Highway Filter Drain Maintenance and Re-Instatement: A Waste Management Issue

Entretien et rétablissement du drain filtrant/tranchées d'infiltration : Un problème de gestion des déchets

E Gordon Rowlands [1] and J Bryan Ellis [2]

[1] Carnell Contractors Ltd, Gothic House, Market Place, Penkridge, Staffordshire ST19 5DJ, UK (Gordon.Rowlands@carnellcontractors.com)

[2] Urban Pollution Research Centre, Middlesex University, Queensway, Enfield, London EN3 4SA, UK (B.Ellis@mdx.ac.uk)

RESUME

Les activités essentielles de maintenance sur les éléments de drainage de chaussée d'autoroute impliquent la rénovation des drains filtrants et des tranchées d'infiltration qui peuvent générer des quantités substantielles "de déchets contrôlés". La classification qualitative de ces déchets est problématique et il est difficile d'identifier avec certitude les risques posés par ces matières ou même de définir les méthodes les plus efficaces de gestion et d'élimination. Nous décrivons un procédé novateur pour leur remise en fonction en vue d'offrir une solution plus durable pour la gestion des drains filtrants et des tranchées d'infiltration.

ABSTRACT

Essential maintenance activities on highway BMP drainage controls involve refurbishment of filter (French) drains and trenches which can generate substantial amounts of "controlled waste". The quality classification of these wastes is problematical and it is difficult to reliably identify the risks posed by such materials and the most effective forms of management and disposal options. An innovative procedure for their re-instatement is described which offers a more sustainable option for filter drain/trench management.

KEYWORDS

Arisings; Highway filter (fin and french) drains; Infiltration trenches; In-situ backfill renovation; Waste disposal; Waste management

1 INTRODUCTION

The 7,500 km strategic road network in England (trunk roads and motorways) is the largest publicly owned asset in the UK and valued at £72 Billion, with drainage being a significant proportion of that value, although operational maintenance expenditure on this asset is confined to in-year discretionary spend (Revitt and Ellis, 2001). From on-going CCTV inspection and GPS surveying it is known that there is only a relatively poor knowledge of the condition of the drainage network and the number and location of drainage assets and outfalls, although this is currently being addressed following a critical National Audit Office March 2003 report on highway maintenance. This audit followed serious flooding events. Highway runoff has been identified as a potentially significant source of receiving water pollution and one estimate suggests that such drainage could contribute as much as 50% of the total suspended solids, 16% of total hydrocarbons and between 35% and 75% of the total pollutant inputs to urban receiving waters in the UK (Ellis *et al*., 1987). Whilst recent long term studies on UK motorways have generally confirmed these key determinands as frequently exceeding maximum and annual average concentrations for EU Drinking Water and Freshwater Environmental Quality Standards, little if any evidence was found of impact on downstream river quality and ecology (Moy *et al*., 2003). Nevertheless, the range of observed event mean flow weighted pollutant concentrations was higher than quoted in the UK Highways Agency (1999) "*Design Manual for Roads and Bridges*" (DMRB). The range of median concentrations quoted in the DMRB Volume 11, Section 3:10 (Water Quality and Drainage), being itself based on previous work reported from the US (Driscoll *et al*., 1990).

The principal function of highway drainage is to remove surface water as rapidly and efficiently as possible from impermeable surfaces in order to minimise risks to vehicular traffic and to provide for adequate drainage of the road foundation and construction layers. Such runoff collection and conveyance is normally provided by conventional kerb-gully systems, slot drains, surface water channels/ditches, filter (and fin) drains and infiltration trenches, all of which also provide a pollutant treatment function. These drainage systems essentially only remove solid-associated pollutants through sedimentation and physical separation or adsorptive filtration mechanisms from the runoff water (Sansalone and Buchberger, 1995). Both filter drains and infiltration trenches collect surface water and control the groundwater level below the road (Luker and Montague, 1994) with the latter allowing further infiltration into the underlying subsurface. Both systems have been shown to be effective in retaining solids and solid-associated pollutants (Colwill *et al*., 1985; CIRIA, 1996) with as much as 80% TSS, 75% metals and 70% of oils being retained (Perry and McIntyre, 1986). Inevitably such systems will eventually become clogged with contaminated sediment and accumulated litter, with the voids at the base of the drain/trench and around the drainage pipe becoming full of captured material. Estimates of the effective operational lifetime of filter drains are in the region of 10 years, and following substantial reduction in the conveyance and treatment efficiency, the removal and replacement of the granular infill material would be deemed necessary (Luker and Montague, 1994; DoT, 1992). National advice given by all the UK regulatory authorities including the Highways Agency (HA), is to encourage such source control drainage, but there are caveats in the advice guidelines, warning against direct infiltration where there may be a danger of prejudicing groundwater quality.

The cost of the filter material replacement and softening of the pavement foundation and structure following clogging of the drain together with the need for regular maintenance, problems of stone scatter and potential for groundwater pollution have been cited as reasons for a decline in the use of highway filter drains in the original 1991 DMRB published by the UK Department of Transport. The current Volume 4, Section 2 DMRB (Highways Agency, 1999) guidance is that filter drains are not generally suitable for urban applications although feasible in verge and embankment cuttings in rural highway situations, especially where groundwater problems may occur. However, this advice ignores existing drain filter assets and assumes that a costly full off-site removal and replacement of the granular drain backfill material will always be required. Despite such official advice, the use of filter drains on new roads and car parks continues and does not appear to have substantially affected its popularity. This paper is concerned with maintenance issues associate with filter drains and trenches and the classification of arisings as controlled waste. A novel on-site method for re-cycling contaminated backfill material from such highway BMPs is also described.

2 HIGHWAY FILTER DRAIN DESIGN

Traditional drainage practice has used filter (and fin) drains to intercept and convey highway runoff from contributing areas of less than 5ha, with such drains running alongside 50% of the English high-speed road network. Such drains normally take the form of a trench taken below road formation level which is filled with uniformly-graded stone in the range 20-40mm to provide support to the trench sides and together with a drain pipe (porous, perforated or open-jointed non-porous), for a permeable conduit for water to a convenient outfall. The design of filter drains generally follows the same principles as other pipe drainage systems although they have relatively larger pipe diameters to cater for intercepted groundwater. The system serves both as surface and subsurface drainage and is thus termed a “combined filter drain” in the DMRB (Figure 1). The drain also provides runoff storage capacity (up to 10mm rainfall depth for a 1:30 year event) during storm events that can help to delay and attenuate flood peaks within the receiving stream. A geotextile membrane is used to prevent fine material entering the filter drain while permitting ingress of water and also inhibits plant root growth and has some limited oil retention capability. In many instances the upper trailing edges of the geotextile liner are found to be wrapped over the backfill ostensibly to prevent ingress of soil and surface litter. Such practice however, can prejudice the drain conveyance and treatment function.

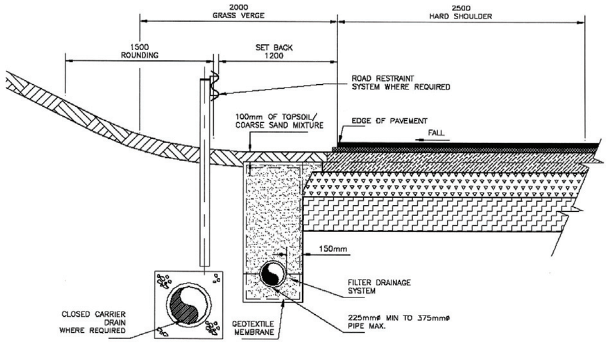

Figure 1. Typical Design of a Filter Drain
[After: DMRB, Highways Agency, 1996)

The advantages of a filter drain include:

- early installation and usage for collection of drainage runoff during the construction stage (although entry of excessive construction waste should be avoided)

- removal of groundwater beneath the pavement to a greater depth than would be possible with narrow filter or fin drains
- easier construction than other drainage systems, incorporating both surface water carrier drains and fin or narrow filter drains
- easier inspection and maintenance than is possible with fin or narrow filter drains
- facility for collection of water from drainage measures installed separately in the side-slopes of cuttings.
- removal of pollutants arising from highway use, specifically those that are associated with the fines that are washed off the highway and trapped by the drain
- rapid removal of stormwater in the event of heavy storm events but with sufficient capacity to attenuate water flow at the outfall, hence reducing the risk of flooding.

3 FILTER DRAIN OPERATION & MAINTENANCE ISSUES

The majority of filter (or french) drains have never been refurbished, and thus there is a strong likelihood that significant amounts of stormwater do not make it to the intended outfalls, with some going to ground without removal of pollutants. There is no doubt that the amount of funding for drainage maintenance falls far short of what is required to ensure satisfactory performance, which in part is due to the fact that drainage work does not score highly under the current value management process adopted by the HA. Road safety has to be an issue for routine maintenance of drains to become a priority under the present system of funding. Furthermore, Managing Agents and Managing Agent Contractors are initially awarded contracts for 5 years, which is considerably shorter than the 10 years expected maintenance interval for filter drains.

Apparent problems with filter drains have resulted in a policy of non-recommendation by the Highways Agency (Advice Note 39/38), but it is generally considered that most problems are caused by use of inappropriate designs and / or poor construction practice at the build stage, with subsequent lack of maintenance over many years. The only inherent problem with filter drains is the risk of stone scatter in the event of vehicles overrunning the drain. However, there are now various proven solutions to this problem that can be incorporated at the construction stage or which could be installed during routine drainage maintenance in priority areas. Where filter drains are not functioning correctly there is the potential for spillages to infiltrate directly into underlying fissured strata, leading to rapid groundwater pollution, as demonstrated in the UK by Price (1994) and Ellis (2006) and Zimmerman *et al* (2004) in Germany; this has been a major concern to the regulatory Environment Agency (EA). Nevertheless, filter drains have been retained in respect of reconstruction works dealing with large groundwater flows from highway cuttings and on long road lengths with relatively flat gradients. In addition, filter drains are advocated as a feasible urban source control BMP in the UK Sustainable Urban Drainage Systems (SUDS) Design Manual (CIRIA, 2000).

A number of design problems are apparent in the installation of filter drains that may have some impact on their operation and treatment capabilities. These include:

- the use of combined systems of kerb and gullies with filter drains and connection of gully or surface water channel carrier pipes directly into filter drain pipes. To maximise attenuation and treatment benefits, the basal pipe should really only be provided over the last few metres before the outlet or adjacent to a manhole.
- the use of grass verge (over-the-edge drainage) with filter drains where the grass edging forms an elevated “grass kerb”. This can generate a ponding effect during wet weather conditions with the ponded water preferentially discharging at a point into the filter drain and thus overloading the filter media. The grass “kerb” is

often removed during maintenance activities to facilitate drainage and herbicides are applied to prevent re-growth, making the introduction of toxicants into the drainpipe much easier.

- filter drains receiving drainage from adjacent land where herbicides and other chemicals are applied. In some rural locations it is not uncommon to find that field drains have been connected to the filter drain. Such connections can readily introduce fertilisers, pesticides and herbicides into the filter drain for onward transmission to groundwater.
- the use of overlapping geotextile to wrap over the filter drain surface which can creates blockage and maintenance problems.

In all these cases, the risk is probably higher on older road networks where the medium surrounding the drainpipe is not properly sealed and pipe joints are cracked or broken. This complicates the characterisation of the pollutant removal efficiency of the filter drain. Other identified issues relate to the relatively short 10 year life time of filter drains which can be significantly shorter on motorways or dual carriageways due to compaction by vehicular over-run. The usual 3m wide hard shoulder does not give sufficient clearance, particularly for heavy goods vehicles, when pulling over from the inside running lane. Following such over-run and compaction, the hydraulic efficiency of the system decreases, allowing little or no runoff water to permeate to the drainpipe in the affected area, as well as causing substantial stone scatter. As mentioned above reinforcement of the filter drain during routine drainage maintenance can substantially address this problem.

4 IN-SITU MAINTENANCE OF FILTER DRAINS

It is undoubtedly the case that the major problem encountered in this type of drainage system is lack of adequate and regular maintenance, despite the UK Highways Agency estimate that filter drain maintenance has an annualised cost of between £20M - £100M at 1995 figures. It is highly unlikely that this level of expenditure is actually incurred. Normal operation and management (O&M) practice to date has been to "dig out and replace" (at a rate of about 1 tonne per metre length), with the excavated contaminated material being taken off site and sent to landfill if the waste cannot be stored locally and the stone recovered. Hence there is clearly a need for an efficient, safe, and environmentally sustainable process together with a programme of filter maintenance and renovation for the proper management of the nation's vital road infrastructure.

There is now available an on-site method for removing contaminated sediment that accumulates close to the surface and/or within a stone-filled filter drain/trench located at the edge of a highway pavement. The process utilises a dry separation technique and is sustainable in that it re-cycles in-situ the existing stone present in the drain. It also minimises the volume of additional new stone that may have to be transported to site, thus significantly reducing the number of vehicle movements to and from the site. The StoneMaster® system is capable of operating within a single lane closure, including a motorway hard shoulder and the process is self-contained within a specifically designed mobile vehicle (Figure 2) that also allows the operation to meet all site safety requirements. To date, the system has been used to re-cycle in-situ some 450 km of filter drain over the last 4 years since developing the process. Hence around 450,000 tonnes of silted stone have been processed in that period. If this material had been excavated and replaced or re-cycled off-site, it would have required an additional 45,000 HGV journeys to remove silted stone and subsequently import new or cleaned stone. The cleaning process applied to the clogged aggregate allows in-situ "*as good as new*" replacement. A single night shift can produce between 60 to 100 tonnes of waste ie. around 10 tonnes per hour. This waste is predominantly material under 10mm, the aim being to ensure that 95% is above 10mm. StoneMaster routinely achieves 98% above 10mm. The waste is contaminated silt, together with organic detritus originating from grass cutting and leaves, soil that may have been placed over the drain, construction waste, and fines from poorly specified stone used in the initial construction. Should the drain be "dug out" all the material both the stone and silt will be classified as waste until such time as cleaned stone is recovered and put back to use.

Given the long periods between maintenance, the initial pollution discharging from the road is diluted by the time it is removed from the filter drain and placed in the tipper due to the presence of the other extraneous material previously referred to. There are also the additional effects of leaching and degradation that have taken place over the 10 – 15 year period whilst pollutants are retained within the drain. The arisings have been found to be generally below 500 ppm for Total Petroleum Hydrocarbons (TPH) with very low concentrations of Class 2 carcinogens and no samples breaching the 10,000 ppm level for Class 3 carcinogens. Without speciation, the limits on TPH for non-hazardous landfill classification are 1,000 ppm, and 500 ppm for disposal at an inert landfill site.

Figure 2. StoneMaster® in Action on Motorway.

5 WASTE ARISINGS AND DISPOSAL

The majority of waste arisings from filter drain refurbishment have proven to be non-hazardous using criteria enforced by the UK Environment Agency. However, the EU Framework Directive on Waste (75/442/EEC) defines waste as "*any substance…which the holder discards….or is required to discard*" and represents the first major piece of EU legislation relating to waste management. Whilst there is an increasing awareness and documentation concerning O&M procedures for BMP drainage controls (filter drains, soakaways, pond/wetlands etc..), there is much less appreciation of waste issues associated with the contaminated arisings generated during maintenance and cleaning operations. These arisings only become "controlled wastes" following maintenance activities. When the filter drain, soakaway or infiltration trench is "dug-out", all of the material remains waste until the stone and gravel content is recovered and put to use. The main contaminants are heavy metals and TPHs. The quantities and exact nature are subject to the inherent variability in source composition, degradation products and timing of the maintenance schedule. For example, it is normally not possible to say if the site has been subject to spillage at some time in the past or to excessive verge-side herbicide applications. Nevertheless, the EA has agreed that the overall waste arisings can be classified as being inert for landfill purposes, if the appropriate waste acceptance criteria (WAC) can be met. Otherwise, disposal at non-hazardous landfill site should not be an issue, bearing in mind that the location of landfill sites has a major impact on transport costs and hence it is preferable that either type of landfill can be used.

Whilst the arisings are non-hazardous and may be suitable for inert landfill existing UK regulations do not allow the waste to be disposed of and landscaped adjacent to the verge as an alternative disposal route. This is because suitable exemptions were not provided at the time the legislation was drawn up and the process of planning application is not feasible for drainage maintenance actvities, where such activities may have to be undertaken at short notice anywhere around the network. For similar reasons spreading on land for commercial developments such as golf courses is not a feasible proposition Acceptance for inert landfill also requires that the Total Organic Content is below 3%. This is to avoid methane generation as part of the EC's aim to reduce greenhouse gases and to ensure that humic/fulvic acids are not generated leading to increased leaching rates of heavy metals. However, it is not possible to control TOC unless verge maintenance is carried out more frequently, and organic waste (such as grass cuttings) is routinely removed.

From the above it can be seen that O&M of BMP facilities such as filter drains have some significant hurdles to deal with, and yet their main purpose is to facilitate stormwater disposal, itself a contaminated waste material in the context of operating a highway. It is estimated that there are 140 Million tonnes of contaminated stormwater to be removed from the English high speed road network pa. This therefore raises an important issue in the development of BMP facilities, where it needs to be recognised that such facilities will at best extract and store pollutants – they do not make them disappear. Hence there is therefore a pressing need for environment agencies to consider how waste management regulations can best accommodate the waste generated by BMP facilties, which, unlike pollution and waste from a factory or other commercial enterprise, is not under the control of the highway maintenance contractor. In the case of highways, it is the road using public who cause the pollution, not the maintenance contractor.

The maintenance of filter drains also involves administrative overheads. Section 34 of the 1990 EPA provides for a "*duty of care*" for all controlled waste and filter drain arisings, which must be continually assessed to confirm they are non-hazardous with a waste transfer note identifying and coding the waste when it is transferred to a carrier or to a disposal site. A waste transfer note is required every time the waste is removed from one site to another and copies must be retained for two years. Waste transfer notes covering a period of time can be used if the nature of the waste does not change during the period and all arrangements remain the same during that time. It aslo has to be recognised that when maintenance is carried out will have important consequences. Night-time O&M activites have become commonplace on UK highways, and it is generally the case that the arisings generated have to be temporarily stored until daytime opening of official landfill and/or waste transfer sites. Such temporary overnight storage must not exceed 50m^3 of waste and must be securely and safely located. Waste transport companies may have planning permission to store waste in larger quantities but unless the waste can be left in a tipper overnight, the waste material has to be double handled in order to free the tipper for other duties.

From the above it can be seen that waste management legislation has considerable management and cost implications for the operation of BMP drainage controls such as filter drains. As the arisings become more heavily contaminated so the situation becomes more complex, particularly in the case of hazardous waste which cannot be co-disposed with non-hazardous waste. BMP urban drainage now has to recognise that stormwater drainage O&M activities need to be viewed as waste management, both of the contaminated runoff itself and the pollutants carried with it and in the sedimented sludge or arisings. Future climate change is only likely to lead to more severe storm events with less predictability and thus reinforce the waste arisings issue, which in all probability will become a high priority for urban drainage BMPs. Initial BMP design needs to consider and anticipate the waste issue with some urgency as it is likely to become an increasing problem when it comes to disposal as part of either planned or unplanned maintenance operations; hopefully planned, because best practice waste management cannot be reactive in its approach.

6 CONCLUSIONS

Whilst there is a legal requirement to ensure that stormwater waste arisings do not present risks to the environment or human health, there are undoubtedly problems related to understanding and identifying the risks posed by such "controlled waste" and to assess the most effective form of management and disposal routes. Further, if specialised disposal is required, there are also problems in identifying what is hazardous "waste" amongst other "waste" streams in the arisings. The innovative re-cycling filter drain process StoneMaster helps to raise awareness of the value of properly maintained filter drains, and promotes planned drainage maintenance as a way of ensuring that drainage assets do not become liabilities when it comes to compliance with environmental legislation, as well as making an important contribution to sustainable drainage. The process illustrates best practice in filter drain management, which is increasingly focussing on achieving the required water quality and control of water flow from highway outfalls, as well as ensuring there is no water damage to the unbound sub-base of the road whilst providing a safe running surface for the road user.

REFERENCES

CIRIA. (1996). *Infiltration Drainage: Manual of Good Practice*. Report 156. Construction Industry Research & Information Association, London.

CIRIA. (2000). *Sustainable Urban Drainage Systems: Design Manual for England and Wales*. Report C522. Construction Industry Research & Information Association, London.

Colwill, D.M., Peters, C.J and Perry, R. (1985). *Water Quality of Road Runoff* TRRL Supp.Report 823. Department of Transport, HMSO. London.

DoT. (1992). *Trunk Road Maintenance Manual*. Vol.2, TRMM2. HMSO, London.

Driscoll. E.D., Shelley,P.E and Strecker, E.W. (1990). *Pollutant Loadings and Impacts from Highway Stormwater Runoff.* Vol.1;Design Procedure. Tech. Report FHWA-RD-96-095. Federal Highway Administration, Washington DC, US.

Ellis, J.B. (2006). A UK and European perspective of sustainable urban drainage (SUDS) with particular reference to infiltration systems and groundwater pollution. 2-1 to 2-8 in Proc. 26th Ann. Conf. Int. Assoc. Hydrogeologists (Irish Group); *Sustainable Urban Drainage Systems and Groundwater Monitoring.* 25-26 April 2006, Tullamore, Ireland. ISSN 1393-1806.

Ellis, J.B., Revitt, D.M., Harrop, D and Beckwith, P. (1987). The contribution of highway surfaces to urban stormwater sedments and metal loadings. *Science Total Envir.*, 59, 339 – 349.

Highways Agency. (1999). *Design Manual for Roads and Bridges*. Highways Agency, London.

Luker, M and Montague, K. (1994). *Control of Pollution from Highway Surfaces*. CIRIA Report 142, Construction Industry Research & Information Association, London.

Moy, F., Crabtree, R.W and Simms, T. (2003). *The Long Term Monitoring of Pollution from Highway Runoff*. R&D Tech. Report P2-038/TR1. Water Research Centre, Swindon.

Perry, R and McIntyre, A.E (1986). Impact of motorway runoff upon surface water quality. 53 – 67 in J Solbe (Edit): *Effects of Landuse on Freshwater*. Ellis Horwood Ltd., Chichester.

Price, M. (1994). Drainage from roads and airfields to soakaways: Groundwater pollution or valuable reacharge? *Journ. Chart. Inst. Water & Environ. Managt*., 8(6), 468 – 479.

Revitt, D.M and Ellis, J.B. (2001). 67 – 102 (Chapter 4) In: *The Environmental Management of Highways*. Institution of Highways & Transport, London. UK. ISBN 0 902933 31 0.

Sansalone, J and Buchberger, S. (1995). An infiltration device as a best management practice for immobilising heavy metals in urban highway runoff. *Water Science Tech*., 32, 119 – 125.

Zimmerman, J., Dierkes, C., Gobel, P., Klinger, C., Stubbe, H and Coldewey, W.G. (2004). 1253 – 1260 in: *Proc. 5th Int.Conf on Sustainable Technologies & Strategies in Urban Water Management*. NOVATECH04, Graie, Lyon, France.