The Appropriateness of Using US EPA Water Quality Criteria as Goals for Urban Area and Highway Stormwater Runoff Water Quality Management

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The federal Clean Water Act prohibits NPDES-permitted wastewater discharges from causing ambient water quality standard violations in the receiving waters for the discharge. This approach is being used to regulate point source discharges of domestic and industrial wastewaters. The US EPA (1990) implemented a national urban area and highway stormwater runoff water quality management program which requires that **pollution of the receiving waters by stormwater runoff from permitted areas be controlled to the maximum extent practicable (MEP) using best management practices (BMPs).** Urban areas above a certain population (phase 1-- 100,000) and highway stormwater runoff management entities are issued NPDES permits for these discharges. Urban area and highway stormwater discharges must, under current regulatory requirements, also meet the traditional point source discharge Clean Water Act requirements of not causing exceedances of water quality standards in the receiving waters for the discharge.

Inappropriateness of Using US EPA Water Quality Criteria for Urban Stormwater Runoff Regulatory Purposes

The nature of urban area and highway stormwater runoff at times having high flows for short periods of time and then extended periods of time with no flow would require the construction of large treatment works to treat urban area and highway stormwater runoff to the same degree as is being used for traditional point source discharges of domestic and industrial wastewaters, i.e. no more than one exceedance of a water quality standard in the receiving waters for the discharge for more than once in three years. This would cause urban dwellers regulated under the NPDES stormwater permit to have to spend between $1 to $2 per person per day in perpetuity to achieve this degree of constituent control in highway and urban area stormwater runoff.

While it has been possible to require that traditional point source discharges of wastewaters achieve this degree of treatment, i.e. no exceedance of a water quality standard in the receiving waters at the edge of a mixing zone, if allowed more than once in three years, it is recognized that that approach often leads to unnecessary expenditures for wastewater effluent constituent control. The application of traditional point source discharge requirements to urban area and highway stormwater runoff would lead to an even more over-protective situation due to the short-term, episodic nature of stormwater runoff and the fact that many of the constituents of potential concern in stormwater runoff from urban areas and highways are in particulate, non-toxic, non-available forms.

The US EPA (Perciasepe, 1996), in an attempt to address this situation, has determined that while NPDES permitted urban area and highway stormwater runoff must conform to Clean Water Act requirements of not causing exceedances of water quality standards in the receiving waters for the runoff, such exceedances do not represent a violation of the NPDES permit. The situation has therefore evolved to one of using US EPA water quality criteria and state standards based on these criteria as goals for implementing BMPs to control "pollution"

to the MEP. This paper addresses the appropriateness of using US EPA water quality criteria as goals for urban area and highway stormwater runoff water quality management and presents an alternative, more cost-effective approach for regulating urban area and highway stormwater runoff that focuses on controlling real water quality use impairments in the receiving waters for the runoff.

One of the most significant fundamental problems with the current urban area and highway stormwater quality impact evaluation and management programs is a proper assessment of the **pollution** caused by such runoff-associated constituents. Far too often a chemical constituent, such as a heavy metal, that has been found at a location in a waterbody at some time to be adverse to aquatic life in that waterbody and therefore is appropriately labeled a pollutant that impairs use of that waterbody, is assumed to be adverse to aquatic life in a waterbody at all locations at all times where it causes an exceedance of a water quality standard at the point where the stormwater enters a waterbody. Under these conditions, chemical constituents, irrespective of their chemical forms and duration of exposure, are considered to be pollutants. Obviously, such an approach is technically invalid and can result in massive waste of public and private funds in developing treatment works for chemical constituents in urban area and highway stormwater runoff that are not adverse to the designated beneficial uses of the receiving waters for the runoff.

Appropriate Use of Pollution Control Funding

In situations where there is a large surplus of funds available for managing environmental problems and there are no other significant social problems which need funding, it may be acceptable to conclude that as part of "pollution" prevention it is appropriate to control heavy metals and other constituents in urban area and highway stormwater runoff so that the receiving waters for such runoff do not have exceedances of water quality standards for regulated chemicals more than once in three years at the point where the stormwater runoff enters the receiving waters. However, today where there are significant societal problems for which there is need for funds and there are limited funds available for water pollution control, it is important to focus the funds available on managing real, significant water quality use impairments of the receiving waters for the stormwater runoff.

Why Urban Area and Highway Stormwater Runoff Should Be Regulated Differently

A critical review of how US EPA water quality criteria were developed relative to the characteristics of urban area and highway stormwater runoff-associated constituents shows that, in general, significant exceedances of water quality standards based on US EPA water quality criteria can occur in urban area and highway stormwater runoff without adversely impacting the designated beneficial uses of the receiving waters for the runoff. This situation arises from two characteristics of US EPA criteria. The first of these is the aquatic chemistry of the constituents in the toxicity testing used to establish the criteria for potentially toxic chemicals. Urban area and highway stormwater runoff-associated constituents are largely in particulate forms and have been, in general, demonstrated repeatedly since the 1960s to be non-toxic and non-available to be adverse to aquatic life through potential toxicity or to public health through bioaccumulation in aquatic organism tissue used as food.

The short-term, episodic nature of urban area and highway stormwater runoff relative to the duration of time used in the toxicity tests or the period of time necessary to achieve significant bioaccumulation of the constituents of concern is short compared to the time necessary to be adverse to aquatic life. While the US EPA water quality criteria and state standards based on these criteria have one-hour exposure criterion values, it is understood that these one-hour exposure concentrations, i.e. acute criterion, do not properly represent the real exposures that can occur for most constituents to aquatic life without adverse impact on the organism. Therefore, exceedance of a water quality criterion at the point where stormwater runoff from urban areas and highways

occurs should not be interpreted to mean that this exceedance represents a potentially significant impairment of the designated beneficial uses of the receiving waters for the runoff.

For potentially toxic chemicals, in order for this exceedance to be of significance to the public who must ultimately pay for controlling constituents in urban area and highway stormwater runoff, it must significantly alter the numbers, types and characteristics of desirable forms of aquatic life. For potentially toxic chemicals, this means that the stormwater runoff should be toxic at the point of discharge and the toxicity should persist for a sufficient period of time and over a sufficient area to be significantly adverse to aquatic life within this area and that these adverse impacts are manifested in terms of reduced numbers of aquatic organisms of concern to the public.

For chemicals of concern because of potential bioaccumulation, such as mercury in urban area and highway stormwater runoff, the concentrations of mercury in such runoff, either alone or in combination with mercury in a bioaccumulatable form already in the receiving waters, should result in excessive bioaccumulation of mercury in edible organism tissue that causes or could cause a human health advisory to be issued for the use of the organisms as food. Eventually as wildlife-based critical tissue concentration criteria are established, consideration of the bioaccumulatable impacts of constituents on wildlife should be included in evaluating whether whole organism tissue residues are potentially adverse to wildlife.

One of the most significant problems associated with the use of exceedances of water quality criteria/standards to judge potential water quality problems from urban area and highway stormwater runoff is that only a limited number of the chemical constituents present in urban area and highway stormwater runoff are regulated, i.e. for which there are water quality criteria. There is growing evidence that the primary constituents of concern in urban area and highway stormwater runoff are unregulated chemicals for which there are no criteria, such as the organophosphorus pesticides as well as other pesticides and fungicides.

Lee and Jones-Lee (1995a) have discussed the appropriate use of numeric chemically-based water quality criteria. They have also discussed the problems with the US EPA's Independent Applicability Policy in regulating chemical constituents from urban area and highway stormwater runoff (Lee and Jones-Lee, 1995b). Based on a review of the characteristics of US EPA water quality criteria and urban area and highway stormwater runoff, it may be concluded that using US EPA water quality criteria as goals for regulating regulated chemical constituents in urban area and highway stormwater runoff can lead to technically invalid approaches. Further, their use can inappropriately focus control programs on inert constituents of limited water quality significance, while at the same time fail to identify important constituents in urban area and highway stormwater runoff that are adverse to the beneficial uses of a waterbody receiving such runoff. Of particular concern are the organophosphorus pesticides, such as diazinon. Diazinon is widely used by homeowners for the control of structural pests, such as termites and ants. It is also widely used to control insects in lawns, shrubbery and flowerbeds. This pesticide is being found to be a widespread, common cause of aquatic life toxicity in urban area stormwater runoff. The US EPA thus far has not developed a water quality criterion for diazinon, with the result that it is unregulated in urban area and highway stormwater runoff.

Alternative Goals for Stormwater Runoff Water Quality Management

An alternative approach for developing more technically valid, cost-effective management of real water quality problems associated with urban area and highway stormwater runoff involves examining the receiving waters for adverse impacts in what is called an "Evaluation Monitoring" program. As discussed by Lee and Jones-Lee (1995b; 1996a,b; 1997a,b), rather than measuring a suite of heavy metals and other constituents that are of

concern because of their potential toxicity to aquatic life at the edge of the pavement for urban area and highway stormwater runoff as it enters a particular waterbody, the Evaluation Monitoring approach measures toxicity using sensitive species in standard toxicity tests. The toxicity assessment involves the use of the same kinds of tests that have been used to establish the water quality criteria, and therefore the organisms are responding to the same kinds of impacts as are protected by the criteria.

The Evaluation Monitoring approach focuses on toxicity and considers such issues as the fate, areal extent and persistence of toxicity within the receiving waters to determine whether toxicity in a stormwater discharge occurs in the receiving waters to a sufficient degree to be potentially adverse to aquatic life in the waterbody. Toxicity due to the unregulated chemicals, such as the organophosphorus pesticides used in urban areas, that is present in urban area stormwater runoff is also assessed in the Evaluation Monitoring program through the direct measurement of toxicity.

Evaluation Monitoring considers not only toxicity, but also addresses bioaccumulation through direct measurement of excessive tissue residue of organisms in the region. If excessive concentrations of chlorinated hydrocarbons or mercury, i.e. those chemicals for which there are critical human health tissue residues, are found, then the source(s) of the constituents specifically responsible for the available forms that are bioaccumulating to excessive levels is determined through forensic studies within the waterbody and watershed.

Evaluation Monitoring is implemented as a watershed-based regulatory agency, discharger, environmental group and public stakeholder program that focuses on finding significant water quality use impairments in the receiving waters for the stormwater runoff that warrant the public's expenditure of funds for pollutant control using site-specific BMPs to the MEP. In addition to considering toxicity and bioaccumulation, all other use impairments such as excessive fertilization, sanitary quality problems associated with contact recreation, impairment of domestic water supply raw water quality, excessive siltation, turbidity, aesthetic quality, oil and grease accumulation and litter, etc. are evaluated with respect to their significance in causing use impairments of a particular waterbody.

Basically, in accord with recommendations of Lee and Jones-Lee (1995a,b), US EPA water quality criteria and state standards based on these criteria are used in the Evaluation Monitoring approach as guides to potential water quality problems for the regulated chemicals. If an exceedance of a water quality criterion/standard is found, then the waterbody is examined to determine whether the potential problem associated with that exceedance is, in fact, occurring due to the constituent causing the exceedance. For example, the concentration of copper in urban area and highway stormwater runoff is typically above the US EPA water quality criterion for protection of aquatic life from toxic effects. However, the criterion value is based on essentially 100% available/toxic forms of copper where the organisms were exposed for extended periods of time. It is being found repeatedly that the copper in urban area and highway stormwater runoff is in a non-toxic, non-available form and that the duration of exposure to the concentration above the criterion value is normally short compared to the exposure necessary to be toxic to aquatic life if the copper in the stormwater runoff were in a toxic form. Therefore the copper in the urban area and highway stormwater runoff is a chemical constituent but not a pollutant since it does not cause toxicity in the receiving waters for the stormwater runoff. A violation of Clean Water Act water quality requirements by the exceedance of the copper criterion/standard in urban area and highway stormwater runoff does not cause pollution, and therefore there should be no need to develop a BMP to control the copper input to the waterbody.

A similar situation exists with respect to lead in urban area and highway stormwater runoff. The concentrations of

lead in such runoff frequently exceed US EPA water quality criterion. However, repeated studies over the years have demonstrated that the lead in urban area street and highway runoff is in a non-toxic, non-available form and therefore does not cause an impairment of the designated beneficial uses of the receiving waters for the runoff.

The Development and Implementation of a Stormwater Management Program

The typical approach being used by many stormwater runoff water quality managers is to assume that the exceedance of a water quality criterion in the runoff waters represents a significant adverse impact on the receiving waters that requires control of the constituent responsible for the exceedance. Some communities are spending substantial amounts of funds identifying the sources of constituents that cause an exceedance of a US EPA criterion/state standard without first determining whether the exceedance is an administrative exceedance which reflects the overly protective nature of US EPA criteria and state standards based on these criteria or represents a real water quality use impairment. The first step in any technically valid stormwater runoff water quality evaluation and management program should be the determination of whether the exceedance of the standard represents a potentially significant water quality problem. For example, for lead and copper, since both of these are of concern because of their potential toxicity to aquatic life, the toxicity in runoff waters should be assessed. If toxicity is found, then through the use of appropriately conducted toxicity investigation evaluations (TIEs), it is possible to determine if the toxicity found is due to copper and/or lead or some other constituents in the runoff waters. It was through this approach that diazinon was found to be a common cause of urban area and highway stormwater runoff toxicity. It was also through this approach that both lead and copper are found to not cause aquatic life toxicity in urban area street and highway stormwater runoff.

While an exceedance of the water quality criterion for copper, lead or other constituents represents a violation of NPDES permit conditions, if it is found through proper studies that this exceedance is not a real water quality use impairment exceedance, i.e. is administrative, then rather than trying to control the sources of copper and/or lead that are causing administrative exceedances of the water quality criterion, the stormwater manager should focus the resources available on working to obtain a more appropriate regulatory approach than the one being used by the US EPA today to regulate potentially toxic constituents where the Agency requires, because of its Independent Applicability Policy, that NPDES dischargers control chemical constituents in wastewater discharges and stormwater runoff that are of concern because of potential toxicity, even though appropriately conducted studies have shown that the constituents are in non-toxic, non-available forms. Administrative exceedances can only be effectively addressed through administrative approaches, rather than through very expensive chemical constituent source control and/or treatment.

Reliability of Environmental Indicators

There is widespread recognition today that the traditional stormwater runoff water quality "monitoring" is ineffective in providing information on what, if any, real water quality problems exist in the receiving waters for the stormwater runoff. Regulatory agencies and stormwater dischargers are shifting their monitoring efforts away from end-of-the-pipe, edge-of-the-pavement monitoring of a suite of chemicals to evaluation of the water quality impacts associated with stormwater runoff-associated constituents in the receiving waters. Recently there have been a number of attempts by the US EPA (1996a,b) and others (Claytor and Brown, 1996) to develop environmental "indicators" that can be used to assess water quality impacts of urban area and highway stormwater runoff-associated constituents. Caution must be exercised in using this approach since many of the so-called indicators proposed by the US EPA for assessing stormwater quality impacts are not real indicators of water quality problems - use impairments. It is essential in any reliable stormwater runoff water quality impact

assessment to focus on use impairments as opposed to using a water quality "indicator" such as an exceedance of a water quality standard that is in some ill-defined way related to water quality issues of concern to the public. The public does not care how much copper or lead is in the water; they are concerned if the copper or lead impairs the use of the water for various purposes. The coupling between the concentration of copper/lead as normally measured and water quality impacts is poorly understood.

The Evaluation Monitoring approach shifts the emphasis from chemical constituents that could, in some situations cause water quality problems, to defining real water quality problems - use impairments associated with urban area and highway stormwater runoff, determining their cause and through forensic studies, the source of the constituents responsible for the problem - use impairment. Rather than using inappropriate water quality criteria/standards as goals for BMP development, which often diverts attention away from real water quality issues of concern to the pubic, the Evaluation Monitoring approach uses the control of significant water quality use impairments as the goal for BMP development. While this approach is different than the traditional chemical constituent approach that the US EPA adopted in the early 1980s, it recognizes what was well known then and is well known today-- that aquatic chemistry, aquatic toxicology and hydrodynamics/mixing all play important roles in determining whether a chemical constituent in a particular discharge or runoff waters impairs the beneficial uses of the waterbody receiving the runoff.

The Evaluation Monitoring approach also quickly points out the inappropriateness of traditional "BMPs" that have been used for urban area and highway stormwater runoff "water quality" management such as detention basins, filters, etc. to remove particulate forms of constituents such as inert heavy metals and focuses BMP development on source control for those forms of the constituent that are, in fact, causing real use impairments in the receiving waters for the stormwater runoff. The traditional BMPs were not developed based on a finding that they control real water quality problems in the receiving waters for the stormwater runoff. They were developed based primarily on hydraulic considerations which ignored what has been known since the 1970s in the fields of aquatic chemistry, aquatic toxicology and water quality about how chemical constituents impact aquatic organisms and other beneficial uses of waterbodies. Expensive structural BMPs should only be used where it is appropriately demonstrated that they will, in fact, be effective in controlling a real, significant water quality use impairment in the receiving waters for the runoff and appropriate consideration of MEP has been given. The current approach of placing a detention basin or a filter at a stormwater runoff location because it is listed in a BMP manual and has been used in the past at some locations will soon be terminated in favor of finding real water quality problems in the receiving waters for the runoff, determining their cause and developing site-specific BMPs for their control to the MEP.

Evaluation of the Efficacy of Stormwater Runoff Water Quality BMPs

One of the primary uses made of water quality criteria and state standards is as goals to determine the efficacy of stormwater runoff water quality structural BMPs. Traditionally, an effective stormwater runoff water quality management BMP is one that results in a lower concentration of regulated constituents than enters the treatment unit. This approach ignores the fact that decreasing the concentration of regulated constituents often has no impact on the beneficial uses of the receiving waters for the treated stormwater runoff. A prime example of this type of inappropriate approach occurs with detention basins and filters which are designed to remove particulate forms of constituents, such as heavy metals. One hundred percent removal of particulate heavy metals in a filter or detention basin, while highly effective in removing total metal content, has no relevance to water quality since the particulate heavy metals removed are inert in the receiving water system.

Lee and Jones-Lee (1997c) have discussed the development of appropriate goals for urban area and highway stormwater runoff water quality management. As they point out, the efficacy of BMPs should not be based on across-the-unit percent removals of regulated constituents, but instead should focus on the improvement in the designated beneficial uses of the receiving waters for the stormwater runoff. This can only be reliably assessed through site-specific investigations of reduced toxicity, reduced bioaccumulation, etc., neither of which can be assessed through measurement of chemical constituents relative to water quality criteria and standards.

Conclusion

Because of the confusion that exists today in the role that water quality criteria/standards play in regulating urban area and highway stormwater runoff water quality impacts, there is an urgent need to revise the Clean Water Act to allow stormwater dischargers and regulatory agencies to focus the water pollution control programs on the goal of defining and solving water quality problems - use impairments and abandon the misguided goal of achieving water quality standards in the receiving waters for the stormwater runoff. Adoption of this approach will result in much more cost-effective, technically valid management of real water quality problems associated with urban area and highway stormwater runoff than is occurring today.

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