

# Issues in Monitoring Hazardous Chemicals in Stormwater Runoff/Discharges From Superfund and Other Hazardous Chemical Sites

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*Deficiencies in design and execution render stormwater-runoff monitoring programs for many hazardous chemical sites inadequate for assessing the potential environmental quality and public health impacts of chemicals in the runoff. Two pervasive problems are the use of analytical methods that are inadequate for measuring certain hazardous chemicals at potentially hazardous concentrations, and the application of "criteria/standards" that are inappropriate for evaluating the environmental/public health impacts of chemicals. These concerns are most notable for carcinogens and chemicals that bioaccumulate in edible aquatic organisms, including arsenic, chromium, beryllium, mercury, dioxins, organochlorine pesticides (such as DDT), and polychlorinated biphenyls; unrecognized pollutants; and nanomaterials. In order to appropriately evaluate whether the runoff/discharge from a hazardous chemical site is a threat to human health, the analytical methods must be sufficiently sensitive in critical concentration ranges; sampling regimens need to be sufficiently rigorous to provide reliable characterization of the content of the runoff, receiving water, and, for bioaccumulatable chemicals, levels in edible organisms in receiving water. Proper sampling and analysis will then provide data to enable the appropriate criteria/standards to be applied. © 2010 Wiley Periodicals, Inc.*

## INTRODUCTION

For more than 45 years, the authors have been involved in conducting studies of the water-quality and public health impacts of potentially hazardous chemicals in waste management/disposal areas (e.g., landfills and waste ponds), and in industrial areas where potentially hazardous materials/chemicals have been manufactured, used, or spilled. At such sites, there is concern about releases of chemicals from the site through stormwater runoff/discharge and the associated pollution of groundwater and surface water. However, in the authors' experience, in some situations inadequate attention has often been given by site investigators and regulatory agency staff to the design and conduct of studies; owing to deficiencies in their design and execution, many investigations cannot be reasonably expected to provide a reliable assessment of the potential environmental quality and public health impacts of chemicals in surface-water runoff from the area, as well as in groundwaters that are impacted by past waste/chemical disposal/management.

Summary reviews of our experience in evaluating and monitoring stormwater runoff from hazardous chemical sites are available as Lee and Jones-Lee (1997, 1998, 2004).

Two key problems commonly encountered in such studies are the use of analytical methods that are inadequate for reliably measuring the hazardous chemicals at the low concentrations that are potentially hazardous, and the application of “criteria/standard” that are inappropriate for evaluating the environmental/public health impacts of chemicals in stormwater runoff/discharges from hazardous chemical sites.

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At a number of locations, it is apparent that those responsible for conducting/supervising site investigations have relied upon standard U.S. Environmental Protection Agency solid waste testing analytical procedures for assessing release of site chemicals into stormwater runoff/discharges. They also have relied on US EPA drinking water maximum contaminant levels (MCLs) for evaluating the potential for contaminants in groundwaters and runoff/discharge waters to cause cancer in those who use the groundwater or receiving waters for domestic water supply. Such approaches do not reflect an understanding of the reliability limitations of the testing protocols or of the relationships between US EPA drinking-water MCLs for some of the carcinogens (e.g., arsenic and chromium) and the cancer risk potential of those chemicals in water supplies. They also do not recognize the critical importance of reliable detection and quantification of some potential carcinogens in runoff/discharge waters and discharges to groundwaters and in receiving waters in concentrations at and below the MCL values. This report reviews these types of problems and their significance in water-quality protection and management.

## EVALUATION OF HAZARDS OF HUMAN CARCINOGENS IN DRINKING WATER AND SURFACE WATER

A major problem exists in regulating the human health hazards of some chemicals, including arsenic, chromium, and others discussed later. Regulatory agencies typically regulate stormwater runoff/wastewater discharges with respect to protecting drinking-water quality, based on the US EPA MCLs for specific chemicals. However, the MCLs are often considerably higher than the US EPA cancer-risk-based water-quality criteria for those chemicals. This disparity is a result of the US EPA’s establishment of drinking-water MCLs at levels that consider not only human health impacts, but also the costs to remove pollutants during drinking-water treatment. Therefore, drinking water containing concentrations of some carcinogens, such as arsenic and chromium, at levels at or even somewhat below the MCLs, may increase cancer risk.

### *Arsenic*

Arsenic is a common constituent naturally present in many water supplies at concentrations of a few  $\mu\text{g/L}$ . The drinking-water MCL for arsenic is  $10 \mu\text{g/L}$ . However, the US EPA (2009) risk-based criterion for arsenic—the risk of one additional cancer in a million people consuming 2 L of the subject water per day over a lifetime (70 years)—is  $0.018 \mu\text{g/L}$ .

Thus, drinking water that “meets the arsenic MCL” can still pose an increased risk of developing cancer. The US EPA’s justification for allowing an elevated cancer risk associated with consuming drinking water with  $10 \mu\text{g/L}$  of arsenic is that it would be too expensive to require that municipal water authorities greatly increase the cost of water

treatment to achieve a more normal cancer risk of one additional cancer in a million people who consume 2 L/day over 70 years.

## Chromium

As with arsenic, there is a significant difference between the existing US EPA MCL for chromium and levels of chromium in drinking water that are associated with increased cancer risk. The California Office of Environmental Health Assessment (OEHHA) has the responsibility for establishing critical concentrations for chemicals in drinking water. The OEHHA recently reviewed the human health hazards associated with chromium in drinking water and proposed to establish a public health goal (PHG) for hexavalent chromium (Cr VI) of 0.06  $\mu\text{g/L}$  based on its potential to cause cancer in people who drink water containing chromium VI ([http://oehha.ca.gov/public\\_info/facts/chrom6facts.html](http://oehha.ca.gov/public_info/facts/chrom6facts.html)). The OEHHA is currently reviewing this proposed PHG for chromium. Information on this review is available on the OEHHA Web site at <http://www.oehha.ca.gov/water/phg/cr6com112409.html>. The US EPA's total chromium MCL is 100  $\mu\text{g/L}$ . Regulating chromium in stormwater runoff and discharges to meet the US EPA drinking-water MCL of 100  $\mu\text{g/L}$  could increase the cancer risk for those who use the receiving waters as a source of drinking water by several orders of magnitude.

## Beryllium

Beryllium is a carcinogen that is commonly associated with coal ash. It could, therefore, be present in stormwater runoff from areas that contain coal ash wastes. The US EPA water-quality criterion for beryllium is 4  $\mu\text{g/L}$ . The OEHHA reviewed the MCL for beryllium in 2003 and established an MCL of 1  $\mu\text{g/L}$ . The OEHHA reviewed that value in 2009 and found it to still be appropriate.

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## Chloroform

Some Superfund site potentially responsible parties (PRPs) approach the control of chloroform derived from a waste source as though it were a drinking-water-disinfection by-product (i.e., as total trihalomethanes, or TTHMs) rather than as the waste-derived chemical that it is in such cases. The reason for this is that the MCL used for regulating TTHMs in drinking water is substantially higher than the US EPA risk-based water-quality criterion for chloroform.

The disinfection of drinking water that contains natural organic matter (such as typical surface waters with a total organic carbon content of several  $\text{mg/L}$ ) using chlorine leads to the formation of chloroform, and, if bromide is present, chlorobromo compounds. The US EPA stated the following with regard to health impacts of consuming TTHMs (the sum of chloroform, bromodichloromethane, dibromochloromethane, and bromoform) that originate from disinfection:

*Total Trihalomethanes. Some people who drink water containing trihalomethanes in excess of EPA's standard over many years may experience problems with their liver, kidneys, or central nervous systems, and may have an increased risk of getting cancer. (<http://www.epa.gov/safewater/hfacts.html>)*

Consuming drinking water that just meets the US EPA MCL for TTHMs carries with it a greater cancer risk than does drinking water that just meets the criterion established for chloroform as a hazardous chemical.

The current US EPA drinking-water MCL for TTHMs is 0.08 mg/L (80 µg/L). That value was a compromise based on balancing the achievement of effective disinfection of a water supply to control pathogens, with the health risk of residual TTHMs in the treated water (see [http://www.epa.gov/safewater/mdbp/qrg\\_st1.pdf](http://www.epa.gov/safewater/mdbp/qrg_st1.pdf)).

By contrast, the US EPA risk-based water-quality criterion for chloroform is 5.7 µg/L (<http://www.epa.gov/waterscience/criteria/wqctable/nrwqc-2009.pdf>).

The US EPA criterion for TTHMs was established as a level associated with the risk of one additional cancer in one million people who consume 2 L of the affected water per day over 70 years. The cancer risks associated with the other components of the TTHMs are similar or even greater than the risks from chloroform. Therefore, consuming drinking water that just meets the US EPA MCL for TTHMs carries with it a greater cancer risk than does drinking water that just meets the criterion established for chloroform as a hazardous chemical.

An example of responsible-party attempts to select the least stringent of available "criteria" for cleanup of chloroform wastes was encountered at the University of California, Davis/Department of Energy (UCD/DOE) Laboratory for Energy-Related Health Research (LEHR) National Priorities List (NPL) Superfund site on the UCD campus. UCD dumped waste chloroform from campus veterinary medicine activities in campus landfills at the LEHR site. That practice resulted in the creation of a mile-long chloroform plume in the primary groundwater aquifer of the area. UCD attempted to convince the regulatory agencies to accept the TTHM drinking-water MCL as the basis for assessing groundwater cleanup for chloroform, rather than the US EPA risk-based water-quality criterion for chloroform. The California Central Valley Regional Water Quality Control Board (CVRWQCB), with the concurrence of the US EPA Region 9, did not allow UCD to use the TTHM MCL as an appropriate criterion for regulating waste-derived chloroform.

Based on how the US EPA TTHM MCL was developed and the findings of the CVRWQCB, the TTHM MCL should be used to regulate chloroform levels only in drinking water. It should not be used in association with disposal of waste chloroform. It should also not be used for regulating domestic wastewater sources that contain TTHMs that either originated from the disinfection of drinking water and were carried through to the wastewater treatment plant discharge or was formed during disinfection of the domestic wastewaters. Chloroform derived from a waste source should be regulated using the risk-based water-quality criterion of about 6 µg/L.

## LEAD

Lead is another chemical in which there is a major difference between the US EPA "MCL" and the projected hazardous concentration in drinking water. The US EPA has established a drinking-water action level of 15 µg/L. The US EPA has established a PHG in drinking water of 0 mg/L. The OEHHA has established a California PHG of 0.2 µg/L. This value is based on lead's potential to cause neurological damage in children (<http://www.epa.gov/safewater/contaminants/index.html>, <http://www.oehha.ca.gov/risk/ChemicalDB/withPHG.asp?name=Lead+and+lead+compounds&number=7439921>).

# EVALUATION OF HAZARDS OF CHEMICALS THAT BIOACCUMULATE IN AQUATIC LIFE

## Dioxins

Dioxins and furans are among those chemicals that are carcinogens but that are rarely monitored in stormwater runoff, even from areas where they can be expected to be present, such as certain types of industrial facilities and areas where combustion residues are present. For example, runoff/discharges from the McCormick Baxter Creosoting Company Superfund site located at the Port of Stockton, California, has caused the fish in the Port's Deep Water Ship Channel to contain sufficient amounts of dioxins to cause them to be hazardous to consume (<http://projects.publicintegrity.org/Superfund/Site.aspx?act=0901129> and [http://yosemite.epa.gov/r9/sfund/r9sfdocw.nsf/b488311d281d26d7882574260072fae1/a58ffd847a0751cc882570070063c2b0/\\$FILE/mccorm699.pdf](http://yosemite.epa.gov/r9/sfund/r9sfdocw.nsf/b488311d281d26d7882574260072fae1/a58ffd847a0751cc882570070063c2b0/$FILE/mccorm699.pdf)).

The US EPA Recommended National Water Quality Criteria (US EPA, 2009) lists the water-quality criterion for 2,3,7,8-TCDD (dioxin) as  $5 \times 10^{-9}$   $\mu\text{g/L}$  for prevention of excessive bioaccumulation of dioxins in edible aquatic organisms. Due to this low criterion, fish taken from areas containing likely sources of dioxins should be monitored for dioxins. The U.S. EPA has established a drinking-water MCL for dioxin at  $3 \times 10^{-5}$   $\mu\text{g/L}$ , four orders of magnitude higher than the criterion for prevention of excessive bioaccumulation in fish tissue.

## Mercury

Mercury is another hazardous chemical that is often inadequately investigated at hazardous chemical sites. It is of concern because it bioaccumulates in edible fish; when affected fish are consumed, the excessive mercury can cause neurological damage in fetuses and young children (<http://yosemite.epa.gov/water/owrccatalog.nsf/1ffc8769fdecba48085256ad3006f39fa/4da7bfbdf51b8c2185256b060072307f!OpenDocument>).

While the US EPA—established California Toxic Rule (CTR) limit for mercury in surface-water runoff discharges that is Clean Water Act “water-quality-limited” is 50 ng/L, the US EPA Region 9 remediation program manager (RPM) and California regulatory agencies the CVRWQCB, the California Department of Toxic Substances (DTSC), and the California Department of Public Health (DPH) have allowed the use of an analytical method for mercury that has a lower detection limit of 200 ng/L, four times higher than levels that are of concern based on the CTR criterion.

Since 1995, the authors have served as US EPA—supported Technical Assistance Grant (TAG) advisors to the Davis South Campus Superfund Oversight Committee (DSCSOC), the group representing the public's interests in evaluating the adequacy of LEHR Superfund Site investigation/remediation. For the past 15 years, and despite evidence of elevated mercury concentrations in receiving-water fish, the federal and state regulatory agencies Lee and Jones-Lee (2008a, 2008b, 2009a, 2009b) reviewed the matter of mercury in stormwater runoff from the LEHR NPL Superfund site and the monitoring of stormwater runoff from the site that is needed to adequately characterize the mercury input to the receiving water at Putah Creek, which is Clean Water Act-listed

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Analytical methods for mercury that have detection limits greater than 5 ng/L are inadequate for the characterization of the potential mercury hazards in runoff from a site where there is potential for bioaccumulation of mercury in edible fish.

as a water-quality-limited waterbody due to excessive mercury bioaccumulation in some edible fish taken from the creek.

As discussed by Lee (2009a, 2009b) the stormwater runoff monitoring prescribed by LEHR site RPMs and allowed by the CVRWQCB is not adequate for a site known to contain hazardous materials. For example, it prescribes collection of only one grab sample at some time during a couple of stormwater runoff events per year. Such an approach is more characteristic of the monitoring required for stormwater runoff from an urban area. It is not a program of the type prescribed by the US EPA (1992) for monitoring stormwater runoff from industrial sites. The monitoring program recommended by the US EPA for industrial sites involves collecting samples of true first-flush runoff and runoff at several times during the runoff event. Further, a sufficient number of events must be monitored in this way each year to properly characterize the hazardous chemical content of the stormwater runoff.

In addition to the inadequacies of the monitoring program, the 50 ng/L CTR mercury criterion used for interpretation of monitoring results is not adequate to prevent excessive bioaccumulation of mercury in edible fish in receiving waters for the runoff (P. Wood, US EPA Region 9, personal communication). At this time, the critical concentration of total recoverable mercury to prevent excessive bioaccumulation in some fish is about 5 ng/L. Analytical methods for mercury that have detection limits greater than 5 ng/L are inadequate for the characterization of the potential mercury hazards in runoff from a site where there is potential for bioaccumulation of mercury in edible fish.

At the time that the US EPA Region 9 adopted the CTR mercury criterion, the Agency indicated that that criterion was only temporary and needed to be revised. Since then, the Agency has indicated that it plans to change the approach for regulating bioaccumulating chemicals, from a water-concentration-based approach to an organism-tissue-based approach. However, to date, neither the CTR criterion approach nor the criterion values has been revised, with the result that the current mercury criterion is not protective and is out of date.

### *Other Bioaccumulatable Chemicals*

For some bioaccumulatable chemicals, such as polychlorinated biphenyls (PCBs), the concentrations in stormwater runoff water that can bioaccumulate to excessive concentrations in receiving-water organisms can be less than the water analytical methods detection limits. Therefore, to evaluate potential impacts of chemicals that can bioaccumulate in edible tissues of aquatic organisms, it is necessary to measure the concentrations of the hazardous chemicals in the edible tissues of aquatic life in the receiving water. Several years ago, the US EPA proposed to change the basis for regulation of some bioaccumulatable chemicals from concentrations in the receiving waters or runoff/discharge to concentrations in edible fish tissue. This is a far more reliable way to identify water-quality problems of bioaccumulatable chemicals in waters receiving runoff/discharges.

An example of this situation is the California CVRWQCB monitoring program for stormwater runoff from irrigated lands in the Central Valley. As discussed by Lee and Jones-Lee (2009c), that monitoring program was focused primarily on previously and currently used pesticides in stormwater runoff, particularly the organochlorine legacy pesticides, such as DDT, and the industrial chemical PCBs. The edible tissue of some fish

in many of the waterbodies in the California Central Valley contains high concentrations of DDT (Lee & Jones-Lee, 2002). Runoff from agricultural lands in the Central Valley has been found to contain DDT in concentrations that can potentially bioaccumulate to levels in fish deemed to pose a risk. The CVRWQCB Irrigated Lands runoff water-quality monitoring program only requires the measurement of the DDT concentrations in a few grab samples of runoff waters each year. Since the lower detection limit of the analytical method for DDT is higher than concentrations that can bioaccumulate to excessive levels in edible fish, irrigated farmland can be contributing to the excessive DDT in receiving-water fish despite the fact that runoff from those lands is reported to contain "nondetectable" amounts of DDT. In situations such as this, it is essential to measure the concentrations of DDT in the fish of the receiving waters.

Another reason that measuring DDT in water is unreliable for assessing its impact is the fact that finding DDT in water samples in concentrations above the US EPA water-quality criterion (US EPA, 2009) does not mean that the DDT is in a form that can bioaccumulate to excessive levels in fish. Particulate forms of DDT and many other potential pollutants in the water column tend not to be bioavailable to adversely affect aquatic life in the water column. Much of the DDT that accumulates in aquatic life is taken up through the benthic organism food web; this mechanism can be independent of water-column concentrations. This is also true for similar chemicals, such as PCBs. Further, the total organic carbon content of water column and bedded sediments influences the amount of DDT and similar chemicals that are available to be bioaccumulated in the food web.

In order to determine if the PCBs and other bioaccumulatable chemicals in aquatic sediments are bioavailable it is necessary to use the US EPA-recommended bio-uptake studies of the type conducted by Lee et al. (2002) using *Lumbriculus variegatus*.

Traditionally, the regulation-allowed concentrations of hazardous chemicals in edible fish and other aquatic life are rooted in a risk-based assessment of the potential for the chemical to cause adverse impacts to humans who use the organisms as food. Recently, the OEHHA changed its approach for establishing recommended safe-consumption guidelines to consider not only the human health hazard associated with the chemical in fish, but also the health benefits of eating fish. That approach is discussed at <http://oehha.ca.gov/fish/general/99fish.html>.

This "balancing" of adverse and beneficial impacts associated with eating fish that contain chemicals that are hazardous to humans in establishing allowable consumption rates is impacting the decisions on the need to regulate some bioaccumulatable chemicals, such as DDT, in agricultural runoff. The OEHHA fish-consumption guidelines did not impact the allowable PCB concentrations in edible fish.

A problem that has occurred at several hazardous chemical sites in assessing the potential impacts of stormwater runoff-associated chemicals is the use of the US EPA toxicity characteristic leaching procedure (TCLP) to determine if the leaching of a hazardous chemical in a waste, soil, or sediment poses a risk due to the mobility of the chemical in a particularly media. Lee and Jones-Lee (2009d) reviewed the inappropriateness of using TCLP results to characterize the potential pollution of hazardous chemicals, such as PCBs, in a waste or soil. As discussed, the TCLP results are not reliable for classifying a waste as "hazardous" or "nonhazardous," much less for assessing whether or not chemicals that can bioaccumulate in receiving-water organisms may be a threat to those who eat those organisms.

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## INADEQUATELY CONSIDERED PARAMETERS

### *Unrecognized Pollutants*

Of key importance in developing a stormwater runoff monitoring/remediation program for areas from which potentially hazardous chemicals may enter stormwater runoff is the selection of the parameters that should be monitored.

It is widely advanced by PRPs and regulatory agency staff for Superfund and other hazardous chemical sites that pollutants are not being discharged from a given site to the environment if the runoff/discharge from the site meets drinking-water MCLs and water-quality criteria for the conventional and "priority pollutants." However, such a position can be in significant error for many hazardous chemical sites. Not only are there problems with detection of some chemicals at the low levels at which they can pose a risk, as discussed earlier, but also only a small fraction of the potential pollutants that are introduced into the environment through manufacture, use, and waste disposal have MCLs and/or water-quality criteria or are otherwise regulated or even monitored in waterbodies, wastewaters, or runoff. Furthermore, there are potentially myriad as yet unrecognized or as yet unidentified chemicals that cause, or may cause, adverse public health or environmental quality impacts in waters receiving stormwater runoff.

Of key importance in developing a stormwater runoff monitoring/remediation program for areas from which potentially hazardous chemicals may enter stormwater runoff is the selection of the parameters that should be monitored. The Lee/Jones-Lee *Stormwater Runoff Water Quality Newsletter* (e.g., issues 7-3, 8-5, 9-3, 10-7, 11-7/8, 11-11, and 12-6; available at <http://www.gfredlee.com/newsindex.htm>) discusses many of the deficiencies in the approaches being used for monitoring and regulating stormwater runoff/discharges, as well as key aspects of developing more appropriate stormwater monitoring programs for more reliable protection of public health and environmental quality. Newsletter 7-3 presents an overview of these issues.

Dr. Christian Daughton, chief of the Environmental Chemistry Branch, National Exposure Research Laboratory, Office of Research and Development, US EPA, Las Vegas, Nevada, has also discussed the inadequacy of water-quality monitoring programs in identifying and quantifying the range of chemicals in wastewaters/stormwater runoff that could be impacting public health and the environment. For example, in his presentation at the US EPA National Center for Environmental Research (NCER) STAR workshop (Daughton, 2005), he stated:

#### Further Truisms Regarding Environmental Monitoring

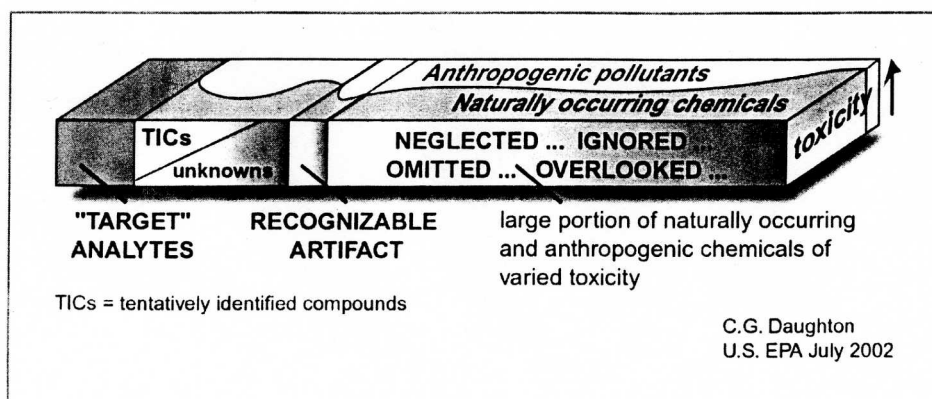
- What one finds usually depends on what one aims to search for.
- Only those compounds targeted for monitoring have the potential for being identified and quantified.
- Those compounds not targeted will elude detection.
- The spectrum of pollutants identified in a sample represent but a portion of those present and are of unknown overall risk significance.

Exhibit 1, extracted from Daughton's presentation slides, illustrates this point.

Background information on unrecognized/unregulated chemicals as environmental pollutants is available at <http://www.epa.gov/nerlesd1/chemistry/pharma/critical.htm> and at <http://www.epa.gov/nerlesd1/chemistry/ecb-posters.htm>.

While water-quality monitoring programs for hazardous chemical sites typically focus on a hundred or so of the millions of chemicals in commerce today, periodically "new"





**Exhibit 1.** Chemical analysis output for a typical environmental sample (Daughton, 2005)

chemicals (which may have been present in waterbodies for many years) are identified. Recently “discovered” pollutants include perchlorate, several flame retardants (polybrominated diphenyl ethers [PBDE] and its replacement, tris (1,3-dichloropropyl) phosphate [TDCPP]), and pharmaceuticals and personal care products (PPCPs) that are both deliberately and inadvertently placed in liquid and solid waste streams. Concerns for these types of pollutants and monitoring in the San Francisco Bay Estuary have recently been raised in San Francisco Estuary Institute (2009) and San Francisco Estuary Partnership (2009).

## Nanomaterials

Nanomaterials are very small-sized particles that are being used in increasingly varied applications. While it is known that these types of materials are getting into the environment, little is known at this time about their impact on water quality. They do have the potential to become significant water pollutants, and are becoming recognized as a “new” group of pollutants. The California DTSC has been given the responsibility by the state legislature to assess the potential hazards posed by these materials to public health and the environment. The DTSC has organized a series of symposia on nanomaterials. The most recent of these symposia, “California Nanotechnology Initiative Symposium V: An Industrial Perspective,” was held on November 16, 2009. The agenda and the PowerPoint slides of the presenters are available at [http://www.dtsc.ca.gov/TechnologyDevelopment/Nanotechnology/upload/NanoV\\_Industry\\_DTSC\\_agenda.pdf](http://www.dtsc.ca.gov/TechnologyDevelopment/Nanotechnology/upload/NanoV_Industry_DTSC_agenda.pdf).

The Internet contains a large amount of information on nanomaterials and their potential public health and environmental impacts. In addition, *Stormwater Runoff Water Quality Newsletters* 12-3 and 12-4 also provide background information on this issue.

Because of the recentness of the development and use of nanomaterials, it is unlikely that stormwater runoff from Superfund or other hazardous chemical sites is presently being impacted by nanomaterials. However, stormwater runoff from areas affected by leaking domestic sewerage systems, from urban areas, and areas where reclaimed domestic wastewaters are used for landscape irrigation could contain nanomaterials that could be impacting receiving water quality. Also of concern are areas where

nanomaterials are being manufactured and used in such a manner so as to be present in stormwater runoff from these areas.

### ***Priority Pollutants***

It is important that those involved in the selection of parameters for monitoring at hazardous chemical-containing facilities have an understanding of the origin and limitation of the list of "priority pollutants," lest it become sacrosanct.

It is important that those involved in the selection of parameters for monitoring at hazardous chemical-containing facilities have an understanding of the origin and limitation of the list of "priority pollutants," lest it become sacrosanct. The list of "priority pollutants" evolved from the 1972 amendments to the federal Water Pollution Control Act, now called the Clean Water Act, by which Congress mandated that the US EPA develop a list of the most significant water pollutants. When the US EPA failed to meet the legislative deadline for developing that list, an environmental group filed suit to force the Agency to comply. The final list of 129 "priority pollutants" (currently 128) was then hurriedly compiled, not through rigorous discussion and review in the technical (scientific and engineering) community, but rather through closed (nonpublic) negotiations between attorneys representing the environmental group and the US EPA. While that list of "priority pollutants" may have met the legislative mandate, it was not peer-reviewed to ensure that those chemicals listed were considered by the technical community to be the greatest threats to water quality or to ensure that there were not others that were as, or more, deserving of a place on the list.

In late 1970s, the National Oceanic and Atmospheric Administration (NOAA) organized an expert technical panel to review the chemical pollutants in the New York Bight; Dr. G. Fred Lee sat on that panel, representing the Corps of Engineers. That panel issued a report entitled "Chemical Pollutants of the New York Bight; Priorities for Research, NOAA Dept. of Commerce, Boulder, CO (1979)" that addressed the validity of the priority pollutant list as a representation of the most hazardous chemicals in the New York Bight and the United States in general. The panel concluded that the way the priority pollutant list was developed was inappropriate, and that the list did not necessarily represent an appropriate compilation of hazardous chemicals that should be the focus of water-associated environmental pollutants. The list narrows the perspective and focus of hazardous chemical site investigations and limits the attention given to determining other chemicals that potentially should be investigated at hazardous chemical sites, and may provide a false sense of security regarding the impact of wastes that enter water environments. (Information on the list of priority pollutants is available at [http://www.scorecard.org/chemical-groups/one-list.tcl?short\\_list\\_name=pp](http://www.scorecard.org/chemical-groups/one-list.tcl?short_list_name=pp).)

The experience at the UCD/DOE LEHR NPL Superfund site illustrates the consequences of the failure to properly consider the complete universe of chemicals posing risks at a hazardous chemical site. UCD dumped solid and other wastes from its campus in pits at the LEHR site. It was subsequently found that the groundwater of the area was polluted with tritium and carbon-14, which presumably had been associated with dumped wastes from university radioisotope tracer studies. As TAG advisors to the public on the adequacy of site investigation, the authors suggested that 1,4-dioxane (a solvent used in scintillation counting of tritium and carbon-14 studies) be included in groundwater monitoring even though it is not on the priority pollutant list, as it is a potential carcinogen and, based on the wastes received, it could be expected to be present. Test results revealed that, as expected, 1,4-dioxane is present in potentially significant concentrations in groundwaters at some locations at the LEHR site.

Information that the Agency for Toxic Substances and Disease Registry (ATSDR) has developed on 1,4-dioxane is available at <http://www.atsdr.cdc.gov/tfacts187.html>.

## SUMMARY

Overall, there can be little doubt that there are carcinogens and other hazardous chemicals are present in many complex sources of wastes that can cause cancer in humans. It is important that evaluation, management, and regulation of releases from hazardous chemical sites to the environment include not only consideration of the conventional pollutants, and designated priority pollutants, but also appropriate attention to unrecognized and unregulated chemicals and unidentified "peaks" that appear in the analysis of conventionally measured potential pollutants. Funds should be set aside for proper follow-up for identifying such peaks and subsequent investigation of associated potential health impacts.

Monitoring programs also need to incorporate greater and more deliberate communication between study managers and laboratory staff. The design of hazardous chemical site investigations is typically compartmentalized, with little communication among those who collect samples, analyze samples, and receive laboratory reports for interpretation and discussion. Often laboratory staff can provide valuable insight on the appearance of other chemicals in the samples that are not on the designated analyte list or of analytical anomalies that should be followed up.

In order to appropriately evaluate whether the runoff/discharge from a hazardous chemical site is a threat to human health, it is imperative that the analytical methods used are sufficiently sensitive to determine whether potential carcinogens are present at concentrations that could cause cancer in humans who drink the water and eat fish that have bioaccumulated the hazardous chemical(s) in edible organisms. Even when all of the "known" commonly analyzed chemicals in runoff/discharge waters from a hazardous chemical site meet current regulatory risk-based criteria there could readily be unmonitored/unregulated chemical carcinogens present. While controversial because of the potential for "reopening" sites with regulatory closure, consideration should be given to considering reevaluating runoff/discharge from hazardous chemical sites and remediated sites every few years, including former Brownfield properties that contain complex mixtures of wastes, in light of new information on the adequacy of previously used analytical methods and hazard criteria that warrants reexamination of the current situation. While some advocate continuing to use outdated, less reliable analytical techniques under the assumption that doing so provides data that are more reliably compared to past studies, such an approach is not technically defensible when the data generated by new methods are more sensitive and reliable.

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