# RAINFALL LOSSES IN URBAN CATCHMENTS

Dr C J Pratt Department of Civil & Structural Engineering,
Trent Polytechnic, Nottingham, NG1 4BU
Tel.(0602) 418248 Ext 2044/2055

1) The Wallingford Procedure accounts for rainfall losses in determining the runoff volume through the prediction of the initial losses prior to runoff, DEPSTOG, and of the constant proportional losses occurring during runoff.

$$DEPSTOG_{pav} = 0.71 \times SLOPE^{-0.48} \qquad (7.9)$$

$$AR_{pav} = \frac{PR}{100^{pav}} \cdot \frac{P}{P - DEPSTOG_{pav}} \cdot AREA_{pav} \qquad (7.10)$$

$AR_{pav} = RC \cdot AREA_{pav}$, similarly for pervious and roof surfaces. The constant proportional loss, or runoff coefficient RC, is not explicitly stated in the printouts, instead the rainfall reduction factor, $PR_{pav}$, and the catchment percentage runoff, PR, are given. For a particular rainfall P on a sub-catchment of known slope type (hence prescribed DEPSTOG), the value of RC may be calculated. The accuracy of calculation of rainfall losses is determined by the appropriateness of the PR and DEPSTOG equations (Eq7.3 & 7.9 resp).

From the results of measurements of rainfall and corresponding runoff, graphs as Figure 1 may be drawn which allow estimates to be made of mean $DEPSTOG_{pav}$ (x-axis intercept, 0.76 mm) and constant proportional loss during runoff (slope of the 'best-fit' line, 0.9). Figure 1 is for data from Clifton Grove, Nottingham where highway surfaces are of a rough-textured tarmacadam, with channel blocks and kerbs both having open joints.

Figure 2 shows $DEPSTOG_{pav}$ – SLOPE relationships for the Nottingham and WASSP data sets : points P are reported to be 'uneven, in bad condition' or are cracked and jointed; point G is 'smooth and without cracks'. Generally, the WASSP data is for sites with smooth asphalt and fine-grained tarmacadam.

Figure 3 is a plot of data from various surfaces and the range of $DEPSTOG_{pav}$ of any slope for the range of paved surfacings (smooth asphalt to flagstones (setts)) is obvious. The one WASSP relationship cannot be expected to cope with predicting initial losses accurately in all urban catchments, which may be surfaced in a wide variety of materials, maintained to various standards and in which paved surfaces may be totally sealed to semi-porous in nature.

It is suggested that WASSP estimates for initial rainfall losses may be low in some cases which could result in WASSP-SIM results indicating earlier runoff prediction and, to a limited extent, higher volumes than observed in sewer survey data.

2) $DEPSTOG_{pav}$ cannot be adjusted within the operation of the procedure. The engineer may modify the . SSD data in order to correct for inaccurate volume/peak discharge prediction by changing the values of the contributing areas, $AREA_{pav}$ (following checks for sewer system data errors), such that the effective contributing areas $AR_{pav}$ produce runoff comparable to observations.

$$AR_{pav} = RC \cdot K \cdot AREA_{pav}$$

where $AREA_{pav}$ is the original .SSD designated contributing area and K is the 'calibration factor' to adjust the simulation volume/peak (K may be $\geq 1$ or $\leq 1$ according to circumstances): $K.AREA_{pav}$ being the adjusted value of contributing area entered into the .SSD file.

Through WaPUG it would be useful to hear of engineers' experiences in the adjustment of simulation .SSD files to achieve comparability of results with observations. Figures 4-6 detail observations of rainfall - runoff on two catchments: (i) a 10.6 ha residential catchment (PIMP 42.5%) where the observed runoff coefficient for the impermeable surfaces was 0.75 and DEPSTOG 1.1 mm; observed $PR_{pav}$ were variable (Fig 4), however, WASSP predictions were steady at around 74% (s.d. 3%) and when RC was calculated values around 0.9+ were predicted, which combined with predicted

FIG. 1

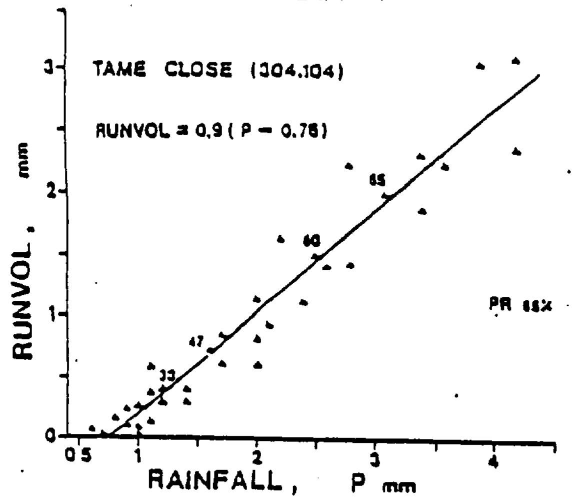



FIG. 2

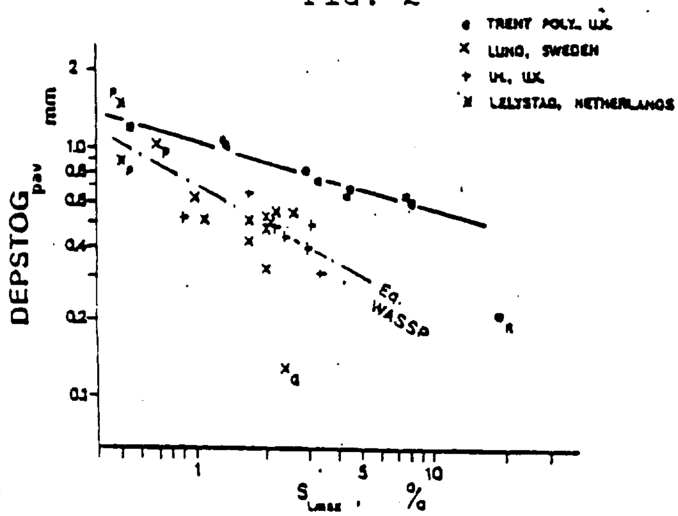
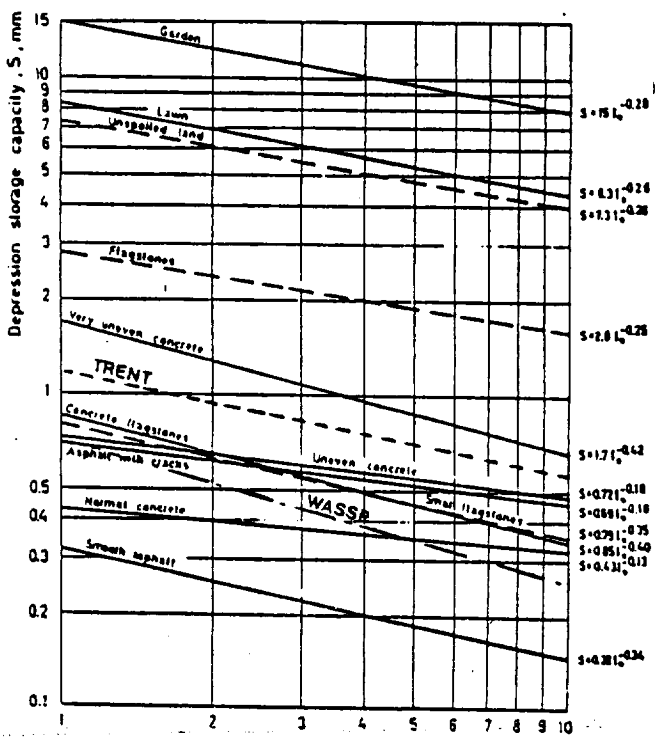



FIG. 3



b) Where PR < 0.7PIMP it is assumed that the pervious areas do not contribute and that all the runoff arise from the impervious areas.

Where PR > 0.7PIMP the excess runoff is assumed to arise from both the pervious and impervious areas in the ratio 0.3 to 1.

Hence:

$$PR_{imp} = 70 + \frac{0.3(PR - 0.7PIMP)}{(1 - 0.7PIMP/100)}$$

$$PR_{perv} = \frac{(PR - 0.7PIMP)}{(1 - 0.7PIMP/100)}$$

These equations produce values of PRperv which vary significantly with PIMP and are zero (since negative values have no meaning) over a wide range of catchment properties.

The equations also produce markedly lower values of percentage runoff from pervious areas than do the Flood Studies equations.

**The Solution at Littleborough**

After consultation with WRc the pervious sub-catchment at Littleborough was successfully modelled by producing an output hydrograph from a separate model of the pervious area alone. In this model the percentage runoff factor was specified as a value calculated from the Flood Studies method. The resulting hydrograph was then input into the main model.

**Discussion**

Littleborough was an extreme case. The Soil Index and UCWI were both high (0.45 and 230 respectively) and the pervious subcatchment was steeply graded. This produced a very high percentage runoff. The pervious area was both large and discrete, and consequently the problem was readily identifiable and relatively straight forward to model. Had the pervious area been interspersed with the urbanised area this form of solution would have been by no means as straight forward and it is possible that in such a case the true problem would not have been identified. A more general solution to these problems should therefore be incorporated into the programs.

**Recommendations**

In order to overcome these problems the programs should be improved by incorporating a system of calculating the percentage runoff factors for each type of surface directly. It is not envisaged that any additional variables would be involved in these equations, however the equation for any individual surface type may not include all these variables. In view of this it may be possible to construct an equation for runoff from impervious areas from some of the existing data. However studies of runoff from small pervious areas, using metered gullies, would probably be required to develop an equation for pervious runoff. Both equations could then be checked together against the existing data.