Appendix C: Gross Pollutant Generation and Treatment

Introduction

Gross pollutants form a significant part of the total amount of pollutants deposited in urban catchments in Australia. Allison et al. (1998) estimated that the total wet mass of gross pollutants deposited within Melbourne amounts to 60,000 tonnes annually. As well as reducing aesthetic values in the catchment, these pollutants play a significant role in disturbing physical habitats and degrading water quality within the waterway.

Allison et al. (1998) have shown that the definition of gross pollutants varies within the published literature. In their study, they adopted the following definition:

"...gross pollutants are defined as material that would be retained by a five millimetre mesh screen."

Using this definition, Allison et al. (1998) only included sediments that were attached to litter and other debris. One of the reasons for adopting this definition was that a five millimetre mesh size was used in both the sampling screen used to collect gross pollutant samples and the gross pollutant trap tested.

Allison et al. (1998) sampled gross pollutants during storm events within an urban catchment in Coburg, which is a suburb of Melbourne. The catchment had an area of approximately 150 ha, with a mixture of land uses including, residential, commercial/residential and light industrial. The conclusions from this sampling indicated that:

- Organic matter generally accounted for 66% by mass of gross pollutants;
- More litter is generated in commercial areas than residential and light industrial areas; and
- Gross pollutant concentration is generally highest during the early stages of runoff events.

As part of their study, Allison et al. (1998) collected data on the amount of gross pollutants collected during ten clean-outs of a CDS gross pollutant trap device in Melbourne. A total of 13 rainfall events occurred during the ten clean-outs of the CDS device. The device was located at the outlet to a 50 ha catchment in Coburg. As with the previous sampling, organic matter constituted the largest component of the gross pollutants collected in the CDS device.

Allison et al (1998) showed that both event rainfall and runoff were strongly correlated to gross pollutant load captured in the CDS device. Other variables, such as maximum discharge rate, days between runoff events and hydrograph shape were also investigated, but were found to be poorly correlated to the gross pollutant load captured. Therefore, it was concluded that the amount of gross pollutants transported in the drainage system was limited by the carrying potential rather than by supply.

Walker and Wong (1999) analysed the data collected by Allison et al. (1998), and showed that the wet mass of gross pollutants can be predicted by the following equation:

\[
M_w = 1462 \ln(R) + 528.4
\]  

where:

- \(M_w\) Wet mass of gross pollutants generated, (g/ha),
- \(R\) Daily Runoff, (mm/day)

As can be seen from Figure 1, the relationship derived from the data by Allison et al. (1998) indicates that events with runoff depths less than approximately 0.7 mm will produce no gross pollutant load. As noted by Walker and Wong (1999), this indicates that events with runoff less than 0.7 mm are not able to mobilise and transport material that has been deposited on the street surface. It is further noted that the shape of the rainfall versus wet load curve suggests that there is a possible upper limit of gross pollutant load that will be transported into the stormwater system. However, as noted by Allison et al. (1998), the data presented in this graph represents sampling collected during a three month period. Although it is recognised that this data is the best available, these relationships can be refined as more data becomes available.
The Gross Pollutant Generation Algorithm Adopted in MUSIC

MUSIC uses the relationship presented in equation 1 to determine the wet mass generated during storm events from the impervious area of a source node only. It has been assumed that no gross pollutants are generated from the pervious area of a source node. In the algorithm adopted, the wet mass per hectare, for each day of the simulation is calculated from the impervious area runoff using equation 1. The total daily wet mass is determined by multiplying this value by the total catchment area. Where equation 1 produces negative values, for events with impervious runoff less than 0.7 mm, the algorithm assumes that the wet mass generated during that day is zero.

The variation in the gross pollutants during each day is calculated by distributing the total wet mass over periods where surface runoff has occurred. The aim of this approach is to attempt to distribute the gross pollutants during the storm event only, and not during baseflow conditions. The wet mass of gross pollutants in each time step during the day is calculated as being proportional to the surface runoff hydrograph. Gross pollutants are routed through the drainage system using the same algorithms adopted for other contaminants. Unlike other contaminants, gross pollutants entering all treatment nodes, except the gross pollutant trap and generic treatment nodes, are assumed to be 100% captured. Stormwater by-passing the treatment nodes will also convey gross pollutant to the downstream node. Gross pollutant and generic treatment nodes allow the user to specify the gross pollutant trapping efficiency to be used.

Treatment of Gross Pollutants and Other Contaminants in Gross Pollutants Traps by MUSIC

MUSIC provides a treatment node for the treatment of stormwater quality using a gross pollutant trap. The treatment node adopted is a variation of that used for the generic treatment node, with the exception that there is no provision for modifying flow rate, as there is with the generic treatment node. The treatment of gross pollutants and other contaminants is modelled in MUSIC using transfer functions. These transfer functions calculate the stormwater effluent concentration from the concentration of the stormwater flowing into the device, using a simple graphical relationship between the inflow and outflow concentration.

The default relationships provided by MUSIC when creating a gross pollutant trap node are one-to-one relationships where the outflow concentration is equal to the inflow concentration. The user can modify these default relationships by clicking and dragging relevant points on the transfer function graphs, as described in Treatment Devices. In this way the user is able to define the specific capture efficiency for the particular contaminant for the device being modelled. Allison et al (1998) have shown that the capture rate for different gross pollutant trap devices can vary depending on the type of device installed.

When a time series graph of gross pollutants is plotted for a gross pollutant trap, the right hand axes of the graph will display the cumulative amount of gross pollutants collected by the trap. It is important to note here, that a gross pollutant trap node will only accumulate gross pollutants when the gross pollutant transfer function has been modified to reduce the concentration of gross pollutants in the device effluent. The gross pollutant transfer function adopted by MUSIC remains constant throughout the simulation. Therefore, it is not possible to directly model the effects of a changing capture efficiency that may result from poor maintenance of the gross pollutant trap.

The main aim of a gross pollutant trap is to collect gross pollutants carried by the stormwater as it flows through the drainage system. However, the nature of most gross pollutants means that other nutrients such as total suspended solids (TSS), total nitrogen (TN) and total phosphorus (TP) are carried in the gross pollutants. Allison et al. (1998) found from their study that the amount of TN and TP carried by organic gross pollutants is about two orders of magnitude smaller than those generated by other sources within the catchment.
Walker et al. (1999) have reported that field observations suggest that particles less than 5 mm are trapped by some gross pollutant traps. In this study they undertook an investigation into the efficiency of a CDS gross pollutant trap in treating TSS, TN and TP entering the device. The device was located in Coburg in Melbourne. The study was undertaken over a period of 22 months, with 15 storms monitored and dry weather samples taken at least every two weeks.

The results presented by Walker et al. (1999) show that where the inflow concentration of TSS is below 75 mg/L some reduction in the outflow concentration was noted. However, in some cases the concentration of TSS in the outflow was larger than that entering the device. It was noted that in some cases where the concentration of the influent fell below the ‘background’ concentration of 75 mg/L, there was little or no treatment by the device. Where the influent concentration of TSS exceeded this ‘background’ concentration, there was significant treatment of TSS taking place within the device. At these higher inflow concentrations the device had a treatment efficiency of 70 % of the concentration above 75 mg/L. The graphical representation of this treatment efficiency for TSS is shown in Figure 2. It was also concluded from the tests undertaken that the CDS device did not affect TSS concentrations during dry weather flow conditions.

Tests undertaken by Walker et al. (1999) also indicated that where the inflow concentration of TP exceeded 0.5 mg/L there was an apparent removal of TP within the device. For inflow concentrations below 0.5 mg/L there was little or no treatment within the device. The estimated removal efficiency for TP for inflow concentrations above this background concentration was found to be approximately 30% of the concentration above 0.5 mg/L. A graphical representation of the treatment efficiency for the treatment of TP by the CDS device is presented in Figure 3. The results from the CDS device also indicated that the removal of TN within the device was erratic during storm events as shown in Figure 4. However, the results for dry weather flow suggest that there is consistent removal of approximately 13 % of TN during dry weather flow conditions.
Conclusions

This appendix provides a brief background on studies that have been undertaken on the generation of gross pollutants in urban catchments. The studies reported are limited in that they relate to limited testing periods undertaken within an urban catchment in Melbourne. The studies reported have also looked at the treatment efficiency of gross pollutant trap devices. It must also be emphasised here that the treatment efficiency results reported in the studies are limited as they relate to a single gross pollutant trap device type in a single catchment. However, the studies reported provide a good basis for estimating the treatment efficiencies to be gained from gross pollutant traps.
MUSIC provides a generic treatment methodology for predicting the treatment effects that will occur within a gross pollutant trap. This provides the user with a flexible tool that can be modified to represent the current best estimates of treatment efficiency, as reported in the studies described in this appendix. One of the benefits of the treatment methodology adopted within MUSIC is that it allows for the incorporation of new research as it becomes available on the treatment efficiencies of different devices, under different maintenance routines and in different climatic zones.

References

