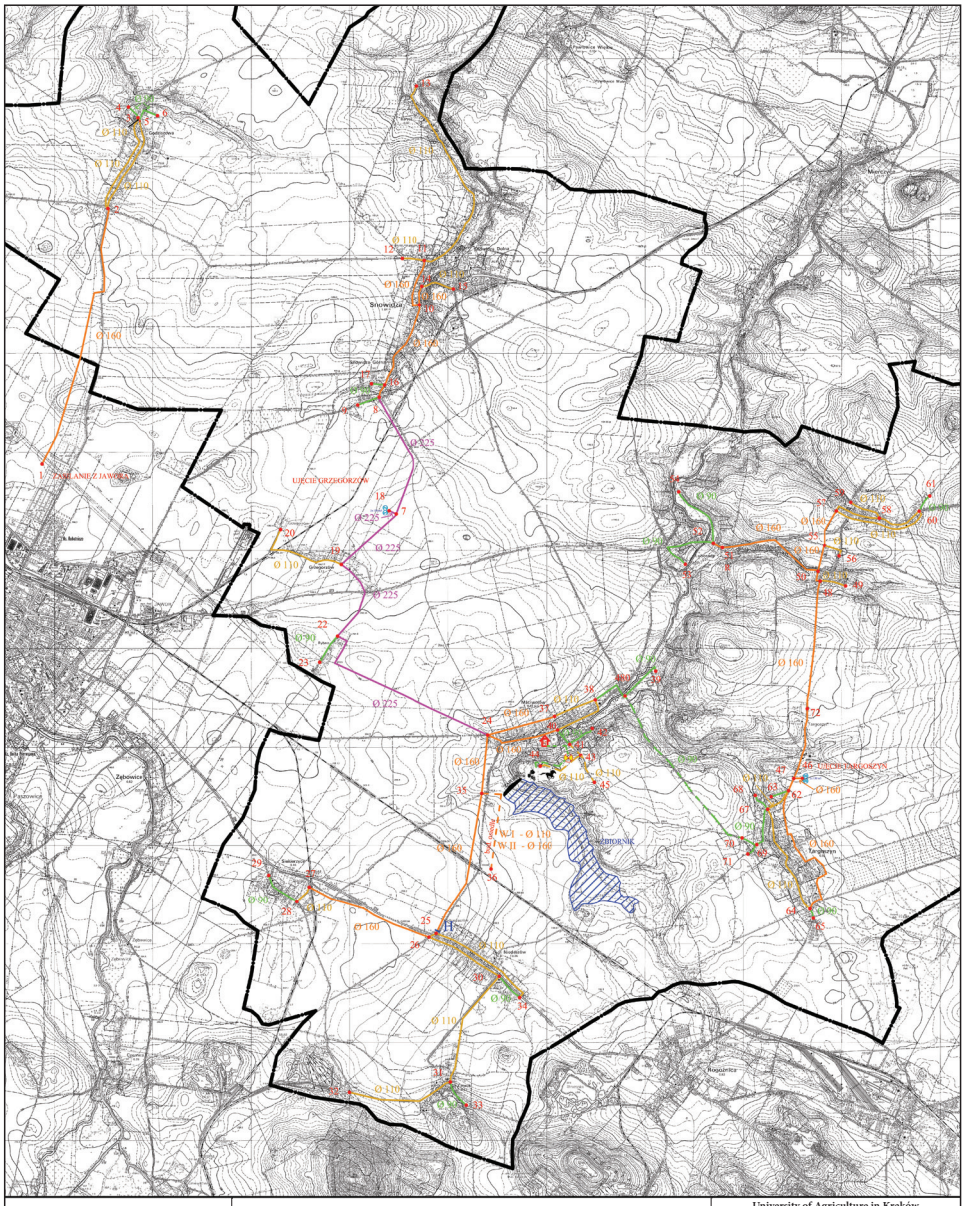


Fig. 2. Longitudinal profile of the network and pressure lines in the Grzegorzów subsystem from node 13 to 39 – state after expansion

Based on the hydraulic calculations above it has been stated that: due to the necessity of supplying the water for the purposes of the planned investments, according to the concept in variant 1, it will be necessary to expand the water supply network with pipeline with a nominal diameter DN 110, whose net length will be 2010 m (sections: 35–36, 41–43, 43–44, 43–45).

Despite the satisfactory results of the hydraulic analysis of variant 1, in terms of covering the demand for water and obtaining the required pressure in the network to increase the reliability of the water supply and to ensure fire safety of the hotel with the restaurant, the stud farm, and the vineyard restaurant. Accordingly to variant 2, the subsystems of Targoszyn and Grzegorzów will be connected. This connection has been made using pipeline DN 90 (section 70–480), 1916 m long. However, it will also be necessary to build pipeline DN 110 (1030 m long, sections 41–43, 43–44, 43–45) and 980 m of pipeline DN 160 (section 35–36). Due to this solution, the total length of water supply network will be equal to 48.603 km (shown on the map).

In order to improve the reliability of the interconnected systems of Targoszyn and Grzegorzów construction of a tank with a capacity of 75 m^3 proposed on the level 205.00 m asl in the immediate vicinity of the node 43. This would be fed with water from the network subsystem Grzegorzów-Targoszyn in an amount of about 0.80 $dm^3 \cdot s^{-1}$. The reservoir would supply water for the stud-farm, vineyard, restaurant and by


SCALE:
1:17 000
0 500 1000 m
LEGEND:
Ø 90 constructed pipeline Ø90
Ø 110 constructed pipeline Ø110
Ø 160 constructed pipeline Ø160
Ø 225 constructed pipeline Ø225
designed pipeline
border of the commune
999 compute node
H hydrophore
R reducer
hotel and restaurant
stud
vineyard and restaurant
fire retention reservoir
retention reservoir
University of Agriculture in Kraków
Department of Sanitary Engineering and Water Management
31-120 Kraków, Al. Mickiewicza 21
Phase: Conception
Figure title: ILLUSTRATIVE MAP Water supply network
Scale 1:17000
Figure number: A
Elaborated: dr inż. Tomasz Bergel, dr inż. Bugajski, dr inż. Jacek Myczka
Elaboration date: June 2012

separate pipeline – the hotel and orangery. Because of the fire safety of the hotel and the orangery, it was suggested that the water for firefighting purposes would also be supplied from this tank. The solution of the water supply system according to variant 2, guarantees that, in the case of a malfunction or other circumstances that would cut off the supply from Grzegorzów subsystem, water would still be supplied for all purposes (water in the tank would be constantly exchanged).

4. Conclusions

Presented in the paper analysis of the water supply system expandability in the commune of Mściwojów, that takes into account the investments which are all part of the pilot project VITAL LANDSCAPES, considered two solutions. In variant 1, the existing Grzegorzów water supply network would be expanded. This will be necessary in order to supply water to the future users, i.e. the hotel, the restaurants, the vineyard, the stud farm, the recreational area(s) and the housing estate (planned on the left shore of the lake). In order to do that, it will be necessary to build the DN 110 pipeline (2010 m long). To increase the water supply reliability and the fire safety for the planned investments, variant 2 was also analyzed. According to variant 2, the subsystems of Grzegorzów and Targoszyn would be connected, which would require construction of pipelines DN 90, 110 and 160. The total length would equal 3926 m, and a tank 75 m^3 in capacity.

Based on the hydraulic analysis of the proposed solutions, it was found that the existing network is sufficient to supply all the users at present and in the near future (after expansion).

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Projekt VITAL LANDSCAPES no. 2CE164P3 – Valorization and sustainable development of cultural landscapes using innovative participation and visualization techniques.

Rozporządzenie Ministra Infrastruktury z dn. 12.04.2002 r. (a) w sprawie warunków technicznych jakim powinny odpowiadać budynki i ich usytuowanie (Dz. U. z 2002 r. Nr 75, poz. 690).

Rozporządzenie Ministra Infrastruktury z dn. 14.01.2002 r. (b) w sprawie określenia przeciętnych norm zużycia wody (Dz. U. z 2002 r. Nr 8, poz. 70).

Rozporządzenie Ministra Spraw Wewnętrznych i Administracji z dn. 24.07.2009 r. w sprawie przeciwpożarowego zaopatrzenia w wodę oraz dróg pożarowych (Dz. U. z 2009 r. Nr 124, poz. 1030).

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