Stormwater Runoff Quality Evaluation and Management - Need for a Different Approach Part I: The Problem

G. Fred Lee, PhD, PE, DEE and Anne Jones-Lee, PhD
G. Fred Lee & Associates
El Macero, CA

The Federal Congress in 1987 as part of reauthorization of the Clean Water Act mandated that the US EPA develop a national NPDES permit system for urban stormwater runoff discharges. The initial phase of this program was to be devoted to urban areas with populations greater than 100,000. Further, industries and construction sites must obtain NPDES stormwater runoff discharge permits. The US EPA's current stormwater quality management program requires that stormwater-caused "pollution" must be controlled to the "maximum extent practicable" (MEP) through the use of best management practices (BMP's). Neither Congress, the US EPA nor state or local regulatory agencies have defined "maximum extent practicable."

There are a wide range of views on what MEP means. There are some who advocate that MEP means achieving water quality standards at the edge of the mixing zone for the stormwater runoff. Others advocate that good housekeeping at industrial sites and street sweeping and litter pick-up for urban areas are adequate BMP's to achieve MEP.

Over the years, based primarily on hydraulic considerations, a number of structural BMP's have been developed for allegedly controlling water pollution from urban stormwater runoff. Stormwater detention basins, grassy swales and other vegetative areas and infiltration areas are often promoted as BMP's for urban stormwater runoff. However, as discussed below, a critical review of the potential impacts of stormwater runoff-associated chemical constituents raises significant questions about whether a stormwater detention basin is, in fact, a treatment system for removal of pollutants in urban stormwater runoff. This paper reviews a number of the issues associated with developing technically valid, cost-effective approaches for evaluation and management of urban and industrial stormwater runoff-caused water quality impairments.

Stormwater Runoff Pollution

The US EPA's stormwater management regulations specifically delineate that urban stormwater runoff management programs control pollution of waters. Pollution is defined in these regulations as well as in the Clean Water Act and in many state regulations as the impairment of the designated beneficial uses of the waterbody receiving the stormwater runoff. In accord with the l972 amendments to the federal regulations governing water pollution control in the US (PL 92-500), all waterbodies in the US were to be classified with respect to their designated beneficial uses. Uses such as domestic water supply, propagation of fish and aquatic life, recreation, agricultural and industrial water supplies, navigation, and waste heat dissipation, etc. are typically considered. The l972 regulations established as a national goal that all waters of this country should be "fishable and swimmable." Normally, propagation of desirable fish and

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aquatic life and body contact recreation (wading and swimming) and for fresh water, domestic water supplies, require the highest quality.

PL 92-500 also establishes as a national goal zero pollutant discharge. This was supposed to be achieved by the mid 1980's. It is important to emphasize that this goal was not zero chemical constituent discharge, i.e. distilled water. Instead it focused on controlling those chemical constituents which in fact cause pollution - impairment of use of the nation's waters. As discussed below, it is very important to clearly distinguish between pollutants and non-pollutants in developing stormwater runoff management programs.

The l972 federal regulations required that the US EPA develop water quality criteria which would serve as a basis for state water quality standards that when achieved will be protective of designated beneficial uses of waterbodies.

There are three types of constituents in urban and industrial stormwater runoff that have the potential to cause water pollution, i.e. an impairment of the designated beneficial uses of a waterbody. One of these is the particulate matter present in stormwater runoff. Suspended and deposited sediments can have impacts on water quality that are not related to the chemical characteristics of the particulate matter. Particulate material (sediments) can cause filling of the waterbody receiving the stormwater runoff interfering with navigation and changing the overall characteristics of the waterbody. The settled particulate matter can also adversely impact fish and aquatic life through smothering of organisms and altering their habitat. This particulate matter can affect the optical properties of the waterbody through causing turbidity which can impact the aesthetic quality of a waterbody and the photosynthesis that may take place in the waterbody.

The second major group of constituents in urban stormwater runoff that is of concern in potentially adversely impacting the designated beneficial uses of a waterbody is pathogenic organisms, especially the enteric waterborne pathogens (bacteria, viruses or protozoans). These organisms are of concern because they can affect a domestic water supply water quality as well as the sanitary quality of a water that is used for contact recreation. While typically in the past the sanitary quality of a water has focused on the fecal coliforms, today increasing attention is given to the enteroviruses and especially the cyst-forming protozoans such as Cryptospordium and Giardia. It is now well-known that waters that meet the coliform standard for contact recreation or domestic water supply are not necessarily safe for consumption or contact recreation since the enteroviruses and the protozoan cysts are more difficult to control through chlorination than the coliforms.

The third group of materials in urban stormwater runoff that is of concern with respect to potentially causing impaired uses of receiving waters is the chemical constituents. Chemical constituents typically receive the greatest attention in urban stormwater runoff quality management programs. Chemical constituents exist in aquatic systems in a variety of chemical forms, only some of which are toxic - available and therefore can be adverse to aquatic life and other designated beneficial uses of a waterbody. Typically, with few exceptions, it is the dissolved forms that are toxic - available. While this has been known for over 25 years, the US EPA has recently acknowledged this situation in its guidance for regulating heavy metals in

ambient waters where the Agency now recommends that dissolved heavy metals be used rather than total heavy metals. The particulate forms such as those that may be removed in a stormwater detention basin are normally non-toxic and non-available. This same situation also applies to most other chemical constituents in stormwater runoff and other sources of chemical constituents. It is for this reason that stormwater detention basins are typically not effective in removing chemical pollutants. They, however, can be effective in removing suspended sediment. The impact of these particulates removed in a stormwater detention basin is not related to the chemical characteristics of the sediment.

Another factor that has to be considered in evaluating the potential water quality impacts of chemical constituents in stormwater runoff is the duration of exposure that aquatic organisms can receive in the receiving waters for stormwater runoff. The shorter the duration of exposure, the greater the concentration of toxic - available forms that can be present without adversely impacting the designated beneficial uses of a waterbody. Because of the short-term, episodic nature of most stormwater runoff events, much higher concentrations of chemical constituents can be present than the worst-case or near worst-case US EPA criteria and state water quality standards and still protect the designated beneficial uses of the waterbody.

Unreliable Reporting of the Water Quality Significance of Urban Stormwater Runoff

Unfortunately the US EPA and state regulatory agencies responsible for conducting the National Water Quality Inventory in which urban stormwater runoff is ranked as the second most important cause of water quality impairment in the US have been providing highly unreliable information to the US Congress and the public on this issue. A critical review of how this ranking was developed shows that it was assumed that any exceedance of a water quality standard in the receiving waters for an urban stormwater discharge represented a water quality use impairment. As discussed herein and as is well known significant exceedances of water quality standards of the type available today can and do occur without any impairment of the designated beneficial uses of the waterbodies in which the exceedance occurs.

Chemical Constituents vs. Pollutants

Significant problems exist today in the stormwater runoff water quality evaluation and management field due to the fact that many of the individuals working in this field do not distinguish or properly distinguish between inert chemical constituents (non-pollutants) and pollutants. In order for a chemical constituent in urban stormwater runoff to be a pollutant, it must be present in the receiving waters for the stormwater runoff in sufficient concentrations of available forms for a sufficient period of time to be adverse to the designated beneficial uses of the waterbody. For aquatic life related beneficial uses, the chemical constituent, either alone or in combination with other chemical constituents, must significantly adversely affect the numbers, types and/or characteristics of desirable aquatic life.

Typically today, those working in the urban stormwater runoff water quality field inappropriately label all chemical constituents in urban stormwater runoff that have been found to be pollutants in other situations as pollutants. It is totally inappropriate to assert that a

chemical constituent, such as copper present in highway or street runoff, adversely impacts the designated beneficial uses of the waterbody receiving this runoff because copper at some other location and source, such as plating or mining wastes, is a pollutant in some other waterbody. This is obviously technically invalid and can result in a massive waste of public and private funds controlling chemical constituents by various types of structural BMP's such as stormwater detention basins that will have little or no impact on the receiving water water quality.

Beginning in the 1960's, several studies were conducted in various locations in the US which demonstrated that urban stormwater runoff contained chemical constituents at significantly elevated concentrations compared to most ambient waters. In the late 1970's and early 1980's, the US EPA conducted a National Urban Runoff Program (NURP) in which studies were conducted in several cities across the US that involved monitoring the chemical constituent concentrations in stormwater runoff. While it was known at the time the NURP studies were initiated from the work done in the 1960's that chemical constituents in urban stormwater runoff were typically associated with particulate matter and were non-toxic non-available, the US EPA in conducting the NURP studies failed to determine the water quality impacts of the elevated concentrations of chemical constituents present in the urban stormwater runoff investigated. This was a highly significant deficiency in the NURP studies which is still adversely impacting the cost effectiveness of urban stormwater runoff quality evaluation and management programs.

Based on the large amount of reliable information that has been developed today and the basic principles of aquatic chemistry, aquatic toxicology and water quality evaluation and management, it is more technically valid to assume that chemical constituents in urban stormwater runoff that are normally considered "pollutants" are non-pollutants. While typical urban stormwater runoff from residential and commercial areas contain a wide variety of chemical constituents at concentrations above US EPA water quality criteria/state standards, it is indeed rare that these exceedances of the water quality standards result in a significant impairment of the designated beneficial uses of the waterbodies receiving the runoff. This situation arises from the fact that most of the chemical constituents in urban stormwater runoff from residential, street and highway and commercial areas are in non-toxic, non-available forms. Further, because of the limited duration of exposure that desirable aquatic organisms can receive near the point of discharge of urban stormwater runoff, even exceedance of US EPA criteria/state standards for toxic - available forms in typical urban stormwater runoff will not result in a significant impairment of the designated beneficial uses of the waterbody.

Therefore, it is appropriate to regulate chemical constituents in urban stormwater runoff differently than the approach that has been used for municipal and industrial wastewaters. Failure to take this approach can readily result in large-scale waste of public and private funds controlling chemical constituents in urban stormwater runoff that have little or no impact on the designated beneficial uses of the receiving waters for such runoff.

While the focus of this paper is urban stormwater runoff, these same issues are equally applicable to rural and industrial stormwater runoff. To require, as is being done today, that industrial stormwater runoff from industrial properties meet state water quality standards at the point where the runoff leaves the property represents gross over-regulation of chemical constituents in industrial stormwater runoff.

Taking a different approach for regulating urban, industrial and rural stormwater runoff chemical constituent control than has been used for municipal and industrial wastewater discharges does not mean that these discharges are also not in some instances being over-regulated today. The 1972 amendments to the federal Water Pollution Control Act initially required that municipal and industrial dischargers achieve fixed degrees of treatment irrespective of the need to protect the designated beneficial uses of the receiving waters for the discharges, i.e. effluent standards. These discharges are now required to achieve water quality standards at the edge of a mixing zone in the receiving waters for the discharges. The water quality standards that are being applied to these discharges are designed to protect the designated beneficial uses under worst-case or near worst-case conditions. This means that normally municipal and industrial wastewaters treated to achieve water quality standards at the edge of a mixing zone in most instances receive more treatment than is necessary to protect designated beneficial uses since the worst-case conditions that the standards are designed to protect rarely occur in US waters.

Therefore, it is not that there is need to regulate urban industrial and rural stormwater runoff chemical constituents differently than the same constituents in municipal and industrial wastewater discharges. It is that in developing approaches for regulating urban stormwater runoff chemical constituents, the US should not make the same mistake that it made in developing regulatory approaches for the classical point source discharges of municipal and industrial wastewaters.

There are some regulatory agencies and environmental groups that are attempting to define "maximum extent practicable" as achieving state water quality standards at the edge of the mixing zone where the stormwater discharge enters the receiving water. While they acknowledge that it is not possible to achieve these standards today, they are attempting to develop regulatory approaches that establish these standards as goals that define MEP and by which BMP's are to be evaluated. Such approaches are technically invalid and will grossly over-regulate stormwater runoff-associated chemical constituents.

Rather than trying to achieve inappropriately developed water quality standards for stormwater runoff discharge situations, the approach that should be followed is to first define on a site-specific basis what, if any, real water quality use impairment is occurring for a particular stormwater runoff discharge. Where specific use impairments have been defined, then efforts should be made to determine the specific cause of the use impairments, i.e. the specific chemical constituents and forms that cause the use impairment. When defined, efforts should be made to control the specific chemical constituents that cause the use impairment at the source. Only in situations where it is not possible to control chemical constituents at the source should structural BMP's be developed to treat the stormwater runoff to control the use impairment.

There is little doubt that the structural BMP's that will ultimately be needed to control real water quality problems associated with urban, street and highway and industrial and rural stormwater runoff will be significantly different than the BMP's of the type that are being fostered today as appropriate for stormwater runoff pollution control.

The evaluation of the effectiveness of the BMP's in achieving MEP should be based on how well the BMP addresses - controls the water quality use impairment and not, as is typically done today, be based on the percent removal of a total chemical constituent across a structural BMP. Such an approach fails to recognize the aquatic chemistry and aquatic toxicology of chemical constituents in stormwater runoff as they may impact water quality.

Part II [http://www.gfredlee.com/Runoff/stmwat_2.pdf] and Part III [http://www.gfredlee.com/Runoff/stmwat_3.pdf] of this paper discuss approaches that have been developed in California as part of the state of California Stormwater Quality Task Force activities for implementing urban stormwater runoff water quality impacts.

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