MODELLING DRY WEATHER FLOW

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1. INTRODUCTION

Dry Weather Flow (DWF) in a sewer is that flow which occurs in the absence of any runoff from rainfall, snow melt or other sources. In order to identify a period of DWF from monitored sewer flows it is best to look for a period of a few days when the flow exhibits a constant daily pattern, that is, when lines drawn through the daily minima and maxima are roughly parallel to the axis as shown in Figure 1. To be certain that it really is DWF, records should be checked to see that no precipitation occurred during the period.

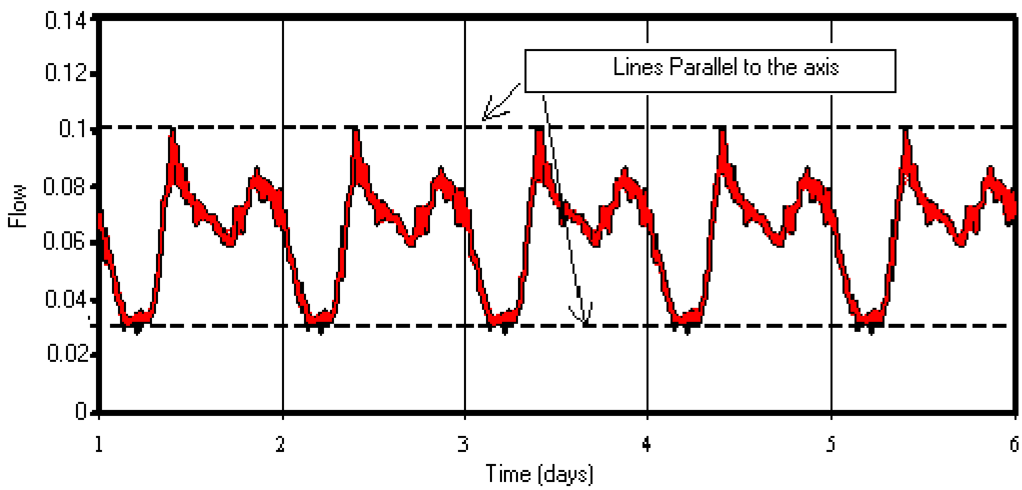

Figure 1 Dry Weather Flow

A hydraulic model of any sewer system, except purely storm water systems, should contain an accurate representation of the average daily DWF and its diurnal variation. This is especially important when sewer quality modelling is going to be carried out because DWF is a major source of pollutants that may be spilled from overflows during storms. Sewer models should also be able to provide sewage treatment plant designers and operators with reliable estimates of DWF to be treated, both in terms of quantity and quality.

The total DWF at any point in a sewer system can be sub-divided into three main component parts, namely residential, commercial/industrial and infiltration.

2. CALCULATION OF AVERAGE DWF

2.1 Residential Component

The residential component of the DWF should be based on the population in the area being modelled and a daily per capita output of wastewater. Figures currently used vary from 135 l/h/d to over 200 l/h/d. If flow survey information is available then this should be used to confirm the appropriate per capita figure. The methodology for doing this is discussed below.

Ideally the populations for each contributing area in the model should be obtained so that the residential DWF can be correctly distributed. The best method for doing this is by digitising the contributing area boundaries and overlaying them on a Geographic Information System (GIS) that contains census information. Such systems are now becoming available in the Water Service plc's and Local Councils. Failing that, the number of properties in each area can be counted and the DWF calculated based on the number of people per property. The number of people per property can be calculated by dividing the population for the total catchment area being modelled by the total number of properties. Total population can be estimated using ward by ward census information. At worst the residential DWF should be calculated using estimated housing densities and assumed occupancy rates.

3. INDUSTRIAL/COMMERCIAL COMPONENT

Tables are usually available from the Trade Wastes section of the Water Service plc's giving the maximum consented volumes of discharge and maximum discharge rates for all industrial and commercial properties. These tables can include minor inputs from such sources as shops and launderettes. Such small inputs are probably best allowed for in the per capita figure used for the residential component of DWF. Major traders, those whose average daily discharge is say 10% or greater than the residential DWF at their point of input, should be identified. Each of these traders should then be treated as a separate input to the model, either by allocating the input to a node that has no other DWF input or by using a hydrograph input file. For in-sewer water quality modelling, the classification of a major trader should also take into account its pollutant input.

The main problem with trade waste tables is that they give maximum rates which may not be indicative of the discharges that were taking place during a flow survey. This could lead to problems with DWF verification. Ideally measured flows should be used. Major traders are often monitored by the Water Service plc's. Alternatively, specific flow monitors could be assigned during a flow survey. Such information is, however, sometimes regarded as sensitive, and actual figures may be difficult to obtain.

Commercial areas which have a high influx of workers during the working day also require special consideration. If census figures are used, these areas could show very low resident populations and hence DWF calculations based on them could be inaccurate. To allow for the transient workers extra population can be assigned to these areas, combined with an appropriate per capita output. Alternatively allowances for DWF can be made based on cubic metres per second per square metre of office/warehouse space.

3.1 INFILTRATION COMPONENT

The only real source for this information is from data collected during a flow survey. It should be borne in mind that infiltration rates can vary significantly with time of year. Consequently, estimates of infiltration will depend on whether the flow survey was installed in winter or summer. Details of how to estimate infiltration are given below.

The amount of infiltration estimated at a particular flow monitor should be distributed pro rata back into the upstream contributing areas. This can be done by expressing the infiltration in units of m^3/s/ha. The infiltration rate may vary across the catchment being modelled and this variation should be taken into account when assigning infiltration rates to individual contributing areas. Once the infiltration component for each contributing area has been calculated it should be input into the model as a separate entity. The technique for doing this will vary with the software being used.

4. DIURNAL VARIATION OF DWF

4.1 Residential Component

The residential component will exhibit diurnal variation with generally low flows in the small hours and a peak at mid-morning. The pattern of variation will vary slightly from day to day with distinct differences between working days, weekends (even between Saturdays and Sundays) and holidays.

One of the problems of trying to assess the diurnal variation from flow survey data is that sometimes each monitor can appear to have its own pattern. Some apparent variations can be attributed, however, to varying levels of infiltration and/or attenuation as the flow passes down the sewer system. The amount of attenuation will depend on the size of the catchment being modelled and also its relative steepness. Figure 2 shows the effects of attenuation in a large flat catchment by comparing the dimensionless diurnal variation from a small (about 20 ha) contributing area with the corresponding variation at the outlet (total area about 2500 ha).

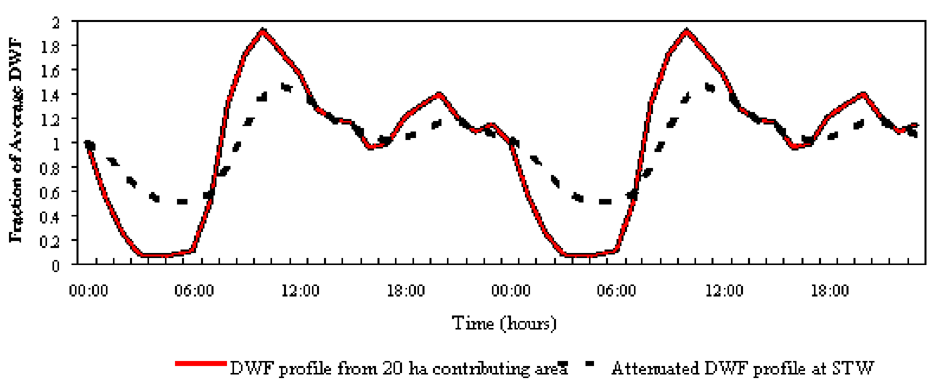

Figure 2 Attentuation of DWF Diurnal Profile

The diurnal variation applied to the residential component in the model should be appropriate to the typical size of contributing area being used. The model should then automatically account for the variations due to infiltration, which is applied separately, and attenuation. Flow survey data collected under standard UK guidelines should always be based on GMT. Therefore during British Summer Time an allowance has to be made in the standard profile for the 1 hour difference.

4.2 Industrial Component

The industrial components may each a show distinct variation over 24 hours depending on the working pattern, such as 24 hour working, 2 shifts or daytime only. Commercial areas with large transient populations will also exhibit diurnal variation with a pattern that may be different to that for normal residential areas.

4.3 Infiltration Component

Over a period of 24 hours it is assumed that the infiltration component will remain constant.

5. ANALYSIS OF FLOW SURVEY DATA

A typical example of a measured daily flow is shown in Figure 3. Before analysis the effects of any major industrial flows that are being dealt with separately, including their diurnal variation, should be subtracted. The remaining flow has then to be disaggregated into its residential and infiltration components. This can be done by solving the following simultaneous equations:

Average of total measured flow = Average residential flow + Infiltration

Minimum measured flow = Minimum residential flow + Infiltration.

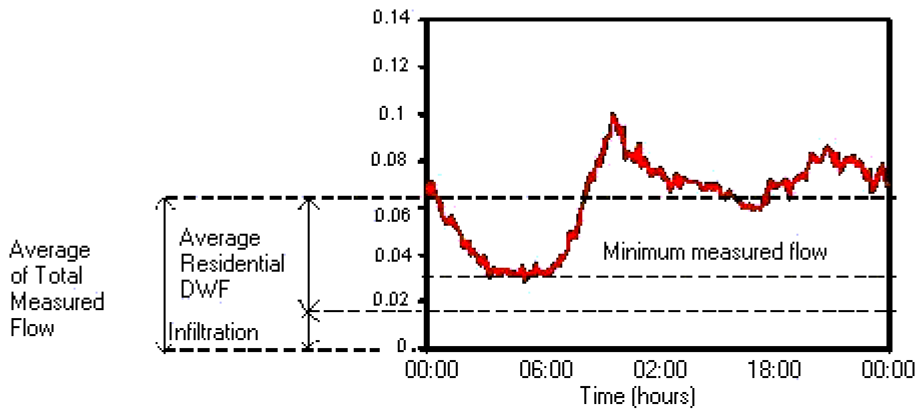

Figure 3 Disaggregation of Dry Weather Flow

The minimum residential flow will depend on the location of the monitor in the catchment. With reference to Figure 2 the minimum residential flow for the small area is about 10% of the average residential flow while the minimum for the whole catchment is about 60% of the average residential flow at that point.

The infiltration component calculated by this method can be used as indicated above. The calculated average residential flow can be used to confirm the per capita output figure by dividing it by the total population contributing to the monitor.

A note of caution needs to be added here concerning the accuracy of the flow monitor data. DWF depths, especially in combined sewer systems, can be very shallow and below the depths required for accurate measurement by conventional ultrasonic Doppler flow monitors. These monitors may originally have been installed to measure storm responses. Before carrying out detailed analysis thorough checks on the accuracy and consistency of the DWF data should be made. The analysis method is particularly sensitive to the accuracy of the data.

AMENDMENTS

Ver	Description	Date
1.	First Published	June 1996
2.	Editorial Amendments	March 2009