

PEAKING FACTORS OF DRY WEATHER FLOWS IN GŁOGÓW COMBINED SEWAGE SYSTEM

Ireneusz NOWOGOŃSKI*, Ewa OGIŁDA

University of Zielona Góra, Faculty of Civil and Environmental Engineering,
Institute of Environmental Engineering
Szafrana st 15, 65-516 Zielona Góra, Poland

This paper presents the results of dry weather flowrate studies in inflow and outflow channels of overflow structure PB-1. The facility is located in P. Skargi Street in Głogów. Based on the results the average daily peaking factor of dry weather sewage outflow was estimated. Low efficiency of the algorithm allows the estimation of the flow when depth of the channel is less than 20 cm and when it is not possible to perform measurements with the ultrasound probe. Pointed to inadequate reconstruction of cross-sectional shape of the channel during device configuration as the cause of getting inconsistent results. The results of corrective calculations based on Manning's formula and typical cross-sections of channels were presented. Obtained results confirm the possibility of significant differences obtained when the channel parameters are configured incorrectly. Confirmed the low quality of the built-in algorithm supporting measurements at low depths, mistakenly called by the device manufacturer "Manning's formula method".

Keywords: combined sewage system, dry weather flowrate, peaking factor

1. INTRODUCTION

In designing of sewer systems, good estimation of design maximum flowrates are very important. Sewer system needs to have capacity large enough to accommodate increased domestic flows associated with increases of population and system expansion (Moulton 1999). Good estimation of minimum flowrates are valuable when designing combined sewer system. If the flowrate is too small, solid deposits can become substantial and adequate self-cleaning isn't achieved. Analysing of existed systems is connected with choosing adequate measurement equipment. The use of profiling flowmeters to measure flowrate in

* Corresponding author. E-mail: i.nowogonski@iis.uz.zgora.pl

the channels seems to be a very good solution. Advanced algorithms for auto-calibration, measurement using more than one ultrasonic probe, suggests the possibility to obtain reliable results. In practice, it turns out that despite the higher cost repeatedly obtained results are far from ideal. The least reliable results are obtained when the small depth is observed. In theory, the method of calculating the flow rate using the Manning's formula is used here. Practically, algorithms that generate the flow curves, based on measurements of large fillings are used. As a result, incorrect results are obtained and their use is not possible.

2. RESULTS

The study was conducted in city Głogów with population of about 67 thousands people located in Dolnośląskie Province 60 km away from Zielona Góra. The combined sewer system serves an area of 3511 ha. Analyzed sewer system in Głogów is equipped with three combined sewer overflows with single side weir and one flow divider connected with storage facility.

Rainfall was measured by six tipping-bucket rain gauges (Fig. 1). Measurements were taken in all seasons of the year.



Fig. 1. Locations of rain gauges and overflow structures in the city

Piotra Skargi

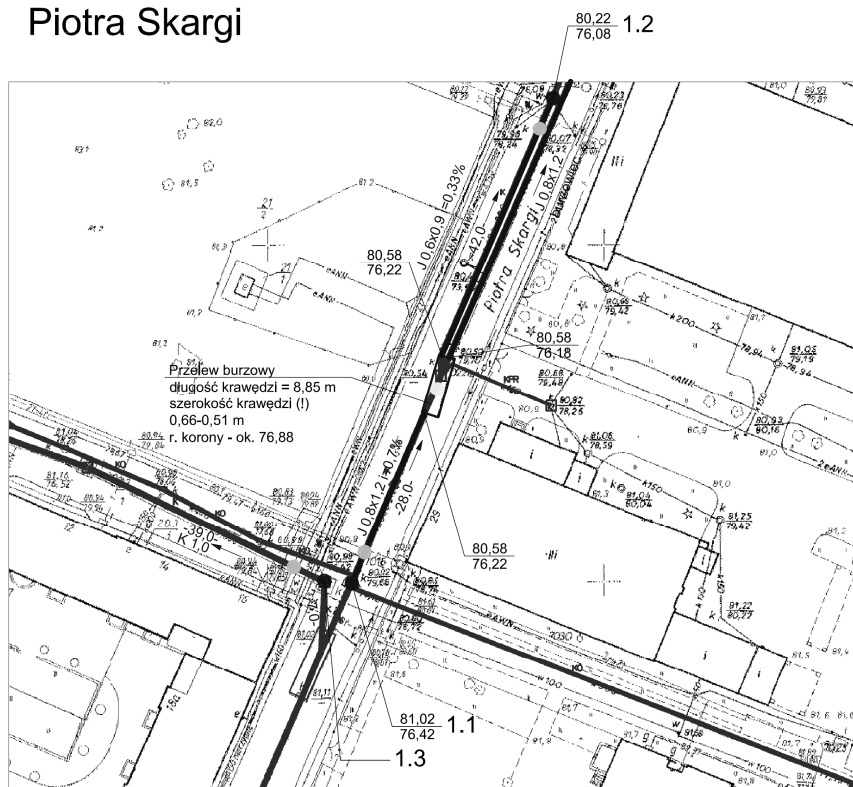


Fig. 2. Locations of flowmeters near overflow structure PB-1

Tab 1. Specification of dry weather minimum and maximum flow rates [lps]

| Month | Skargi 1.1 | | Skargi 1.2 | |
|---------|------------|-----|------------|-----|
| | min | max | min | max |
| 10.2011 | 5 | 64 | 12 | 56 |
| 11.2011 | 5 | 29 | 12 | 56 |
| 12.2011 | 6 | 52 | 12 | 47 |
| 01.2012 | 13 | 54 | 12 | 46 |
| 02.2012 | 14 | 60 | 12 | 51 |
| 03.2012 | - | - | 12 | 52 |
| 04.2012 | 13 | 55 | 12 | 45 |
| 05.2012 | - | - | 10 | 55 |
| 06.2012 | 11 | 51 | 12 | 44 |
| 07.2012 | 8 | 64 | 5 | 51 |

Tab 2. Specification of dry weather minimum and maximum depth [mm]

| Month | Skargi 1.1 | | Skargi 1.2 | |
|---------|------------|-----|------------|-----|
| | min | max | min | max |
| 10.2011 | 77 | 176 | 134 | 262 |
| 11.2011 | 77 | 160 | 132 | 252 |
| 12.2011 | 80 | 145 | 132 | 242 |
| 01.2012 | 86 | 151 | 135 | 224 |
| 02.2012 | 83 | 153 | 139 | 238 |
| 03.2012 | - | - | 143 | 244 |
| 04.2012 | 85 | 150 | 135 | 229 |
| 05.2012 | - | - | 132 | 233 |
| 06.2012 | 82 | 148 | 135 | 231 |
| 07.2012 | 98 | 164 | 137 | 248 |

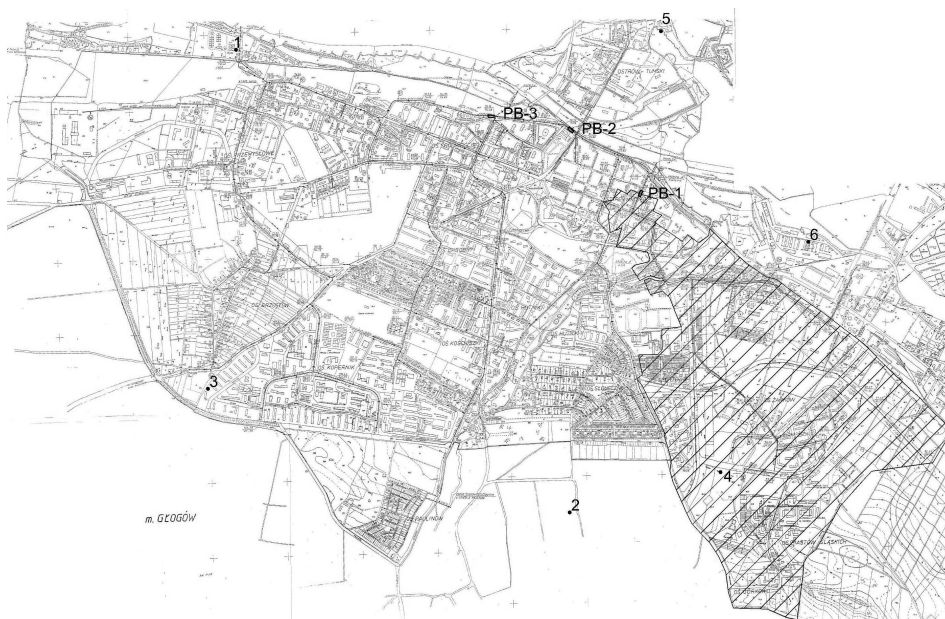


Fig. 3. Subcatchment connected with overflow structure PB-1

Flow rates were measured by ISCO ultrasonic profiling flow meters located at sewer manholes upstream and downstream of the CSO chambers. Special attention was taken to avoid improper installation of the ultrasonic probes (e.g., in sections with backwater effects or places with large amounts of sediments). All instruments were equipped with data loggers, which were fully synchronised and set for 5 min recording intervals. Locations of analysed flowmeters were shown on Figure 2.

Tab 3. Dry weather peaking factors estimation

| Date | Flow rates – Skargi 1.1 | | | Flow rates – Skargi 1.2 | | |
|----------------|-------------------------|---------|----------------|-------------------------|---------|----------------|
| | maximum | average | peaking factor | maximum | average | peaking factor |
| 14.10.2011 | 56,0 | 40,2 | 1,39 | 43,0 | 24,1 | 1,79 |
| 16.10.2011 | 49,0 | 34,4 | 1,42 | 48,0 | 24,7 | 1,94 |
| 29.10.2011 | 22,0 | 15,9 | 1,39 | 39,0 | 25,2 | 1,54 |
| 31.10.2011 | 22,0 | 15,0 | 1,47 | 36,0 | 24,8 | 1,45 |
| 05.11.2011 | 22,0 | 16,2 | 1,36 | 40,0 | 14,0 | 1,51 |
| 15.11.2011 | 22,0 | 14,5 | 1,52 | 36,0 | 22,6 | 1,60 |
| 27.11.2011 | 21,0 | 14,5 | 1,45 | 39,0 | 24,3 | 1,61 |
| 29.11.2011 | 25,0 | 14,2 | 1,76 | 42,0 | 23,2 | 1,81 |
| 26.12.2011 | 52,0 | 34,6 | 1,50 | 43,0 | 24,0 | 1,79 |
| 31.01.2012 | 54,0 | 35,8 | 1,51 | 42,0 | 25,1 | 1,67 |
| 04.02.2012 | 50,0 | 35,6 | 1,41 | 51,0 | 26,4 | 1,93 |
| 07.02.2012 | 51,0 | 34,3 | 1,49 | 37,0 | 23,4 | 1,58 |
| 20.02.2012 | - | - | - | 41,0 | 25,5 | 1,61 |
| 02.03.2012 | - | - | - | 35,0 | 23,4 | 1,50 |
| 03.03.2012 | - | - | - | 52,0 | 25,8 | 2,02 |
| 04.03.2012 | - | - | - | 45,0 | 23,2 | 1,94 |
| 05.03.2012 | - | - | - | 35,0 | 22,0 | 1,59 |
| 07.03.2012 | - | - | - | 43,0 | 22,4 | 1,92 |
| 15.03.2012 | - | - | - | 43,0 | 24,3 | 1,77 |
| 20.03.2012 | - | - | - | 43,0 | 24,3 | 1,77 |
| 01.04.2012 | 47,0 | 32,4 | 1,45 | 37,0 | 22,4 | 1,65 |
| 11.04.2012 | 55,0 | 36,7 | 1,50 | 45,0 | 22,0 | 1,50 |
| 02.06.2012 | 47,0 | 32,4 | 1,45 | 44,0 | 24,5 | 1,80 |
| 24.07.2012 | 53,0 | 38,5 | 1,38 | 41,0 | 23,2 | 1,77 |
| 25.07.2012 | 54,0 | 37,6 | 1,43 | 44,0 | 24,8 | 1,90 |
| 26.07.2012 | 52,0 | 36,6 | 1,42 | 40,0 | 20,5 | 1,95 |
| 27.07.2012 | 56,0 | 37,5 | 1,49 | 51,0 | 27,3 | 1,87 |
| Average | 42,6 | 29,3 | 1,46 | 42,03 | 23,6 | 1,73 |

During dry weather periods minimum and maximum flows and depths of channels were specified from October 2011 to July 2012. The results are shown in Tables 1 and 2. For a detailed analysis 19 days when there was no rainfall were selected for position Skargi 1.1 and 27 for position Skargi 1.2. For each day minimum, maximum and average flow rate were specified. Based on the maximum and average values, peaking factors were estimated. The values of flow rates and peaking factors were shown in Table 3.

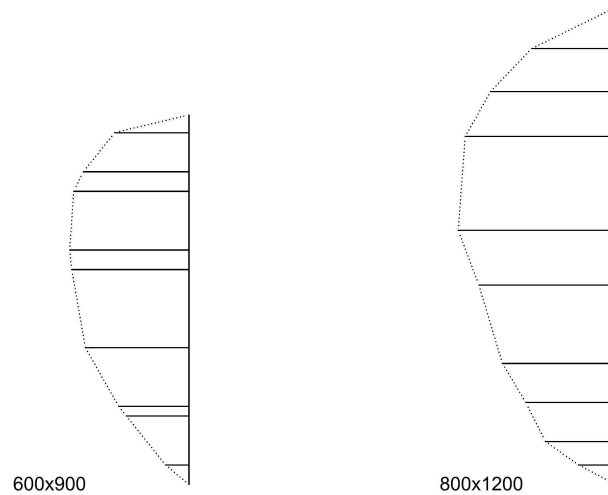


Fig. 4. Cross sections of channels reconstructed during the inventory

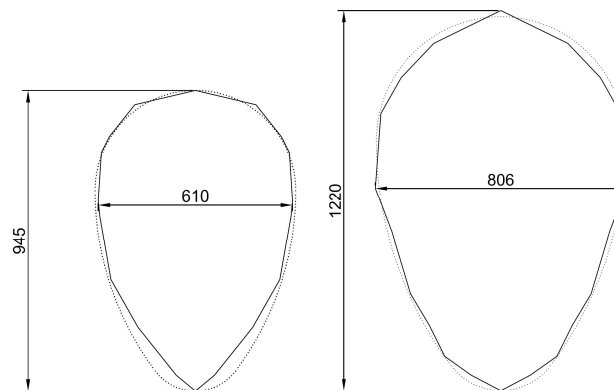


Fig. 5. Cross sections of channels reconstructed and typical

Flow rates in channels were estimated when depth is less than 20 cm and when it is not possible to perform measurements with the ultrasound probe. Obtained results are inadequate to real flow conditions. Flowmeter are located at a distance of less than 80 m. Therefore, the values obtained should be almost identical. As a reason, inadequate reconstruction of cross-sectional shape of the channel during device configuration was pointed (Fig. 4 and 5). This effect connected with low efficiency of the algorithm allows the estimation of the flow when depth is less than 20 cm (mistakenly called by the device manufacturer “Manning’s formula method”) is the cause of getting inconsistent results.

Tab 4. Dry weather peaking factors estimation – corrected values

| Date | Flow rates – Skargi 1.1 | | | Flow rates – Skargi 1.2 | | |
|----------------|-------------------------|---------|----------------|-------------------------|---------|----------------|
| | maximum | average | peaking factor | maximum | average | peaking factor |
| 14.10.2011 | 50,5 | 37,8 | 1,34 | 53,0 | 41,6 | 1,28 |
| 16.10.2011 | 44,8 | 33,1 | 1,35 | 61,7 | 40,1 | 1,54 |
| 29.10.2011 | 44,2 | 33,8 | 1,31 | 54,0 | 41,0 | 1,32 |
| 31.10.2011 | 44,8 | 32,1 | 1,39 | 53,0 | 39,4 | 1,35 |
| 05.11.2011 | 45,4 | 34,4 | 1,32 | 54,0 | 41,5 | 1,30 |
| 15.11.2011 | 44,2 | 31,6 | 1,40 | 52,6 | 37,2 | 1,41 |
| 27.11.2011 | 42,4 | 31,4 | 1,35 | 54,0 | 39,0 | 1,38 |
| 29.11.2011 | 50,5 | 31,0 | 1,63 | 69,8 | 37,3 | 1,87 |
| 26.12.2011 | 46,0 | 32,8 | 1,40 | 55,5 | 38,2 | 1,45 |
| 31.01.2012 | 46,7 | 33,2 | 1,41 | 59,6 | 42,3 | 1,41 |
| 04.02.2012 | 44,2 | 33,0 | 1,34 | 69,2 | 44,0 | 1,57 |
| 07.02.2012 | 44,8 | 32,0 | 1,40 | 55,5 | 41,8 | 1,74 |
| 20.02.2012 | - | - | - | 53,5 | 37,9 | 1,41 |
| 02.03.2012 | - | - | - | 61,1 | 46,8 | 1,31 |
| 03.03.2012 | - | - | - | 72,6 | 49,5 | 1,47 |
| 04.03.2012 | - | - | - | 64,3 | 47,6 | 1,35 |
| 05.03.2012 | - | - | - | 60,6 | 46,4 | 1,31 |
| 07.03.2012 | - | - | - | 65,4 | 46,0 | 1,42 |
| 15.03.2012 | - | - | - | 64,3 | 44,2 | 1,45 |
| 20.03.2012 | - | - | - | 62,2 | 43,4 | 1,43 |
| 01.04.2012 | 48,8 | 35,9 | 1,39 | 56,5 | 40,8 | 1,39 |
| 11.04.2012 | 48,6 | 34,2 | 1,42 | 64,3 | 39,5 | 1,63 |
| 02.06.2012 | 47,9 | 34,9 | 1,37 | 65,4 | 42,5 | 1,54 |
| 24.07.2012 | 55,1 | 42,0 | 1,31 | 64,8 | 50,5 | 1,28 |
| 25.07.2012 | 56,4 | 41,1 | 1,37 | 64,3 | 49,2 | 1,31 |
| 26.07.2012 | 54,4 | 40,2 | 1,35 | 62,7 | 48,1 | 1,30 |
| 27.07.2012 | 64,8 | 41,1 | 1,58 | 80,8 | 49,4 | 1,63 |
| Average | 48,6 | 35,0 | 1,39 | 61,3 | 43,2 | 1,43 |

The results of corrective calculations based on Manning's formula and typical cross-sections of channels were presented in Table 4.

3. RESULTS ANALYSIS

Used measuring system was designed for storm water flows and combined overflows monitoring. ISCO ultrasonic profiling flowmeters measuring range starts at 110 mm, but in real technical conditions profiling starts at 200 mm. Dry weather flows connected with small depths are estimated with algorithms automatically adapting to changing hydraulic conditions within the pipe.

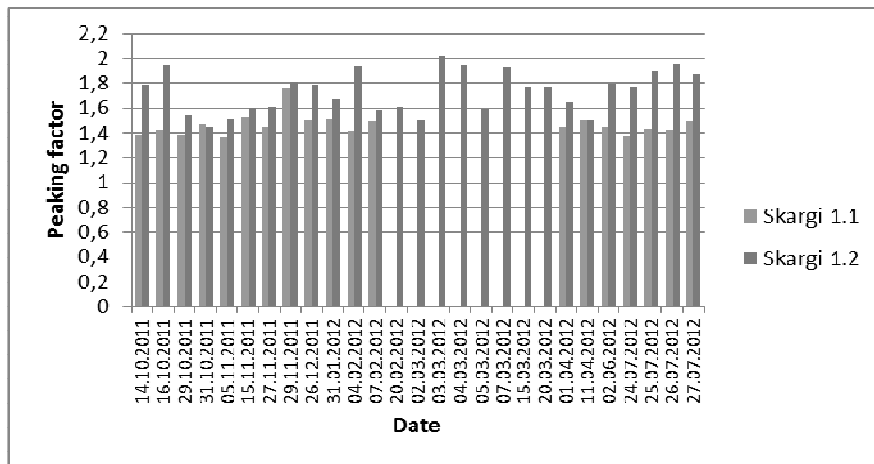


Fig. 6. Dry weather peaking factors – original values

Obtained results are inadequate to real conditions. Peaking factors estimated using logged data are characterized by significant differences between the two positions. In most cases the error exceeds 10% and in seven cases exceeds even 25%. Average peaking factor on Skargi 1.1 position is equal to 1,46. Average peaking factor on Skargi 1.2 position is equal to 1,73.

Peaking factors values calculated using corrected data are estimated with less error between the two positions. In most cases the error is less than 10%, only two cases exceeds 15%. Average peaking factor on Skargi 1.1 position is equal to 1,39. Average peaking factor on Skargi 1.2 position is equal to 1,44. In cities the size of Głogów daily peaking factor is assumed of 1.4 (Gruszecki, Wartalski 1986).

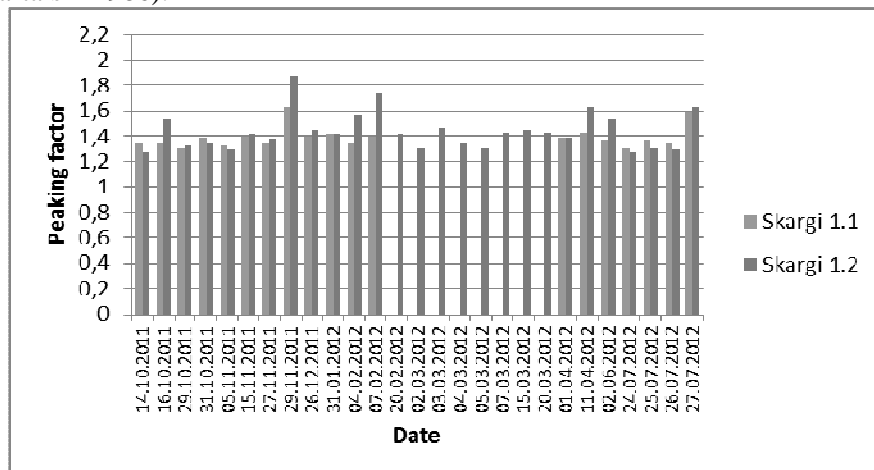


Fig. 6. Dry weather peaking factors – corrected values

4. CONCLUSIONS

Obtained results of corrected dry weather peaking factor are almost identical to typical designing factor. Original values are useless because of low efficiency of the implemented algorithms. An additional problem is limited experience of workers who build and implement measurement systems. Using profiling flowmeters to estimate dry weather values is not possible without manual calibration or correction values with Manning's formula. Optimal, though expensive solution is to apply additional ultrasonic flowmeter for small depths.

The calculations will be continued using the data obtained from measurements of the following years.

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WSPÓŁCZYNNIK NIERÓWNOMIERNOŚCI PRZEPEŁYWU POGODY BEZDESZCZOWEJ W KANALIZACJI OGÓLNOŚPŁAWNEJ GŁOGOWA

Streszczenie

W pracy przedstawiono wyniki badań natężenia przepływu ścieków pogody suchej w kanałach dopływowym i odpływowym z przelewu burzowego PB-1. Obiekt zlokalizowany jest przy ulicy P. Skargi w Głogowie. W oparciu o uzyskane wyniki oszacowano średni współczynnik dobowej nierównomierności odpływu ścieków pogody bezdeszczowej. Stwierdzono niską efektywność algorytmu umożliwiającego szacowanie natężenia przepływu w zakresie 0-20 cm napełnienia kanału, gdy nie jest możliwe wykonywanie pomiarów przy użyciu sondy ultradźwiękowej. Wskazano na mało dokładne odtworzenie przekroju kanału w czasie konfiguracji urządzeń jako przyczyny uzyskiwania sprzecznych wyników pomiarów. Zaprezentowano wyniki obliczeń korygujących wykonane w oparciu o wzór Manninga i typowe przekroje kanałów. Uzyskane rezultaty potwierdzają możliwość wystąpienia znaczących różnic uzyskiwanych przy nieprawidłowo skonfigurowanych parametrach kanału. Potwierdzono niską jakość wbudowanego algorytmu wspomagającego pomiary przy małych napełnieniach, błędnie nazywanego przez producenta urządzenia metodą Manninga.

