



# STATE OF THE NATION'S RIVER 2009

## EMERGING CONTAMINANTS IN THE POTOMAC RIVER

### A TOXIC STEW IS BREWING IN OUR RIVERS

Phthalates, ethinylestradiol, bisphenol, atrazine. The names may sound exotic, but they are the stuff of modern life...found in shampoo, birth control pills, suntan lotion, food containers, product fragrances, children's clothing and more. Every day, we are showered with hundreds of thousands of chemicals. *Additionally, more than 1,000 new compounds are introduced annually.*

Many of these compounds, when acting alone or in tandem with other chemicals, mimic or disrupt the normal functions of the endocrine system. We know that these compounds interfere with the development of many aquatic species, most notably male smallmouth bass that have developed eggs. This condition, known as intersex, has been documented in the Potomac River watershed and beyond.

Almost every place that water and chemicals combine is a potential source of endocrine disrupting compounds (EDCs) in our drinking water. Approximately 90% of the DC area's drinking water supply originates in the Potomac River, so it is critical for human health that the river water does not contain harmful contaminants.

Make no mistake, DC-area drinking water complies with the current set of rules as laid out in the Safe Drinking Water Act (SDWA) and as enforced

by the Environmental Protection Agency (EPA). However, this old regulatory structure was meant to deal with well-documented pollutants and has yet to assess countless new and currently unregulated substances that have a negative effect on aquatic and human health.

This report briefly outlines the history of these new contaminants in the Potomac River system. New research is being published weekly on this topic, so this report is a snapshot of recent advances in our knowledge. New research findings often expose gaps in the regulatory structure that is in place, after all, to protect citizens against pollutants and their ill effects entering our water, air, and food supply. It was only earlier this year that EPA announced that it would investigate 67 pesticides. Many of these compounds have been in production for years and were considered safe by traditional testing guidelines. As we will see, this assessment model does not apply to compounds that disrupt the endocrine system. A new model is needed.

We hope this report will raise awareness of the presence of EDCs and spur action to remove them from our water supply before they have a negative impact on present and future generations.

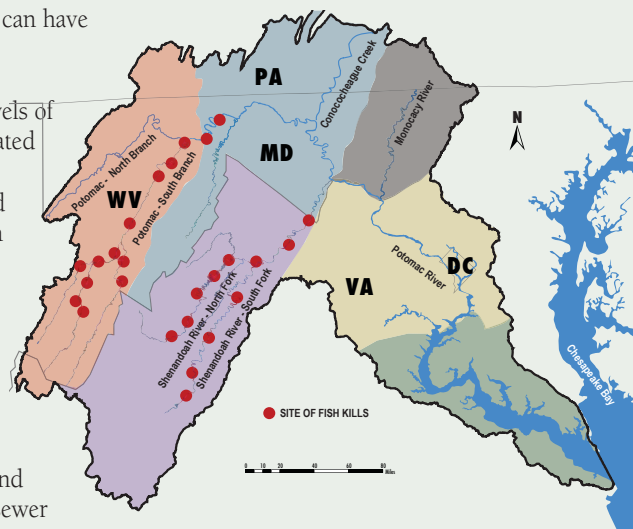
### LAND USE MAKES THE POTOMAC RIVER A CRUCIBLE FOR NEW POLLUTANTS

The appearance of intersex fish in the Potomac and other rivers has been a warning beacon. The fish are a sentinel, alerting scientists and authorities to the toxic levels and additive effects of EDCs, which can have significant implications for both humans and wildlife alike.

Water is a critical pathway in the delivery of many of these new contaminants to humans, particularly pesticides. As far back as 1999, US Geological Survey (USGS) studies found trace levels of different pharmaceuticals in a survey of streams across the United States. The same studies indicated the presence—in low but significant levels—of many of the same EDCs.

During 2003, a high prevalence of intersex was identified in male smallmouth bass collected from several sites on the Potomac River watershed. In 2006, a USGS study of smallmouth bass in the Upper Potomac Basin found that male fish from the most densely inhabited and farmed sites had the greatest likelihood of having immature eggs in the testes. *These studies suggest that EDCs are prevalent throughout the Potomac River.*

How do these compounds end up in our rivers? In our 2007 *State of the Nation's River* report, Potomac Conservancy outlined the land uses in the Potomac River watershed. Most land uses, whether agricultural, residential, or urban, come with a list of negative effects to the environment. The main sources of the impairments on the Potomac River and tributaries are no secret. Agricultural herbicides, pesticides, and veterinary pharmaceuticals run off our farmland and feedlots. In developed areas, rainwater runs off paved surfaces in quantities that overwhelm the sewer system, causing overflows of untreated wastewater into our streams.



Fish kill sites in the Potomac River watershed, 2002–2007.

#### Sentinel: Smallmouth Bass

In 2002, a series of fish kills on the Shenandoah River and the South Fork of the Potomac River led to the discovery that most of the male fish found at the kill sites (see map, above) also had intersex characteristics that were not obvious to the naked eye. As more fish from Potomac tributaries were examined, USGS researchers were shocked to find over 80% prevalence of the intersex condition. Intersex fish are now found in many rivers in the United States and other countries.

Intersex characteristics in freshwater fish, especially very sensitive species like the smallmouth bass (*Micropterus dolomieu*), may be seen as a "canary in the coal mine," and thus, may be used as a sentinel that warns of problems in reproductive health. At the molecular level, fish and humans have functionally similar endocrine systems.

Although no direct link has yet been found between intersex fish and the fish kills, intersex induction by itself may have an ecological impact by significantly affecting reproductive rates. A recent USGS study notes, "The co-occurrence of fish kills with these other reproductive effects suggests that endocrine-disrupting chemicals may affect not just individual fish, but also entire populations due to decreased disease resistance and reproductive effects." The intersex condition affects reproductive rates of species by altering sex ratios and sterilizing males, which will exacerbate the decline of many of these species, but direct toxicity has not been proven. *A decline in fish populations can have devastating effects on the food chain and freshwater ecosystem.*

## The Endocrine System

The discovery of intersex fish in the Potomac River and tributaries has brought to light the importance—and fragility—of the endocrine system. Endocrine systems serve higher-order animals as a means of regulating fundamental biological processes through hormones such as estrogen, androgen, and thyroid. These processes lay at the foundations of normal growth and sexual development in all vertebrate species, including fish and humans.

Chemical compounds that interact with—and possibly interfere with—this important physiologic regulatory system are known as endocrine disrupting compounds, or EDCs. According to The Endocrine Society, all hormone-sensitive physiological systems are vulnerable to EDCs, including brain and hypothalamic neuroendocrine systems; pituitary; thyroid; cardiovascular system; mammary gland; fatty tissue; pancreas; ovary and uterus in females; and testes and prostate in males.

Because these hormones are so important to human development and growth, development of methods and procedures to assess harmful effects of chemicals on these systems is necessary. Unfortunately, only a relatively small number of compounds have actually been researched for endocrine disrupting capabilities.

## The New Math [0+0 = Something]

The Center for Disease Control (2005) states that humans are, at minimum, exposed to hundreds of environmental chemicals, many of which are EDCs. A commonly held theory in toxicology is “the dose makes the poison.” That is, a high dose will be more harmful than a low dose. The high dose then, is at the heart of many regulatory efforts to gauge a “safe” level. However, two qualities mark EDCs as a long-term environmental health problem: additivity and persistence.

**Additivity.** EPA scientists exposed pregnant rats to two pesticides (fungicides) separately, with no ill effect. However, with combined exposures, half of the males were born with a defect. One of the researchers, Earl Gray, coined the term “The New Math” to explain this phenomena. Later experiments with phthalates—common plasticizers/thickeners used in personal care products and household items—showed a marked interruption in male development. Evidently these different chemicals target similar pathways, resulting in an additive effect (e.g., no effect with one fungicide, but a significant rate for a birth defect when the subject is exposed to both compounds, even at low levels).

Additionally, research has shown that chemical present at “no observed effect concentrations” may contribute to cumulative effects of a mixture. The additive impacts of EDC mixtures may help explain the historical increase in incidence of many developmental disorders.

**Persistence.** Another characteristic of EDCs is persistence or lifespan; that is, how long the compound remains unchanged in an environment. The longer the chemical persists in water, air, or soil, the higher chance that humans will interact with it. Additionally, persistence of a chemical can lead to the build-up—or bioaccumulation—of that compound in an animal. When bioaccumulation occurs in a lower organism on the food chain, such as DDT or PCBs in the fat tissue of fish, higher organisms such as humans or birds of prey consume greatly magnified concentrations of these chemicals. *In this way, humans can consume dangerous levels of a compound despite the compound existing within legal limits in water or other environmental sources.*

## THE SOURCES

A majority of the contaminants of emerging concern are components or byproducts of industrial or agricultural processes. These compounds include plasticizers and surfactants, flame-retardants, fungicides, herbicides, and veterinary pharmaceuticals associated with feedlots. Additionally, there are non-synthetic compounds that are also of concern for their environmental and human health impacts, such as naturally excreted steroids and plant-derived phytoestrogens. Estrogens and fertility drugs, whether from humans or animals, pass through the body unchanged, excreted into urine. These compounds are not removed from water in the current wastewater treatment process, so the “clean” gray water discharged back to the rivers is an important source of EDCs. USGS and other agencies indicate that EDCs are most prevalent in industrialized, agricultural, and/or urbanized areas, with particularly high concentrations of these compounds near sewage treatment plants or other sources of wastewater, feedlots, pulp and paper mills, and in urban and industrial areas with high levels of organic chemical contamination.



### Personal Care Products, Pharmaceuticals and Over-the-counter Medicines

EDCs used by individuals enter the water supply in several ways: Prescription or over-the-counter medicines are excreted from the body unchanged, medical cosmetics and lotions are rinsed off in the shower, and excess prescription drugs are flushed into the wastewater system. The presence of pharmaceuticals and personal care products (PPCPs) in soil and water shows that even daily acts such as bathing, shaving, applying suntan lotion, and taking medication can affect the environment in which we live. *For example, estrogen-containing shampoos and skin oils are causative factors of premature puberty in girls, and development of breast tissue in boys.*



### Agricultural Pollution

Runoff from agricultural land has been shown to contain hormonally active chemicals, ranging from common pesticides to veterinary pharmaceuticals. Pesticides and herbicides are particularly widespread, and have considerable negative effect when drained from agricultural, public, and residential lands during rain events.

In 2007, a report found that “synthetic organic pesticides and their degradation products have been widely detected at low levels in the watershed [Susquehanna River Basin, Potomac River Basin, Delmarva Peninsula], including emerging contaminants such as pharmaceuticals and hormones.” Pesticides were detected more frequently in streams than in groundwater. Although the most commonly detected pesticides were found in agricultural regions, pesticides were also detected in streams and groundwater in urban areas at lower concentrations. Groundwater in rural areas—with more permeable ground surfaces and more agricultural use—had the higher observed pesticide levels.

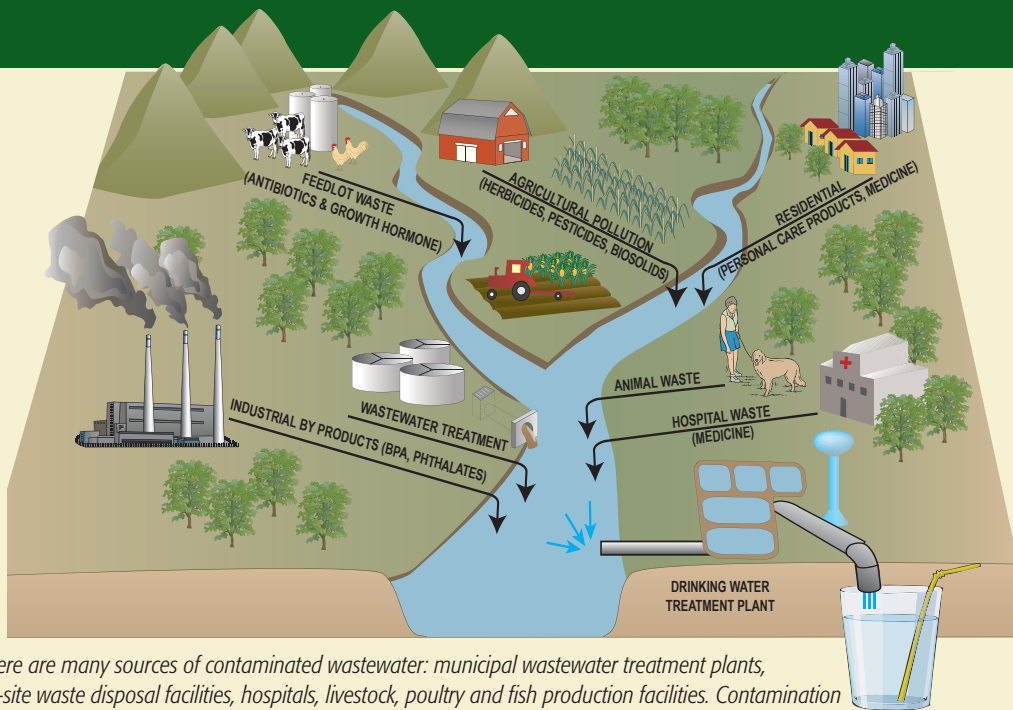
A 2007 study identified 30 insecticide compounds present in the North Fork of the Shenandoah River, which services dozens of townships in the watershed with raw drinking water. Many of the observed compounds were still in widespread use, the most ubiquitous and heavily concentrated of which was atrazine. Sold under various brand names, atrazine is most commonly used in farming states, but it can also be found on lawns, gardens, parks, and golf courses. During summer months, atrazine levels rise in drinking water in agricultural areas. Recent epidemiological studies suggest that small amounts of atrazine in drinking water, including levels considered safe by federal standards, like those allowed under the SDWA, may be associated with birth defects — including skull and facial malformations and misshapen limbs — as well as low birth weights and premature births.



### Animal Feedlots

Some natural hormones as well as antibiotics are commonly used in animal feeding operations to enhance animal growth. These compounds pass through the animals unchanged and can enter the environment through animal waste. It has been reported that approximately 90% of the estrogen load into the environment comes from animal manure at concentrated animal feeding operations. Antibiotic compounds were also detected in the waste from animal feeding operations.

The discharge from cattle-concentrated feeding operations has been repeatedly characterized as containing the properties of male sex hormones, by evidence of alterations to fish in nearby waterways. Although the composition of the chemicals in the discharge is not fully known, some common chemicals used for livestock production are EDCs, including steroids used in beef operations to promote production of muscle mass in the animals.



There are many sources of contaminated wastewater: municipal wastewater treatment plants, on-site waste disposal facilities, hospitals, livestock, poultry and fish production facilities. Contamination continues in smaller concentrations via runoff from impervious surfaces (e.g., roads), and from contaminated sediment, including runoff from areas where treated water and/or residual biosolids from wastewater treatment are applied.

Source: EPA. Symbols courtesy of the Integration and Application Network ([ian.umces.edu/symbols/](http://ian.umces.edu/symbols/)), University of Maryland Center for Environmental Science.

## Water Treatment

At this time, there are no EPA-approved tests for personal care products or pharmaceuticals in our drinking water or our wastewater. Utilities and agencies dealing with wastewater and drinking water sanitization must be prepared to address the growing public concern, especially as research is more publicly debated. EPA, which administers and enforces the SDWA, is assessing the presence of EDCs and their effect on human health.

**Wastewater:** Wastewater treatment plants (WWTPs) serve as collection points for solid/liquid waste originating from or used in residential, commercial, and industrial applications. Often, associated sewage systems also serve as stormwater runoff system. Chemical and biological studies have linked the estrogenicity of WWTP effluent specifically to natural and synthetic steroid hormones, implicating a number of compounds such as the human sex hormones active in oral contraceptive pills, as well as similarly acting compounds found in veterinary medicine.

Effluent from WWTPs is currently the most notably identified point-source contribution of EDCs to the Potomac River. Assessment of these waters showed the significant presence of estrogenic compounds, industrial byproducts; pesticide, fungicide, insecticide residual compounds; detergents and other chemicals related to wastewater treatment. Along with these regionally observed chemicals, phthalates, heavy metals, alkylphenols, and BPA are known worldwide as frequent components of wastewater effluent. In the Feb. 25, 2009 issue of *Chemistry & Engineering News*, Christian Daughton at the Environmental Protection Agency's National Exposure Research Laboratory, said, "You have to keep in mind that sewage treatment plants were originally designed a long time ago to improve the aesthetic quality of treated sewage and to reduce the incidence of disease—to reduce odor and make the water look better and get rid of bacteria and viruses. They were never engineered to remove synthetic substances."

**Drinking water.** There is very little information or regulation regarding pharmaceutical and EDC presence in drinking water. A strong case for the compositional proximity of wastewater and drinking water is made in a German study that found appreciable concentrations of an herbicide regulating plant growth in the tap water. Out of 106 organic contaminants entering a drinking water treatment plant after wastewater treatment, 18 compounds were measured at significant concentrations in drinking water. This pollution is in the United States as well, as selected antibiotics were detected in drinking water of three drinking water treatment plants and concentrations of pharmaceuticals and EDCs were detected in both source and drinking water from 20 utilities.



## Industrial Byproducts

Industrial discharge, atmospheric deposition, spills, leachates from landfills and stormwater runoff all contribute to water pollution in varying extents. Industrial EDCs include polychlorinated biphenyls (PCBs), dioxins, bisphenol-A (BPA), and phthalates.

According to *The Endocrine Society*, EDCs from industrial and commercial sources may strongly contribute to the increased incidence of breast and prostate cancer and prostate hyperplasia in the last half-century.



## Biosolids

Municipal (sewage treatment) and industrial sludge is the material that remains after treatment of wastewater. The land application of sludges (biosolids), usually over farm and forest land, is a long-lived practice that is becoming increasingly common. Although best management practices for land applications are aimed at protecting environmental quality by minimizing losses via runoff and leaching, contamination of water resources can occur when these management practices are not enforced. Typical contaminants associated with farm-sourced biosolids are primarily pathogens (animal wastes) or nutrients (e.g., nitrogen and phosphorus), whereas contaminants associated with municipal or industrial sludge (human wastes) may include heavy metals, toxic chemicals, pharmaceuticals (including estrogens), pathogens, and nitrates. Biosolids can be particularly dangerous because they accumulate and concentrate long-lived compounds, many of which carry known or emerging environmental and health risks.

## AN UNHEALTHY LEGACY

In the United States, traditional pollutants of concern are known as "legacy" pollutants, because federal legislation has acknowledged their detrimental effects on human and animal health. As their title suggests, these compounds maintain an environmental presence even after their collective discontinuation in synthesis and use. Notable legacy compounds include polychlorinated biphenyls (PCBs), dioxin, dichlorodiphenyltrichloroethanes (DDT/DDDE), organochlorine pesticides, polycyclic aromatic hydrocarbons (PAHs), heavy metals, and others.

In the wake of major regulatory efforts to reduce the environmental spread of older (legacy) compounds, new contaminants and EDCs have emerged, including elements common in our daily lives: synthetic hormones; pharmaceuticals and personal care products, man-made industrial/commercial chemicals; plasticizers and surfactants (e.g., BPA, phthalates); flame retardants (e.g., PBDEs); fungicides and herbicides (e.g., vinclozolin).

Many EDCs persist in living organisms because they have low water solubility and are extremely lipid (fat) soluble. These properties allow molecules to move freely through aquatic environments without dissolving, bioaccumulating in the fat tissue of animals and becoming locked in the aquatic food web. For example, BPA and PCBs have become so widespread in our environment that they are detected in the urine of infants.

# THE REGULATORY EFFORT IS NOT WORKING

EDCs could be regulated under a variety of existing federal laws. The number of federal agencies with jurisdiction over elements of the EDC problem is equally large: no less than 12 agencies sit on the federal interagency working group on EDCs. Despite the breadth of regulatory tools and number of involved agencies, few meaningful steps have been taken towards controlling EDCs. Congress charged EPA with determining what chemicals act as endocrine disruptors nearly 15 years ago—not to regulate them, simply to identify them—and EPA only began screening the first EDC this year. *No water quality standards for EDCs have been implemented, nor have any pollution prevention rules been set to limit the introduction of EDCs into the water and environment.*

The Endocrine Disruptor Screening Testing and Advisory Committee, formed in 1996 by EPA, is responsible for establishing processes and criteria for communicating updates in priority setting, screening, and testing information to the public. EDCs also fall within the regulatory jurisdiction of the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA), the Food Quality Protection Act (FQPA), and the Toxic Substances Control Act (TSCA). FIFRA lays out the tests and requirements for registration of a new chemical. FQPA specifically addresses food-use chemicals (chiefly pesticides), and calls

for a complete reassessment of all existing pesticide tolerances. However, FQPA provides little framework for preventing use of and exposure to pesticides and EDCs, and prevents state implementation of stricter legal limits.

TSCA, in principle, is the avenue for preventing toxic substances from being introduced in the first place. However, at its inception in 1976, all chemicals on the market were assumed to be safe. To remove a chemical from the approved list, there must be a finding of “unreasonable risk” in accordance with exposure profiles written by EPA. This leaves EPA with a heavy burden of justification to remove previously approved compounds.

EPA reviews anywhere from 1,500 to 3,000 “new” chemicals annually. No mechanisms for observing the potential impact of exposure to particularly vulnerable populations, including individuals at developmental (including pregnant mothers), occupational, and otherwise heightened risk of direct or ambient (environmental) exposure. The result is a general assessment of risk that is achieved only under “least burdensome” requirements for review. TSCA places a barrier to bringing new chemicals to the market but fails to address the thousands of chemicals that have been grandfathered into the system without the slightest regulatory review.

## RECOMMENDATIONS FOR REGULATION AND MANAGEMENT

There are an estimated 100,000 chemicals currently on the market, with up to 1,000 new chemicals produced annually. Many EDCs are empirically considered safe, but new toxicological evidence, such as that presented in this report, warrants not only the repealing of such status, but an entire redesign of the way that regulatory and management agencies address these types of compounds. The United States lags behind the European Union in the extent to which such chemical groups are managed. While lacking a full understanding of impacts of EDCs, EU regulatory officials are still expected to provide adequate protection.

Our existing regulatory configuration suggests that the presence of EDCs in the environment may be occurring with little to no information and a lack of scrutiny by the relevant regulatory authorities. Along with an expanding list of gaps in the suite of EDC pollution policy, authorities should remove older chemicals that remain on the market from years

of lenient risk assessment and grandfathering policies. The lack of public disclosure of use and toxicity information is a secondary, and perhaps more serious, shortcoming of EDC policy, as it prevents dissemination of useful information in avoiding environmental exposure when new chemicals are introduced.

Although most industrial polluters have strict pollution limits, permits for urban stormwater only require pollution reduction “to the maximum extent practicable.” Historically, that has meant that the regulated jurisdiction develops its own stormwater management plan, implements certain best management practices, and monitors its own progress. In short, stormwater permit compliance generally requires some minimum actions but no measurable, enforceable, or even independently verified results. As a consequence, local governments can be in full compliance with their stormwater permit even while stormwater pollution continues to increase.

## An Ounce of Precaution

The Endocrine Society, in their 2009 scientific statement, notes, “The precautionary principle is key to enhancing endocrine and reproductive health, and should be used to inform decisions about exposure to, and risk from, potential endocrine disruptors.” The principle states that if an action or policy might cause severe or irreversible harm to the public or to the environment, in the absence of a scientific consensus that harm would not ensue, the burden of proof falls on those who would advocate taking the action.

The precautionary principle would only apply to new compounds being introduced, not already existing ones. The principle could be used as an argument to reduce allowable limits of these chemicals in water according to SDWA and FIFRA. For example, a chemical assessed under FIFRA could still be registered for use if it met all the requirements, but the principle could offer guidance for requirements on use if the new chemical is found to be an EDC. Potentially, EPA could set up usage restrictions that would prevent the chemical from entering water supplies.

We do not know exactly what level of exposure causes harmful effects to human health, but we do know that EDC exposure causes problems. To protect human and environmental health, Potomac Conservancy believes that we should exercise the utmost caution about introducing these compounds into our rivers and streams, and ultimately, our drinking water.

## Taking Action

Potomac Conservancy views the following actions as opportunities to break the cycle of allowing EDCs to flourish in our environment. We advocate a “do no harm” approach to introducing new EDCs to the system. We also call on enforcing and strengthening clean water regulations such as SDWA to limit EDCs from entering our drinking water supply. We support legislation that will overhaul regulation of chemicals to include potential effects on our children. We call on EPA to incorporate health and exposure data from drug and chemical manufacturers into their testing profiles.

The level of risk associated with pharmaceuticals and EDCs in drinking water should be a central concern of regulators, as most drinking water

treatment plants use source water that has received less than adequate treatment by wastewater plants. We seek to direct additional funding toward the development of technology to retrofit our wastewater treatment plants and upgrade our drinking water treatment facilities. On the agriculture side, a solution must be found for our burgeoning biosolids problem.

Drug take-back programs show promise and should be considered. Legislation introduced in Congress would encourage state governments to establish programs to recover unused prescription drugs from consumers to prevent them from going into landfills or being flushed into our wastewater system.

## ACKNOWLEDGEMENTS

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Since 1993, Potomac Conservancy has protected the health, beauty, and enjoyment of the Potomac and its tributaries.

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