Stormwater Runoff Quality Evaluation and Management
Part III: Issues in Managing Urban Stormwater Runoff Quality

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Parts I and II of this paper [http://www.gfredlee.com/Runoff/stmwat_1.pdf] [http://www.gfredlee.com/Runoff/stmwat_2.pdf] discussed a number of the technical issues that should be considered in developing a technically valid - cost effective stormwater runoff water quality management program. Part III addresses several additional issues that should be considered in developing stormwater runoff management program including stormwater monitoring and modeling, runoff from highways and classification of stormwater sediments as hazardous wastes. Also presented is a discussion of the potential water quality significance of aquatic plant nutrients associated with urban stormwater runoff on receiving water quality as well as information on the appropriate use of aquatic life toxicity tests to assess toxicity in the receiving waters for urban stormwater runoff.

Aquatic Plant Nutrients

The aquatic plant nutrients, nitrogen and phosphorus compounds, are of potential concern in urban stormwater runoff due to their ability to stimulate excessive growth of aquatic plants in receiving waters. The eutrophication (fertilization) of a waterbody can be significantly detrimental to the water quality - beneficial uses. It was found in the 1970's that urban stormwater runoff contains about 100 times the total concentrations of phosphorus that are typically derived from stormwater runoff from forested areas and about 10 times the amount of phosphorus derived from many agricultural areas. It was also found then that substantial parts of the nitrogen and phosphorus present in urban stormwater runoff are in particulate forms that are not available to support aquatic plant growth.

As with most other chemical constituents in urban stormwater runoff, the total concentrations of a constituent, such as nitrogen or phosphorus is an unreliable indicator of potential water quality problems. Sufficient work has been done, however, on the available forms of phosphorus in urban stormwater runoff to be able to estimate the amounts of algal available P in a runoff water. Normally, the algal available phosphorus is equal to the soluble orthophosphate plus about 20% of the particulate phosphorus.

Some groups are calling for the ban on the use of lawn fertilizers in urban areas in an effort to try to reduce the phosphorus content of urban stormwater runoff. As with the impacts of other chemical constituents in urban stormwater runoff, site specific studies have to be conducted in order to determine whether controlling phosphorus to a certain extent in stormwater runoff will have a significant impact on the water quality related beneficial uses for the receiving water of this runoff. It has been found that in order to change the degree of eutrophication of a waterbody to a perceptible amount, it is necessary to reduce the amount of algal available phosphorus

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entering the waterbody by about 25% of the total phosphorus load. It is unlikely that curtailing the use of lawn fertilizers will have a significant impact in most waterbodies receiving urban stormwater runoff since such fertilizers represent a small part of the total phosphorus load present in urban stormwater runoff. Further, except for some urban lakes which essentially only receive urban stormwater runoff, it will be unlikely that reducing the amounts of nitrogen and phosphorus in stormwater runoff will significantly improve the eutrophication related quality of waterbodies.

Stormwater Runoff Monitoring

Primary emphasis in the stormwater runoff quality management programs today is being given to monitoring stormwater runoff for selected parameters. A critical review of the typical stormwater runoff water quality monitoring program, however, shows that the extent and degree of monitoring that is being done provides essentially no useful information on the potential impacts of the stormwater runoff-associated chemical constituents on receiving water quality. Grabbing a few samples of stormwater runoff from a few storms over a year and analyzing them for a few indicator parameters does not properly characterize the concentrations of total chemical constituents of potential concern, much less the concentrations of toxic-available chemical constituents that could be adverse to the designated beneficial uses of the receiving waters for the stormwater runoff.

About all that can be said for the current urban stormwater runoff quality monitoring program is that it confirms what is already well-known: that, based on total constituent analysis, there are chemical constituents in stormwater runoff from urban areas at concentrations that exceed US EPA water quality criteria and state standards based on these criteria. However, as discussed in Part I, the exceedance of a state water quality standard by a chemical constituent in urban stormwater runoff does not mean that a designated beneficial use impairment will occur in the receiving waters for the runoff. To make that assessment, it is necessary to conduct site-specific evaluations of the impact of the stormwater runoff-associated constituents on the beneficial uses for the waterbody receiving the runoff.

The California Stormwater Quality Task Force has been working toward modifying the stormwater runoff monitoring program requirements so that a number of stormwater management agencies could pool their monitoring resources to develop a fund that could be used to conduct site-specific evaluations of the impact of the stormwater runoff-associated contaminants on the beneficial uses of the waterbody receiving the runoff. This is the approach that should be followed. Rather than collecting additional stormwater quality data on the concentrations of selected constituents in runoff waters, which at best only becomes file cabinet fodder, it is far more technically valid and cost-effective to use the monitoring funds to define whether real water quality use impairments are, in fact, occurring in the receiving waters for the stormwater runoff.

Water Quality Impacts of Stormwater Runoff From Highways

Several years ago, the US Federal Highway Department sponsored a number of studies devoted to evaluating the water quality significance of chemical constituents in runoff from

highways. It has been known since the 1960's that runoff from urban streets and highways contains high concentrations of a variety of chemical constituents that, if in toxic-available forms, could potentially be significantly adverse to the designated beneficial uses of waterbodies receiving the runoff. However, the work that was done in the 1960's showed that many of the chemical constituents in the runoff from streets and highways were in non-toxic, non-available forms. This meant that it was not possible to relate the analytically measured concentrations of chemical constituents in highway runoff to water quality impacts.

Unfortunately, however, those responsible for conducting the mid-1980's studies on behalf of the Federal Highway Administration did not properly evaluate whether the elevated concentrations of chemical constituents in highway runoff were in forms that could adversely impact receiving water quality for the runoff. The authors of the studies for the Federal Highway Administration labeled all of the chemical constituents in highway runoff as pollutants, without once finding a real case of water pollution -- use impairment -- in their studies.

The inappropriate labeling of highway runoff constituents as pollutants in the mid-1980's studies is contributing to significant problems for federal and state highway departments since environmental groups are filing suit against state highway departments in order to have the courts force highway departments to control "pollution" from highway runoff arising from the elevated concentrations of alleged "pollutants" in such runoff. It is the authors' experience, however, that it would be indeed rare where highway and street runoff-associated chemical constituents would have a significant adverse impact on the designated beneficial uses of waterbodies receiving such runoff. The fact that heavy metals and many other constituents in highway runoff are in non-toxic forms, coupled with the short-term episodic nature of runoff events, leads to a situation where it is indeed rare that chemical constituents in highway and street runoff are real pollutants that should be controlled through BMP's being used today such as detention basins, grassy swales, etc.

Highway litter, however, does cause significant impairment to the use of waterbodies receiving stormwater runoff where the litter is transported to the waterbody through runoff events. This litter can also be of significance in contributing to flooding due to blockage of highway stormwater inlet structures. At this time primary emphasis in implementing BMP's for highways should be based on litter control and the control of erosion associated with the construction of new highways. There is no technical justification to assume that the construction of detention basins, grassy swales, etc. for "treatment" of highway runoff is in fact controlling pollutants that are significantly detrimental to the beneficial uses of waters receiving highway runoff. Before any structural BMP's are constructed to treat runoff, site specific investigations should be conducted that demonstrate that there is a real water quality use-impairment associated with the current runoff. Where such use impairments are found, then efforts should be made to try to control them through controlling the specific causes of the use impairment. It is unlikely that conventional structural BMP's will be effective in addressing these types of situations.

Stormwater Quality Modeling

There is a substantial literature that is allegedly devoted to stormwater quality modeling. Highly sophisticated computer models have been developed which purport to provide information that is pertinent to urban stormwater quality impact evaluation and management. However, a critical review of these so-called stormwater quality models shows that they are nothing more than chemical constituent models that can describe to some extent the total concentrations of selected chemical constituents at some location in the stormwater runoff system. In order to be able to relate the concentrations predicted based on such models, it is necessary to conduct site-specific evaluations of the relationships between the total concentrations of the constituents of potential concern and the toxic-available forms in stormwater runoff from a particular area.

Further, there is need to relate the concentration of toxic-available forms in stormwater runoff to site-specific use impairments in the receiving waters for the stormwater runoff. The current stormwater quality "models" do not provide this type of information. They are, therefore, largely computer games which have little relevance to providing useful information on stormwater runoff water quality. To be true stormwater quality models, they must incorporate basic information from aquatic chemistry and aquatic toxicology as they relate to true water quality impacts for stormwater-derived chemical constituents. It will be many years before such models will be available that can reliably assess stormwater quality impacts.

There are some who have asserted that equilibrium based water chemistry models such as the US EPA's MINTEQ model can be used to predict the concentrations of toxic - available forms of chemical constituents in urban stormwater runoff. Such assertions are technically invalid since many of the particulate forms of chemical constituents in urban runoff are of unknown chemical characteristics for which there is no thermodynamic equilibrium data. Further, many of the particulate forms present in urban stormwater runoff do not readily equilibrate with other forms of the constituent in the runoff or receiving waters. At this time, the only reliable approach for assessing whether a particular runoff water will be toxic to aquatic life is through the direct measurement of toxicity. This cannot be done through chemical measurements.

Because of the highly variable concentrations of chemical constituents in urban stormwater runoff, various investigators have attempted to characterize the concentrations found in a runoff event through the use of what is called an event mean concentration. While such an approach makes water quality modeling of stormwater runoff events for total constituents more easily achieved, it fails to properly address how chemical constituents in urban, highway and other stormwater runoff sources impact aquatic life-related beneficial uses of waterbodies. It has been known since the 1960's that aquatic organisms respond to the concentration of available form-duration of exposure relationship that they experience. The event mean concentration for a stormwater runoff event is not a reliable approach for assessing the potential impacts of chemical constituents on aquatic life. The event mean concentration approach should be abandoned since it is technically invalid.

Runoff Toxicity

Since it is not possible to reliably predict based on chemical measurements whether a chemical constituent in stormwater runoff is toxic to aquatic life in receiving waters, the use of aquatic life toxicity tests of runoff waters is now beginning to be more widely practiced. These tests can, if used reliably, be used to determine whether the regulated as well as the unregulated chemicals in runoff present a potentially significant threat to aquatic life in the receiving waters due to toxicity. Caution, however, must be exercised in the interpretation of aquatic life toxicity results. The toxicity tests that are typically used significantly overestimate the toxicity that actually occurs in the receiving water due to the fact that the duration of the toxicity tests provide much longer exposure to aquatic organisms than organisms can typically receive in the ambient waters receiving the stormwater runoff. Ordinarily, the stormwater runoff is rapidly diluted in the receiving waters. Associated with the dilution is a loss of toxicity. The aquatic life toxicity tests of the type available today should only be used as a screen for potential toxicity; they should not be used as a direct regulatory limit. If toxicity is found using these tests, then site specific investigations should be conducted to determine whether the toxicity found in the test conditions is in fact occurring in the receiving waters for the stormwater runoff.

Stormwater Runoff Sediments as Hazardous Waste

Increasing concern is evolving about the potential for stormwater runoff sediments that accumulate in detention basins, highway drop inlets, grassy swales, etc. being classified as a hazardous waste because of excessive concentrations of chemical constituents. Classification of a stormwater detention basin sediment as a hazardous waste can represent a significant increase in the cost of managing the sediments. Often managing a hazardous waste costs about 10 to 50 times more than using them as fill or placing them in municipal solid waste landfills. The US EPA, as part of implementing RCRA, has developed various procedures for classifying materials such as soils and sediments as hazardous waste. While there is potential concern about stormwater sediments from certain types of industrial properties being classified as a hazardous waste based on the origin of the sediment (the Derived-From Rule), the greatest concern for urban stormwater sediments collected in structural BMP's is the leaching characteristics under the Toxicity Characteristics Leaching Procedure (TCLP) test.

This test was originally developed as an administrative test that was to be used to determine whether a solid waste should be placed in a hazardous waste landfill or could be placed in a municipal landfill. The Agency in developing this test was not trying to reliably delineate whether a material in a sediment or soil is hazardous. Rather, the Agency was trying to limit the size of the hazardous waste stream that had to be managed as hazardous waste where the focus of the resources available would be on those wastes that represent the greatest hazard. Unfortunately, this test is being used for a variety of other purposes for which it was not intended and for which it is inappropriate, such as the classification of soils and sediments as to whether they are "hazardous" or not. A sediment or soil that passes the TCLP test can be highly hazardous to public health and the environment dependent on how it is managed.

Another common mistake made in using the TCLP test to classify a material as hazardous waste or not is that it is assumed that because it would be classified as hazardous according to TCLP that it would be hazardous to aquatic life. TCLP classification is based on the leaching of

selected chemical constituents from the solid material under certain conditions which mimic to some extent the environment present in a municipal solid waste landfill, where the concern is that the leached constituents would become part of a groundwater-based domestic water supply. This approach has no relationship to whether the material is hazardous to aquatic or terrestrial life. The TCLP test focuses primarily on the potential for chemical constituents to cause cancer in people who are exposed, over their lifetime through drinking water. These constituents are primarily Priority Pollutants. The critical concentrations for many of the Priority Pollutants regulated through the TCLP test have no relationship to the critical concentrations for the same constituents to aquatic life. In some cases aquatic life is more sensitive, and in others it is less sensitive than the TCLP values used for classification of a material as hazardous waste.

The situation of sediments in detention basins, etc. of being classified as hazardous waste is even more complicated in some states, such as California where the state has developed its own set of hazardous waste classification values. California uses a somewhat different leaching test and also has a set of total concentrations of chemical constituents in sediments or soil which cause the sediment or soil to be classified as a hazardous waste. These values developed through the Department of Health Services' Title 22 regulations are often highly arbitrary and have limited technical merit for properly assessing whether a sediment or soil is a real hazard to public health. A detention basin sediment that passes the TCLP test may fail the state of California Title 22 hazardous waste classification and would have to be managed as a hazardous waste. However, independent of the arbitrariness of these classification values, they are regulatory requirements that those who manage sediments in stormwater detention basins have to consider in the disposal of the sediments.

Lead is one of the constituents of greatest concern in urban stormwater runoff with respect to causing sediments that accumulate in a detention basin to be classified as a hazardous waste. Urban soils and soils near highways often contain lead at concentrations of at least 500 and frequently 1,000 - 1,500 mg/Kg. Ordinarily, this lead, which was originally derived from being an additive in leaded gasoline, does not leach sufficiently in the TCLP test to exceed the US EPA's arbitrary 5 mg/L established hazardous waste classification limit. It does frequently cause sediments to exceed the California DHS Title 22 limit of 1,000 mg/Kg for classification of the sediments as hazardous waste.

The TCLP limits are based on an arbitrary assumption that leaching in excess of 100 times the drinking water standard (MCL) should result in the material being classified as a hazardous waste. The 5 mg/L leaching standard for lead in the TCLP test was based on the US EPA's drinking water maximum contaminant level (MCL) of 50 µg/L. Some years ago the US EPA decreased the lead drinking water "MCL" to 15 µg/L. The Agency has been inconsistent in how it addresses this issue since it did not adjust the TCLP hazardous waste classification level for lead to 1.5 mg/L. It is the authors' experience that while frequently lead in the TCLP test does not leach to a sufficient extent to exceed the 5 mg/L standard, it often does leach to a sufficient extent to exceed a 1.5 mg/L standard that would logically evolve from the Agency's following a consistent approach of using 100 times the drinking water MCL as the TCLP allowable leaching.

The approach that should be used to evaluate the potential public health and environmental impact of chemical constituents present in sediments associated with stormwater treatment

structures such as BMP's is to make a site-specific evaluation of the hazards that these constituents represent at the various locations where the sediments could be placed. The stormwater runoff quality regulated community should work with federal and state agencies to eliminate the use of the arbitrary approaches that are in effect today for classification of stormwater-derived sediments as hazardous waste.

Overall

The implementation of the 1987 Clean Water Act requirement for controlling pollution of the nation's waters by urban and industrial stormwater runoff faces a number of complex technical issues that need to be resolved in order to cost-effectively manage real water quality problems associated with stormwater runoff. At this time, this country is far away from developing a specific definition of approaches that should be used to implement controlling stormwater runoff caused pollution to the maximum extent practicable. The key issue in developing a stormwater runoff management program that must be evaluated as the highest priority is whether the current stormwater runoff is in fact having a significant adverse impact on the designated beneficial uses of the waterbody receiving the runoff. Failing to properly define real pollution associated with stormwater runoff can lead to massive waste of public and private funds in regulating stormwater runoff.

Lee, G. F. and Jones-Lee, A., "Stormwater Runoff Management: The Need for a Different Approach," Water/Engineering & Management 142(3):36-39 (1995).
http://www.gfredlee.com/Runoff/stmwat_1.pdf

Lee, G. F. and Jones-Lee, A., "Implementing Urban Stormwater Runoff Quality Management Regulations," Water/Engineering & Management 142(4):38-41 (1995).
http://www.gfredlee.com/Runoff/stmwat_2.pdf

Lee, G. F. and Jones-Lee, A., "Issues in Managing Urban Stormwater Runoff Quality," Water/Engineering Management 142(5):51-53 (1995)
http://www.gfredlee.com/Runoff/stmwat_3.pdf