

The Story on "Water Quality" in Four Mile Run

Introduction

The quality of streams and rivers across the country is often described using terms like "pristine," "pure," or "polluted." These terms often describe general perceptions about water quality rather than scientific examination. Today, the terms "degraded" or "impaired" also reflect official designations by the US Environmental Protection Agency (USEPA) or a state environmental agency and specifically describe whether a water body meets appropriate water quality standards designed to protect public health and the environment. This paper will attempt to put those anecdotal as well as regulatory designations into perspective by providing a discussion of the regulatory framework for water quality, a brief history of the watershed, and a summary of the main water quality issues and challenges in Four Mile Run today.

Although not always the case, streams and lakes located in naturally forested areas or land areas that have not been touched by human endeavors are typically the most pristine water bodies. This does not automatically mean that pristine water bodies contain drinkable water or are capable of sustaining fish or providing a good swimming hole. For example, watersheds like the Snake River in Wyoming's Grand Teton valley support healthy aquatic ecosystems, but such rivers also often contain natural bacteria that can cause gastrointestinal illness when ingested without filtration. The hot springs in Yellowstone National Park hold water near the boiling point with high concentrations of toxic minerals that allow only certain species of unique bacteria to thrive. The glacially fed rivers in Denali National Park are heavily laden with glacial sediments and do not maintain fish or aquatic organisms. These latter two examples both describe surface waters reasonably untouched by human endeavors but not being in a 'swimmable' or 'fishable' condition. Even those streams rising in relatively pristine forested areas like the Snake River that do sustain aquatic life are not considered drinkable waters for humans because of the prevalence of waterborne microbial diseases like giardia in wildlife populations. Nevertheless, streams flowing through uninhabited forested watersheds typically are considered the "gold" standard for water quality from an ecological perspective.

Merriam Webster's Online Dictionary defines pollution as "the action of polluting especially by environmental contamination with man-made waste". The general field of Environmental Science paints water pollution into two broad categories relating to the source of the pollution: 1) Point Source Pollution and 2) Non-Point Source Pollution. Point source pollution is discharged directly into the environment at a specific location, e.g., a discharge pipe from an industrial process. In contrast, non-point source pollution is less specific in the location of release to the environment. Fertilizer that is applied to a lawn and migrates with rainwater to Four Mile Run is an example of non-point source

pollution. Another example would be the oil and grease that drop from automobiles onto streets and parking lots to be washed off by rainwater into our streams and creeks. Both non-point and point source pollution can cause a significant decline in the quality of the aquatic environment.

The Clean Water Act

In 1972, facing a significant decline in the quality of waters across the US, Congress passed the Federal Water Pollution Control Act. This legislation, commonly referred to as the "Clean Water Act," was aimed at restoring the quality of the nation's surface waters to a pristine state able to sustain aquatic and terrestrial populations and recreation uses appropriate to the water body. Although not in exactly the same phrasing, water quality practitioners have described the intent of the Clean Water Act as restoring the nation's waters to a "Swimmable" and "Fishable" condition. The passage and enforcement of the Clean Water Act has been a key factor in cleaning up many rivers in the US, including the Potomac River. Like the Potomac River, the chief sources for pollution impacting the nation's rivers in the late 1960s were from untreated industrial discharges and raw sewage.

Excerpt from "THE CLEAN WATER ACT"

FEDERAL WATER POLLUTION CONTROL ACT
(33 U.S.C. 1251 et seq.)

"DECLARATION OF GOALS AND POLICY

SEC. 101. (a) The objective of this Act is to restore and maintain the chemical, physical, and biological integrity of the Nation's waters. ... "

In contrast, over the three decade life of the Clean Water Act, non-point source pollution and associated impacts have actually grown. In order to confront this increasing impact to the nation's waters, the USEPA has established programs aimed at reducing non-point source pollution. This included expanding the National Pollution Discharge Elimination System (NPDES) permitting program in the early 1990s to include the regulation of municipal separate storm sewer system (MS4) networks. Today, all four jurisdictions comprising the Four Mile Run watershed - Arlington and Fairfax counties and the cities of Falls Church and Alexandria - hold MS4 permits and have significant stormwater management programs to address their permit requirements. The NPDES MS4 program focuses on practices and technologies that reduce non-point source pollutants to the 'maximum extent practicable.' This somewhat ambiguous performance standard reflects and acknowledges the significant challenge of reducing non-point source pollution in an urban environment.

Nationwide, the NPDES MS4 program is still relatively new, with municipalities having fewer than 100,000 residents receiving permits only within the past few years. As a result, and also because of the substantial and currently unregulated non-point source pollution from agricultural areas, non-point source pollution remains a mostly unchecked and increasing problem across the country.

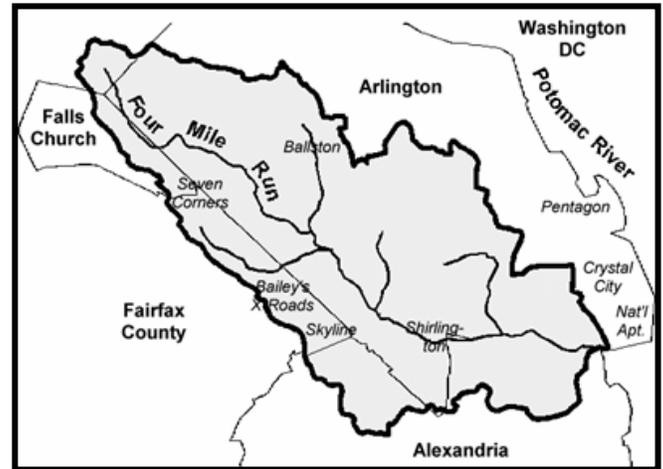
The impacts of point-source and non-point source pollution on aquatic systems are often quite different in terms of acute and chronic effects on human health and aquatic ecosystems—and the

impacts are often watershed specific. These differences will be explored in the next sections of this paper as they relate to Four Mile Run.

The Evolution of Pollution in the Four Mile Run Watershed

Four Mile Run is 9.2 miles long, and is a direct tributary of the Potomac River, which ultimately carries the water flowing from Four Mile Run to the Chesapeake Bay. Four Mile Run can be divided into two parts: tidal and non-tidal. The lower portion, beginning just upstream of the Mount Vernon Avenue Bridge and extending to the mouth of Four Mile Run, includes all of the run impacted by the tidal influence of the Potomac River. Upstream of this point, Four Mile Run is non-tidal.

Although once set in pristine forest land and holding substantial populations of beaver, deer, and fish, Four Mile Run is now set in one of the most urbanized areas of the country. The shaded area in the map to the right delineates the 19.7 square mile area, known as a watershed, that drains to the mouth of Four Mile Run at the confluence of the Potomac River near Ronald Reagan Washington National Airport.



As with many of the nation's urban waterbodies, the balance between point and non-point source pollution impacts to Four Mile Run has shifted over the years.

In the early 20th century, for example, the watershed contained mainly rural and agricultural uses, and non-point source pollution from farming operations likely had impacts on Four Mile Run. In the 1940s and 1950s, as the watershed population grew dramatically following World War II, demand for wastewater treatment increased as well. Wastewater treatment technology at the time, however, was not up to the task. As a result, by the end of the 1940s, the lower portion of Four Mile Run was severely impacted by point source discharges of partially treated and untreated sewage. The immediate human health risks and aquatic organism and habitat impacts in this portion of Four Mile Run were likely orders of magnitude greater than those posed by any of the water quality problems in lower Four Mile Run today.

During this same time period, the upper portions of Four Mile Run, which were unaffected by wastewater treatment plant discharges, were just beginning to be affected by the explosive residential development pressures following World War II. As a result, urban non-point source pollution was just starting to become an issue for the watershed.

Today, the Arlington County wastewater treatment plant (also known as the Water Pollution Control Plant) which serves most of the watershed population discharges into the tidal portion of the Four Mile Run just downstream of Mt. Vernon Avenue. The plant operates at a highly effective level with stringent environmental permit limits. As a result, the water quality in lower Four Mile is dramatically

improved relative to the post-war period. The impacts of urban non-point source pollution in the watershed, however, have increased significantly.¹

As of the 2000 US Census, approximately 183,000 people claimed the Four Mile Run watershed as home. In order to meet the needs of all of these residents and those of workday commuters passing through or to the watershed, two major interstate highways, I-66 and I-395, cross the watershed. Those highways, along with numerous arterial and secondary roadways along with densely sited buildings often surrounded by extensive parking areas, contribute to the watershed's total impervious coverage, which currently is estimated at 40 percent of the total watershed area. Where impervious areas exist in the watershed, rainwater is prevented from infiltrating or being absorbed into the ground as it would in a pristine or pervious watershed. The impervious areas force the stormwater to flow off the land surface, into the Four Mile Run stream system, usually by way of the extensive underground stormwater drainage pipe network.

As this stormwater runoff makes its way across rooftops, lawns, roadways, and parkland it carries with it the pollutants picked up along the way. This includes fertilizers from lawns, pet waste from yards and common areas, pesticides and herbicides, sediment from construction sites, oil and gasoline spilled from car leaks and refueling, metals that are toxic to aquatic organisms (e.g., from wear of automotive parts and from copper roofs and gutters), and litter, grit, and grime from roadways. Even the deposition of air pollution from car exhausts and factory stacks is collected and transported by the runoff to Four Mile Run. Once the pollutants are picked up by the stormwater runoff they are virtually assured of reaching Four Mile Run, given the extensive stormwater collection network that was effectively engineered to move stormwater quickly to prevent flooding of streets and houses. This collection network includes gutters and underground pipes that eventually discharge to Four Mile Run and its small tributary streams, without any treatment or attenuation.² And in time those pollutants flow on to the Potomac River and ultimately to the Chesapeake Bay.

¹There is only one other permitted point source in the watershed—the concrete batch plant in Shirlington. Although pollutant discharges from this plant do impact Four Mile Run (mainly fine sediments and elevated pH), these impacts are considered to be relatively small and isolated.

² Only a small portion of the stormwater runoff in the watershed is treated before it reaches Four Mile Run. This treatment takes place mainly within small filters and separation tanks on individual parcels or a few scattered engineered ponds and wetlands installed during the past decade or so as a result of recent stormwater quality regulations. However, it should be emphasized that stormwater runoff from most of the developed areas of the watershed, including the vast road network, is not treated or attenuated in any way.

Water Quality Issues in Four Mile Run Today

Overall, the problems affecting water quality and aquatic habitat in Four Mile Run today can be attributed primarily to the urban nature of the watershed. Urban non-point source pollution and its related impacts to Four Mile Run can be placed into eight major categories:

Water Quality Issues for Four Mile Run:

1. Quantity and Rate of Flow
2. Loss of Instream and Riparian Habitat
3. Sediment Erosion and Transport
4. Litter
5. Excessive Nutrients
6. Substances without Standards
7. Water Temperature
8. Water Quality Standards

The first and second categories listed are not generally thought of as pollutants, but both the "Quantity and rate of flow" and the "Loss of instream and riparian habitat" are direct results of human impacts on the Four Mile Run watershed and greatly affect the quality of water and habitat in Four Mile Run. Categories 3 through 7 focus on a variety of urban non-point sources, as described in the preceding paragraph. It is important to note that Category 8 - Water quality standards, reflects the current water quality condition of Four Mile Run from a regulatory perspective. As described below, these water quality issues together characterize the complex threat to the health of Four Mile Run, which is typical of most urban streams in the nation.

Quantity and Rate of Flow: The quantity of water in Four Mile Run swings rapidly from very low baseflow conditions when it is not raining to very high flow conditions when it does rain. The roads, parking lots, roofs and other impervious surfaces that constitute the 40 percent impervious coverage in the watershed work to make the baseflow conditions lower than the baseflow conditions that existed prior to development. This is because water is unable to infiltrate into the soil and recharge the groundwater that is the primary source of baseflow in streams.

Impervious surfaces also make the high flows higher by the same process. The water that would have infiltrated into the soil runs directly off the land, finding its way almost immediately to the stream network through the extensive network of gutters, stormwater drainage pipes, and direct overland flow, thus, creating higher flows than would have otherwise occurred in Four Mile Run. The higher flows tend to cause substantial erosion in the streambeds and banks. This not only diminishes water quality by contributing significant sediments loads to the stream, but the erosion either eats away the places for plant and aquatic habitat in the stream, or smothers these habitat areas with sediment when flows drop. When the rain subsides, streamflows drop rapidly and the low baseflows can hardly

fill the bottom of the wider and deeper eroded stream bed that is necessary to carry the larger flows during storms, thereby isolating the stream from its floodplain and adversely affecting the adjacent riparian habitat along the stream corridor.

Loss of Instream and Riparian Habitat. As urbanization has increased in the Four Mile Run watershed, the pressures to develop right up to the banks of Four Mile Run also increased. In order to contain the stream within its banks during rainy times, developers, the municipalities, and the federal government have each hardened or altered the banks and stream bed along much of the stream's length. In addition, many natural stream segments have been replaced by underground storm sewers over the years. The rock-filled wire baskets, known as gabions; the large stones, known as riprap; the concrete flood walls; and the substantial reduction in natural streamside vegetation have eliminated much of the tree cover and natural habitat along much of Four Mile Run that once provided cooling shade, habitat, and protection for the aquatic life in the stream. Without such protection and nourishment, the balance found in natural stream ecology is tipped. In many locations along Four Mile Run, only hardy (and often alien and invasive) species that can adapt to the hostile instream conditions and the adjacent riparian environment can thrive. On a positive note, however, many of the remaining streams in the watershed are located on County or City parkland. This has helped to preserve some natural areas along the stream, and also provides a significant opportunity for restoration.

Sediment Erosion and Transport: Excessive sediment also threatens the water quality of Four Mile Run. Not only does sediment mix with the waters of Four Mile Run by eroding from the banks and beds of the stream network itself, but sediment also is carried to the stream by stormwater runoff from unstable construction sites and patches of exposed soil, as well as from streets and roadways. Sediment is more than grit, dirt and soil; the sediment typically found in urban stormwater harbors many pollutants including nutrients like phosphorus and pathogens like E. coli bacteria. The finer parts of the sediment remain suspended in the waters of Four Mile Run, eventually entering the Potomac River and the Chesapeake Bay. The suspended sediments choke aquatic life by clogging gills of fish and aquatic insects and block out sunlight to the aquatic plants that provide habitat and nourishment for many of these organisms. The bigger and heavier sediments tend to deposit in streams, smothering aquatic habitat and spawning areas.

Litter: One type of pollution that everyone can relate to because of its high visibility is litter. The aesthetic impacts of litter should not be understated, as it creates a perception of streams as dumping sites, thereby encouraging additional littering behavior. In addition to these aesthetic impacts and related behavioral issues, certain litter items (e.g., car batteries, motor oil cans) can release hazardous or toxic chemicals and heavy metals into the stream. As a safety issue alone broken bottles and rusty metal objects that find their way into Four Mile Run remain in the stream for decades. Their presence threatens injury to dogs, humans, and other animals. Because of the sheer number of people in the watershed and the substantial litter problems in Four Mile Run, significantly improved litter control efforts in the watershed (from education to technologies that remove litter from stormwater runoff) are essential to the restoration of the stream.

Excessive Nutrients: Nutrients in appropriate amounts are necessary to sustain plant life. Common nutrients in fertilizer are nitrogen, phosphorus, and potassium. Every year these nutrients are applied to urban and suburban landscapes to encourage lawns, playing fields, and other grassy areas to grow and stay green. Improper application of fertilizers either by over-applying or by applying them at the wrong time of the year when they cannot be absorbed by the soil or plant material leads to excessive runoff of these nutrients into Four Mile Run. Once the concentrations are high enough and environmental conditions are right, these excess nutrients lead to uncontrolled algal growth. When the algae die, the decomposition process consumes the life-sustaining oxygen in the water.

Excess algal growth from the concentration of nutrients occurs mainly along the streambed in Four Mile Run. However, the main impacts of nutrient "enrichment" are not so detrimental to Four Mile Run itself, as the flow in the stream tends to keep the water well-oxygenated. But as nutrients delivered from Four Mile Run and other streams reach the more quiescent waters of the Potomac River and the Chesapeake Bay, excess algal growth and subsequent decomposition creates significant habitat problems in these waterbodies. As a result, scientists have concluded that nutrients are the chief threat to the ecological health of the Bay. A great deal of publicity about water quality in this area revolves around "Saving the Bay". The primary thrust of this effort is focused on nutrient reduction. Currently, no nutrient water quality standards are in place in Virginia. This situation is expected to change in the near future as part of the Bay cleanup effort.³

Substances without Standards: Just like nutrients and litter, there are other pollutants threatening the health and safety of Four Mile Run. Many of these pollutants are associated with items that are used every day (e.g., various medicines, hormones from birth control pills, caffeine, and many more). These are items that have been approved for human consumption in certain dosages. Our bodies do not always absorb all of the compound or the chemical is excreted without being altered to an inert substance. The substance is then flushed down the toilet as sewage and carried to the wastewater treatment plant. Today's wastewater treatment plants were never designed to process or filter many of these dissolved chemicals. As a result, these substances flow right through the plant and out to Four Mile Run. New research is currently underway to examine the effects of these substances to aquatic ecosystems, but recent studies in the Shenandoah River and elsewhere have shown disquieting biological effects like hermaphroditism in smallmouth bass, for example.

Water Temperature. Fish and aquatic life tolerate temperatures only within some expected ranges. As a watershed becomes more urbanized, the asphalt and concrete surfaces associated with development cover substantial portions of the watershed. These dark colored surfaces absorb the sun's heat far more readily than the vegetated areas that once existed. Consequently, the stormwater that runs off of these surfaces into the stream network tends to be significantly warmer, especially during summer afternoon thunderstorms. Over the years, the resulting abrupt temperature fluctuations have increased in magnitude as paved surfaces have increased.

³ It should also be noted that, in addition to nutrient inputs from urban and agricultural fertilizer use and farming operations, atmospheric deposition of nitrogen-oxides from vehicle exhaust is a major nutrient input to the Bay and its tributaries.

The effect of these temperature impacts, together with the other impacts described above has substantially reduced the suitable habitat for aquatic species in Four Mile Run. For example, elevated temperatures and lack of shade from riparian trees and vegetation ensure that trout (once native to Four Mile Run) stocked in Four Mile Run for the annual spring fishing event that are not caught by local anglers do not survive very long into the heat of the summer.

Water Quality Standards: Under the authority of the Clean Water Act, the USEPA oversees the Commonwealth of Virginia's ongoing effort to develop and maintain ambient water quality standards for the surface waters of Virginia. This is done by the Virginia Department of Environmental Quality (VADEQ) under the State Water Control Board.⁴ These standards cover an array of chemicals, heavy metals, toxics, bacteria, acidity, and temperature. Water quality standards, although covering a broad spectrum of substances, are not exhaustive. As described earlier, substances like caffeine, medicines, artificial hormones that are not effectively destroyed during the wastewater treatment process, as well as litter, and even sediment are not yet the subject of existing standards. In addition, there are substances for which water quality standards do exist that may not yet have reached levels in the water column or within aquatic organisms that exceed these standards. For example, herbicides and pesticides are widely applied by individual property owners, often to improve their lawns. Once these chemicals are carried by runoff into streams they can affect aquatic organisms like fish, which tend to accumulate such toxins in their fatty tissues. These substances are used in the Four Mile Run watershed, but, at this time, no pesticide- or herbicide-related impairment exists for Four Mile Run.

Water quality criteria are developed for specific parameters that are "harmful to human, animal, plant, or aquatic life".⁵ VADEQ, regularly monitors the stream network in Virginia to determine how its streams measure up to these standards. In compliance with the Clean Water Act, every two years VADEQ files a report to the USEPA describing how well its surface waters meet adopted Virginia water quality standards and criteria. If a stream does not meet any one of the water quality standards it is listed as "Impaired" for that standard as required under Section 303(d) of the Clean Water Act.

In 1994, the non-tidal portion of Four Mile Run was listed by VADEQ and reported to the USEPA as impaired for fecal coliform bacteria. In 1996, the tidal portion of Four Mile Run was similarly listed as impaired for bacteria. In 2002, the tidal portion of Four Mile Run was also listed as impaired for toxic PCBs in fish tissue.⁶ This chemical was once commonly used in electrical equipment like transformers as an insulating material.

Once a stream is listed as impaired, a TMDL, "Total Maximum Daily Load", or water pollution budget, must be developed for the water body specific to the offending water quality parameter. This water

⁴ Virginia's water quality standards are found in the Virginia Administrative Code, 9 VAC 25-260, at <http://www.deq.virginia.gov/wqs/pdf/WQS04.pdf>.

⁵ Virginia Administrative Code (9 VAC 25-260-20).

⁶ 2002 Virginia 303(d) Report <http://www.deq.virginia.gov/wqa/303d.html>

pollution budget shows the maximum loads of that pollutant that can enter the stream from all sources without the stream exceeding the standard. Such a water pollution budget or TMDL was developed for bacteria impairment in the non-tidal portion of Four Mile Run in 2000.⁷ This TMDL study was followed up by an implementation plan in 2002.⁸ The implementation plan compiles a list of actions, to be taken by the watershed jurisdictions in order to bring the water body back in compliance with the specific water quality criterion, in this case, bacteria. The appropriate TMDLs and subsequent implementation plans will be developed for tidal Four Mile Run by 2010.

It is interesting to note that, of all the existing water quality standards (let alone the other problems described in this section), bacteria and PCBs are the only pollutants for which Four Mile Run has been officially listed as "Impaired." To date, there have been no reported cases of bacterial illness due to contact with water from Four Mile Run. In order to encourage responsible stream behavior in light of this potential health threat, the jurisdictions have posted informational signs in targeted locations and prepared educational materials.

Because of the concern of PCBs in fish tissue the Virginia Department of Health (VDH) issued a fish consumption advisory for the Potomac River Basin that included Four Mile Run. Under that advisory it is recommended to NOT eat Carp or any Channel Catfish over 18 inches in length. These fish species are specifically identified because they are bottom feeding fish. PCBs are primarily associated with the fine sediments in the Potomac, and these fish appear to be particularly vulnerable to tissue contamination because of their diets and feeding habits. Additionally, the advisory recommends limiting the intake of other fish taken from Four Mile Run to two meals per month.⁹

Summary

This paper paints a troubling picture of water quality conditions in Four Mile Run, but one that is shared by almost every urban stream. However, it must be emphasized that there are a number of regulatory and voluntary efforts underway to restore Four Mile Run (and indeed similar urban watersheds nationwide). These efforts are not discussed in detail here, but it is important to note that they exist and to recognize that it will take time to improve urban watersheds like Four Mile Run, even though people now understand many of the adverse impacts of urban development on streams. Since the establishment of point source regulations authorized by the Clean Water Act in the 1970s, water quality conditions in Four Mile Run have undoubtedly improved due to improvements in wastewater treatment technology. And the severity of the public health threat to humans has also diminished due to improved wastewater treatment.

Nevertheless, the overall ecological condition of Four Mile Run continues to be significantly affected by the impacts of urbanization described in this paper. The primary threat to the long-term health of Four Mile Run and the safety of its users is now caused by urban non-point source pollution and its

⁷ The Bacteria TMDL for the non-tidal portion of Four Mile Run can be found at <http://www.novaregion.org/bacteriatmdl.htm>

⁸ The Implementation Plan for the Bacteria TMDL for the non-tidal portion of Four Mile Run can be found at <http://www.novaregion.org/bacteriainplementation.htm>

⁹ The VDH website is located at <http://www.vdh.state.va.us/hhcontrol/potomacrivier.asp>

related impacts. These impacts may be much harder to solve than the point source challenges of the past because of their dispersed nature and also because of their strong correlation with the land uses and individual behavioral choices throughout the watershed.

It should also be noted that complete restoration of Four Mile Run to a 'pristine' state is simply not possible, given the severely altered watershed hydrology. However, Four Mile Run can be enjoyed even in its current condition if proper precautions are taken to ensure safe use. For example, Arlington County has recommended the following precautions in order to interact with urban streams (including Four Mile Run) in a safe and healthy manner:

- Never drink stream water.
- Wash your hands after coming into contact with stream water, and especially before eating.
- Keep stream water out of your eyes, ears, mouth or any open sores. Children who are too young to understand these precautions should not be allowed to play in streams.
- Fishing and wading are OK, but do not swim or bathe in streams. Do not eat uncooked fish caught in local streams. Do not eat fish species for which a fish consumption advisory from the State has been issued.
- Use caution when wading to avoid falling on slippery rocks, and wear shoes to protect your feet from broken glass and other sharp objects.

More information regarding Four Mile Run and the programs involving its restoration can be found at: <http://www.novaregion.org/fourmilerun.htm>