TAP VERSUS BOTTLE:

A MIXED METHODS ANALYSIS OF PUBLIC WATER SUPPLY AND THE BOTTLED WATER INDUSTRY IN THE UNITED STATES

by

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ABSTRACT
TAP VERSUS BOTTLE: A MIXED METHODS ANALYSIS OF PUBLIC WATER SUPPLY AND THE BOTTLED WATER INDUSTRY IN THE UNITED STATES

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Discrepancies exist between the regulation of public tap water by the EPA and bottled water by the FDA. The Safe Drinking Water Act mandates the EPA to set national contaminant standards for drinking water as well as regulations to ensure source water protection, treatment, monitoring, compliance, enforcement, waste water, and public access to water quality information. Bottled water is subject to a differing mandate. As a food product regulated by the FDA, bottled water is required to comply with FDA food regulations as well as specific bottled water regulation regarding standards of identity, quality and cGMP. As a result of the discrepancies between tap and bottled regulatory frameworks, the water quality of bottled water is less certain than the quality of tap water. The purpose of this research is to examine EPA and FDA regulation of drinking water and determine if differences in water quality exist. To explore the regulatory frameworks, a mixed methods approach is employed examining regulatory regimes and compliance. The first method is a comparative analysis of EPA and FDA regulatory standards for 19 contaminants. The second method is a compliance analysis of 60 bottled water brands and 11 municipal water systems in the U.S. This study unpacks the complex system of U.S. drinking water regulation. Lack of water quality data is problematic for public health and should be corrected by thorough monitoring and reporting.

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CCR	Consumer Confidence Report
cGMP	current Good Manufacturing Practice
CWA	Clean Water Act
DEHP	di(2-ethylhexyl)phthalate
HAAs	Haloacetic Acids
U.S. EPA	Environmental Protection Agency
U.S. FDA	Food & Drug Administration
USGS	Geological Survey
U.S. GAO	Government Accountability Office
IBWA	International Bottled Water Association
MCL	Maximum Contaminant Level
MCLG	Maximum Contaminant Level Goal
MF	Membrane Filter Method, FDA
MTF	Multiple-Tube Fermentation Method, FDA
NRDC	National Resource Defense Council
NPDWS	National Primary Drinking Water Standards
PPB	Parts Per Billion
PWS	Public Water System
SDWA	Safe Drinking Water Act
TTHMs	Total Trihalomethanes

1. Introduction

More popular than beer and milk, bottled water is the second most popular beverage in the United States, second only to soft drinks [1]. The total average amount of bottled water consumed per capita has increased exponentially since the 1970s. In 2012, the average American used 167 disposable, single-use water bottles and recycled only 38 [2]. The industry which produces and markets the product presents a fascinating study of U.S. water policy, our 21st century relationship with water, and consumer psychology, the driving force manufacturing demand for bottled water.[1] Bottled water and public tap water systems (PWS) are regulated and monitored by different government agencies. The U.S. Food and Drug Administration (FDA) regulates bottled water, technically a "food product", while tap water is regulated and monitored by the U.S. Environmental Protection Agency (EPA).

This thesis, firstly, explores the differences in the regulatory frameworks of tap and bottled water. Secondly, the consequences of these differences are examined by analyzing tap and bottled water quality data: a comparative 11 city tap water analysis and a 60 brand bottled water quality analysis. This evidence from these analyses demonstrates the consequences of the different regulatory frameworks. Thirdly, this thesis offers secondary discussion of other issues regarding bottled water. Finally, based on the findings of analyses, this thesis offers policy recommendations.

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[1] The average American uses between 80-100 gallons of water per person, per day. USGS: The USGS water science school. (2014). Retrieved 4/10, 2014, from http://water.usgs.gov/edu/qa-home-percapita.html

The majority of Americans are served by publicly owned water and sewerage utilities regulated by state and federal government. Millions of taxpayer dollars fund public water supply and regulation. Yet, the public is distrustful of tap water. Due to overt and subvert advertising campaigns disparaging tap water, the bottled water industry is partly culpable for the public's wariness towards tap water. According to the National Resource Defense Council (NRDC), it is absolutely clear that a leading reason for the explosion in bottled water sales is public perception, fueled by heavy industry advertising, that bottled water is pure and pristine, and thus a healthier choice than tap water [3]. And, according to Peter Gleick of the Pacific Institute, in many developed countries, fear of tap water is fueled by public reporting of violations of drinking water quality standards (e.g., Toledo Blade 2006; WISCTV 2006), by advertising that implies that bottled water imparts special health benefits (Water Technology New 2006b; U.S. FDA 2006), and by public ignorance of the actual quality of their municipal supply [4]. The American public is largely uninformed that the EPA's regulatory framework is in many regards more thorough and comprehensive than FDA regulations for bottled water.

A 2009 report from the U.S. Government Accountability Office (GAO) entitled "Bottled Water: FDA Safety and Consumer Protections Are Often Less Stringent Than Comparable EPA Protections for Tap Water" found key differences between the FDA's regulation of bottled water compared to the EPA's regulation of tap water. For example, "the FDA does not have the specific statutory authority to require bottlers to use certified laboratories for water quality tests or to report test results, even if violations of the standards are found" [5]. Additionally, the GAO report cited concern about the FDA's lack of regulation of di(2-ethylhexyl)phthalate (DEHP), a contaminant known to

cause negative human health impacts, as well as the lack of information provided by bottlers to consumers on the source and quality of their water. This thesis builds upon the GAO report that left important gaps in their analysis of bottled water regulation.

In the 1960s a series of studies were conducted by the Public Health Service on drinking water in the United States. The results of these studies demonstrated high contaminant levels. As a result, new federal safe drinking water laws were debated in congress resulting in the passage of the Safe Drinking Water Act (SDWA) of 1974 [6]. With this legislation, our government prioritized citizens' access to clean, affordable, accessible water. Accustomed to this high-quality, reliable, low-cost commodity, we have little awareness, understanding, and appreciation for water and its management and delivery system. We simply turn on the tap expecting clean water. This disconnect, fueled by fear instilled by bottling companies, plays a central role in explaining why consumers choose to purchase the in many cases less regulated, more expensive bottled product over the nearly free water that comes from their faucets [7]. According to Charles Fishman, "our relationship to water is at least as much emotional as it is analytical. That is why a bottle of Evian tastes so good that we pay a thousand times more for it than for the same amount of water from the kitchen faucet" [8].

In order to determine whether the water bottling industry's self-regulation is sufficient for safeguarding consumers, this thesis compares the regulatory frameworks of bottled water and tap water, identifies differences that exist in regulation, and inspects water quality data for tap and bottled water to examine whether the regulatory differences result in water quality discrepancies. The structure of this thesis is as follows. The introduction (1) provides the reader with background including historical context

regarding water degradation and subsequent regulation in the United States. This section also introduces some of the incongruities between the EPA regulated public water systems and the FDA regulated bottled water industry. The project specification (2) outlines the thesis: the different tap and bottled water regulatory regimes in the cases analyzed in this study yield divergent water quality outcomes for tap and bottled water supply, as well as introduces the arguments and evidence. Covering the methods & findings, the research (3) identifies the two analytical methods employed in the evaluation of the regulatory differences between tap and bottled water: a comparative analysis of selected EPA and FDA contaminant regulations followed by a two-part analysis of EPA and FDA compliance records. The three-part analysis & evidence (4) section includes evidence, regulatory differences and a compliance analysis. The section entitled a Secondary discussion of bottled water (5) explores public perception and externalities of the bottled water industry and acknowledges the limitations of this study. The last section of the thesis, policy implications & conclusions (6), highlights the primary conclusion, provides nine key policy recommendations, and identifies opportunities for future work on the subject.

1.1. Background

During the 19th century, governments began to bear the responsibility of public health. Scientific discoveries in chemistry and microbiology provided the evidence for publically funded water and sewerage systems including increasingly advanced technologies such as sand filtration systems and, over time, advancing to modern-day practices of chlorination, regulation and enforcement of contaminant discharge, and the establishment of enforceable water quality standards.

In the United States, environmental pollution became a pressing concern following World War II, especially due to public awareness regarding atomic fallout and the link between pollution and human health. An environmental movement gained momentum spurred on by images of Ohio's Cuyahoga River on fire and Rachel Carson's book "Silent Spring". As a result of society's increasing environmental consciousness, Congress began passing regulations to mitigate the environmental degradation caused in large part by previously unregulated manufacturing industries.

In 1948 the Federal Pollution Control Act was passed eventually becoming the Clean Water Act of 1972, amended in 1977. The EPA was founded in 1970 to protect public health and the environment by creating and implementing regulations to enforce environmental laws passed by Congress. Designed to protect the quality of municipal drinking water, the SDWA was ratified by Congress in 1974. Municipal water in the United States passes through numerous checkpoints ensuring its safety and quality before it reaches the consumer. For example, municipal water must comply with EPA-determined National Primary Drinking Water Regulations (NPDWR), including both enforced Maximum Contaminant Levels (MCLs) and recommended though non-enforceable Maximum Contaminant Level Goals (MCLGs). Additionally, the SDWA requires municipal water providers to follow specific protocols in the unfortunate event of contamination. It is important to note EPA PWS regulations do not apply to systems with less than 15 connections or serving fewer than 25 people. As a result, the drinking water of approximately 15 percent of the nation's population, 43 million people, is not

federally regulated [9]. Many states and towns do not require periodic sampling of private wells after they are initially installed making this the responsibility of homeowners.[2]

In addition to the PWS regulations mentioned above, the EPA also sets MCLs for approximately 90 contaminants as listed in the NPDWRs. These MCLs and MCLGs are determined by EPA scientists conducting cost-benefit analyses by factoring in human health, available technology, and the cost of removing the contaminant from the water to certain degrees. The EPA also determines water testing schedules and methods as well as contamination procedures. At minimum, states must comply with EPA MCLs but may, if they so choose, tighten their regulatory standards to have more stringent regulation. EPA regulated contaminants are generally organized into the following six groups: microorganisms, disinfectants, disinfection byproducts, inorganic chemicals, organic chemicals, and radionuclides.

The quality of U.S. drinking water resources have improved since the implementation of PWS standards and other environmental regulations. For example, the number of Americans receiving water that met health standards went from 79 percent, in 1993, to 92 percent, in 2008 [10]. However, despite the improvements, many water quality and quantity problems persist which threaten the sustainability of our nation's health, economy, and environment. These problems are the result of decades of irresponsible management due to under-regulation of our natural resources. Sustained degradation of our environment, such as the long-standing practice of disposing of toxic waste by dumping untreated or partially treated waste into waterways, relied on dilution

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[2] Historical information on public drinking water legislation can be found on the U.S. EPA website. http://water.epa.gov/drink/resources/topics.cfm

to take care of the water quality problems. This “out of sight, out of mind” mentality is pervasive throughout our nation and the world. According to Jeff Opperman, a Senior Freshwater Scientist at The Nature Conservancy, over the past 200 years in the U.S. we have built a sophisticated public water system that brings water from rivers, lakes, and aquifers right into our homes. As far as many Americans can tell, their water comes from the tap. In a 2011 poll conducted by The Nature Conservancy, 77 percent of Americans could not accurately identify the natural source of the water used in their homes and well over half declined to hazard a guess [11].

Collective negligence has produced environmental calamities such as the “trash vortex”, an island of trash floating in the Pacific Ocean twice the size of the continental U.S. Inadequate regulatory protection has also played a role in recent environmental disasters including the 200 million gallons of oil which spilled into the Gulf of Mexico in the 2010 Deepwater Horizon oil spill as well as the 2014 chemical spill which rendered West Virginia’s Elk River unusable to more than 30,000 residents even for secondary uses such as bathing and cooking.

Anthropogenic degradation has disastrous impacts on the health and sustainability of human, animal, and biological communities. Cleaning and purifying contaminated water to a degree acceptable for human consumption is in most cases possible with our current technologies. However, the utilization of these techniques comes at a cost. The more polluted the water, the more expensive and energy intensive the clean-up process. With over seven billion people on earth and the increasing variability of temperature and precipitation due to earth’s changing climate, mitigating and responsibly managing earth’s increasingly scarce and degraded freshwater resources

will be the challenge of our generation. The desalting of water through the energy intensive desalination process is thought by some to be the solution to water scarcity. However, according to an article in the Scientific American, scientists and environmental advocates have voiced concerns about desalination's high cost, energy intensiveness, and overall ecological footprint citing it as a last resort for needy populations. According to the article, the process of desalination burns up many more fossil fuels than sourcing the equivalent amount of freshwater from freshwater bodies; the conversion of salt to fresh water is both a reaction and contributor to climate change. Additionally, for every gallon of freshwater produced through desalination, another gallon of doubly concentrated salt water must be disposed of having the ability to wreak havoc on marine ecosystems if dumped offshore without care [12]. Strict freshwater conservation measures are the most economically and environmentally viable options.

Drinking water regulation in the U.S. must act to address the host of new contaminants which have continued to emerge since the 1970s. According to a 2011 GAO report, "systemic limitations" exist in the EPA's process for determining whether additional drinking water contaminants should be added to the list of drinking water contaminants regulated by the agency [13]. The GAO report continues on by pointing out data availability, rather than concern over the greatest public health impacts, have been the primary driver of EPA's selection of contaminants for inclusion in regulatory limitations finding that improvements in implementation are needed to better assure safe drinking water.

Despite the water quality challenges that impact public water systems and the inherent vulnerabilities and budgetary constraints, bottled water quality may be worse.

Reliable bottled water quality data is primarily nonexistent, the result of the FDA regulatory framework. In this thesis, tap and bottled water are explored in the following manner. Firstly, a selection of EPA and FDA water regulatory standards are examined and the differences and gaps identified. Secondly, water quality outcomes are analyzed by investigating a range water quality data for tap and bottled water. Reliable and verifiable data on tap water is provided annually in the form of Consumer Confidence Reports (CCR), an EPA regulation for public water systems. Explored in the evidence section (4.1) of this paper, the FDA does not require systematic, public water quality reporting. As a result, trustworthy data on bottled water quality is extremely limited. For this study of bottled water quality, a 2011 bottled water analysis conducted by the Los Angeles County's Environmental Toxicology Bureau on 60 brands of bottled water is utilized.

2. *Project Specification*

2.1 Thesis Differences exist in the frameworks of the EPA's regulation of tap water and the FDA's regulation of bottled water. The likely outcome is quality differences in tap and bottled water. Data analyzed in this study demonstrate differences in regulatory regimes and water quality.

2.2 Arguments A common misperception is that bottled water is of superior quality to public tap water. In reality, bottled water is subject to different and, in the cases explored in this thesis, less comprehensive regulation than public water supply. These regulatory differences are likely to result in differences in water quality between bottled water and tap water. Briefly introduced here, the three-part analysis & evidence section

of this thesis are as follows: evidence, regulatory differences, and compliance analyses. The evidence is outlined below.

Evidence

- Information on Water Quality: *The EPA requires public water systems to publish annual CCRs reporting independently-tested contaminant levels to consumers, among other things. The FDA does not require bottlers to make similar in-depth, verified water quality information available to consumers. If the FDA does not require bottlers to make independently-tested water quality reports available to consumers, this supports the thesis that differences exist between EPA and FDA regulation of drinking water.*
- Exemptions: *Loopholes in FDA regulation and monitoring of bottled water allow bottlers to sell water of uncertain quality to consumers. Bottled water for sale within the state in which it was bottled is exempt from FDA bottled water specific regulation. Varying levels of state oversight is required by 40 states; 10 states report no oversight of the bottling industry. If bottled water sold within the state in which it was bottled is exempt from FDA bottled water specific regulation, this supports the claims of this paper that differences in EPA and FDA regulation of drinking water result in the uncertain water quality of bottled water.*
- Sourcing Information*: Bottled water companies are sometimes less than forthcoming in reporting the sources of their water. Consumers are often surprised and angered to learn that the bottled water they purchase at a premium is often tap water. Ironically, this tap water has likely passed more quality checks than other potential sources of water used by bottlers. If bottling companies do not make sourcing*

information readily available to the public or if bottling companies attempt to misrepresent the source of their water, this supports the thesis that differences exist in EPA and FDA regulatory regimes.

- Testing*: The frequency and objectivity of the FDA's required bottled water quality testing is different from EPA tap water frequency and objectivity stipulations. For example, the EPA requires municipal suppliers to test hundreds of times per month for bacterial contaminants while bottlers are not required by the FDA to test for bacterial contaminants. Additionally, the EPA requires independent labs to conduct quality testing for PWS while FDA regulations instruct bottlers to conduct their own testing. Monitoring of bottlers self-testing is low priority for the FDA and bottlers regularly passing FDA facility tests are tested less frequently. If the FDA's required bottled water testing procedures are less frequent than the EPA's required tap water, this supports the thesis. If the EPA requires independent testing and the FDA does not, this additionally supports the thesis.*
- Reporting*: The EPA requires PWS to alert the public within 24 hours if a MCL violation occurs. However, bottler violations are not always reported to the public or, if reported, sometimes appear long after the product has been sold and consumed. The reporting and enforcement of bottler violations are the responsibility of the FDA. If evidence shows bottler reporting is less timely and informative than PWS reporting of violations, this supports the thesis.*

The second half of the analysis & evidence chapter includes an analysis of regulatory differences for the 19 selected contaminants followed by a comparative 11 city analysis and bottled water quality study of 60 brands.

3. *Research* Methods & Findings

Two methods are employed to assess whether water quality differences exist between public water supply and bottled water. Firstly, a comparative analysis of EPA and FDA contaminant regulations and goals for 19 selected contaminants are outlined and the initial findings presented (3.1). Secondly, a two-part analysis of selected EPA and FDA compliance records is conducted and, again, the initial findings explored (3.2).

3.1 Contaminant Regulations and Goals

In order to assess EPA and FDA regulatory frameworks pertaining to contaminant regulations and goals, the author selected and analyzed maximum contaminant levels for 19 contaminants. These contaminants were chosen for evaluation because they are common indicators of drinking water quality and because data was available for these contaminants. The findings of the contaminant regulations and goals section will allow the author to draw conclusions about FDA and EPA regulatory regimes.

3.1.1. Contaminant Information

Of the hundreds of contaminants regulated and monitored by the EPA and the FDA, 19 were chosen for in-depth examination in this study as they are standard indicators of drinking water quality, of critical importance to human health, and, because reliable monitoring data is available for these contaminants. Given the scope of this

thesis, not all contaminants could be included in the analysis. Extending this study to analyze all contaminants currently monitored and/or tested is an opportunity for further research. The 19 selected contaminants are listed in the table below (Table 1). Also identified in the table are the EPA's category for each contaminant, common sources of the contaminants found in drinking water, and potential human health impacts.

Table 1. Contaminant Information: Name, Source, Health Impacts
Source: Author

Category	*Pollutant Name*	*Sources of Contaminant*	*Potential Health Impacts*
Physical/ Chemical	Arsenic (mg/L)	Erosion of natural deposits, runoff from electronics production	Skin damage, problems with circulatory systems, increased risk of cancer
	Chloride (mg/L)	Naturally occurring; road salt	
	Chromium (total) (mg/L)	Discharge from steel mills, erosion of natural deposits	Allergic dermatitis
	Fluoride (mg/L)	Additive to prevent tooth decay and the risk of dental fluorosis	May cause dental fluorosis altering the appearance of children's teeth
	Mercury (mg/L)	Discharge from factories, runoff from landfills and crops, found naturally in water	Kidney damage
	pH (units)	Potential of hydrogen is naturally occurring in water	pH is considered aesthetic but can damage pipes
	Total Dissolved Solids (mg/L)	Metals and salts naturally occurring	Not associated with health effects
Organic	Atrazine (mg/L)	Herbicide runoff	Cardiovascular system/reproductive problems
	Benzene (mg/L)	Discharge from factories and landfills	Anemia; increased risk of cancer
	Haloacetic acids (HAAs) (mg/L)	Byproduct of drinking water disinfection	Increased risk of cancer
	Polychlorinated biphenyls (PCBs) (mg/L)	Discharge of waste chemicals; runoff from landfills	Skin changes; immune deficiencies; reproductive system difficulties; increased risk of cancer
	Total Trihalomethanes (TTHM) (mg/L)	Byproduct of chlorination	Cancer and adverse reproductive outcomes
Microbial	Total Coliform Bacteria (MPN/100mL)	Human and animal feces	Used to indicate whether other potentially harmful bacteria may be present
	Giardia lamblia (0 to 4.5 cysts/50L)	Human and animal feces	Gastrointestinal illnesses
	Cryptosporidium (100cyst/50L)	Human and animal feces	Gastrointestinal illnesses

Lead & Copper	Lead (mg/L)	Corrosion of household plumbing	Children: delays in physical or mental development; Adults: kidney problems, high blood pressure
	Copper (mg/L)	Corrosion of household plumbing	Gastrointestinal distress, liver/kidney damage
Other Violations	Turbidity (NTU)	Filtration malfunction, soil runoff	Nausea, cramps, diarrhea, headaches
	Nitrate (mg/L)	Runoff from fertilizer; leaking from septic tanks, erosion of natural deposits	Infants would become seriously ill and die. Symptoms include shortness of breath and blue-baby syndrome

Findings

Contaminated drinking water can impact human health in a variety of ways ranging in severity from temporary gastrointestinal illness to permanent, reproductive problems or death. Because of the serious negative human health impacts that can result from drinking water contamination, the EPA and FDA regulate contaminate levels in drinking water. Populations most vulnerable to illness resulting from drinking contaminated water include infants, children, pregnant women, the elderly, and citizens with compromised immune systems. Of the contaminants listed in Table 1, giardia lamblia and cryptosporidium are relatively common and cause temporary gastrointestinal illness. Also included in Table 1 are contaminants which at high concentrations can have permanent health impacts such as mercury which can cause kidney damage and lead which can cause developmental delays in children. Relatively new contaminants for which the human health impacts are still being studied include haloacetic acids (HAAs) which are a suspected carcinogen and polychlorinated biphenyls (PCBs) which can cause immune deficiencies and an increased risk of cancer. Total trihalomethanes (TTHMs), a byproduct of the chlorination process, can also negatively impact reproductive systems and cause cancer.

3.1.2. EPA vs FDA Contamination Regulations and Goals

Expanding upon the contaminant information explored in the previous section, this section examines the EPA's regulatory standards of allowable concentrations of 19 contaminants in tap water and the FDA's regulatory standards of concentrations of the same contaminants in bottled water. EPA NPDWRs set enforceable standards regarding the concentration levels of approximately 90 contaminants in drinking water. Water utilities are required by law to comply with these regulations. FDA allowable contaminant levels likewise set maximum contaminant limits for bottlers though the monitoring and enforcement mechanisms as well as reporting guidelines differ significantly between the EPA and the FDA. A selection of these differences are further explored in the evidence section (4.1).

The EPA and FDA regulations of maximum contaminant levels for the 19 contaminants are listed below in Table 2. An understanding of these regulations will aid in the next portion of the analysis, compliance data from 11 U.S. cities and the 60 brand bottled water quality study. In addition to contaminant concentration limits analyzed, other differences such as testing frequency, legitimacy, and reporting are worthy of consideration (4.1).

Table 2. EPA and FDA Regulations and Goals
Source: Author

Contaminant	EPA MCL or TT (mg/L) [14]	FDA Allowable Levels (mg/L) [15]
Arsenic	0.010	0.010
Chloride	250.0	250.0
Chromium (total)	0.10	0.10
Fluoride	4.0	Varies depending on temperature, other factors
Mercury	0.002	0.002

pH (units)	6.5-8.5	No standard
Total Dissolved Solids	500.0	500.0
Atrazine	0.003	0.003
Benzene	0.005	0.005
Haloacetic acids (HAAs)	0.060	0.060
Polychlorinated biphenyls (PCBs)	0.0005	0.0005
Total Trihalomethanes (TTHM)	0.080	0.080
Total Coliforms	5.0 percent[3]	See discussion below
Giardia lamblia	TT	No standard
Cryptosporidium	TT	No standard
Lead	TT; Action Level = 0.015[4]	0.005
Copper	TT; Action Level = 1.3[5]	1.0
Turbidity	TT	5.0
Nitrate	10.0	10.0

Notes:

Definitions

- *TT - a required treatment technique intended to reduce the level of a contaminant*
- *MCL-Maximum Contaminant Level*
- *MCLG-Maximum Contaminant Level Goal*
- *N/A-Not applicable/Not analyzed/Not provided*

Findings

For the contaminants analyzed, the differences are noteworthy between EPA Maximum Contaminant Levels by which PWSs must abide and FDA regulations of allowable contaminant levels for bottlers. In six of the 19 contaminants, the EPA

[3] No more than 5.0 percent samples total coliform-positive in a month. Every sample that has total coliform must be analyzed for either fecal coliforms or E. coli. If two consecutive TC-positive samples, and one is also positive for E. coli or fecal coliforms, system has an acute MCL violation.

[4] Lead and copper are regulated by a Treatment Technique that requires systems to control the corrosiveness of their water. If more than 10 percent of tap water samples exceed the action level, water systems must take additional steps.

[5] See 4, above

contaminant level is more stringent than the FDA contaminant level. For ten of the 19 contaminants, FDA maximum contaminant levels are equal to EPA maximum contaminant levels. In addition to the different standards for fluoride and total coliforms, as described above, FDA regulations do not set enforceable standards for pH, giardia lamblia or cryptosporidium. In contrast, the EPA sets MCLs for these same three contaminants. Though not included in the scope of this thesis, other contaminant level differences between EPA and FDA regulatory regimes include the FDA's failure to institute limits on heterotrophic-plate-count (HPC) bacteria, acrylamide, asbestos, DEHP, or epichlorohydrin, all of which are limited in the EPA's regulation of public water systems [16]. The findings of this analysis demonstrate that differences exist in the EPA's regulation of tap water and the FDA's regulation of bottled water.

Examining EPA and FDA regulations was challenging in several cases because the measurement methods and techniques differ significantly between agencies. For example, for total coliforms, the EPA requires that PWS serving 50,000 customers or more test at least 60 times per month and those with 2.5 million customers or more test at least 420 times per month [17]. Coliforms must not be found in more than five percent of the samples taken each month. If the percentage of positive tests exceeds five percent, the state and the public must be notified. Additionally, repeat samples of the positive tests must be taken within 24 hours and if positive results are confirmed, the PWS has an acute MCL violation.[6]

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[6] For more information on the 1989 Total Coliform Rule and the 2012 Revisions, visit the EPA's website. U.S. Environmental Protection Agency. (2013). Total coliform rule requirements. Retrieved 3/20, 2014, from http://water.epa.gov/lawsregs/rulesregs/sdwa/tcr/regulation.cfm

The FDA's regulation of total coliform differs significantly from the EPA's regulation. The FDA's rule (74 FR 25651 [18]) states that bottlers must test for total coliform at least once a week, unless the source of the water is PWS in which case no additional testing is required. FDA requires bottlers to utilize either the multiple-tube fermentation (MTF) method or the membrane filter (MF) method. The MTF method requires that not more than one of the analytical units in the sample shall have a most probably number (MPN) of 2.2 or more coliform organisms per 100 milliliters and no analytical unit shall have an MPN of 9.2 or more coliform organisms per 100 milliliters. The MF method requires that not more than one of the analytical units in the sample shall have 4.0 or more coliform organisms per 100 milliliters and the arithmetic mean of the coliform density of the sample shall not exceed one coliform organism per 100 milliliters. If coliform is detected, bottlers are required to conduct follow-up testing to determine if any of the organisms are E. coli. If E. coli is detected, bottlers must rectify or eliminate the cause of the contamination [19].

As demonstrated by the example of the EPA and FDA differing coliform regulations, regulations are in some cases exceptionally complex. These complexities further obscure the analysis of EPA and FDA drinking water regulations and subsequently encumber the ability of regulators and consumers to determine the quality of their drinking water. As demonstrated, differences exist in the frameworks of the EPA's regulation of tap water and the FDA's regulation of bottled water. These regulatory differences are likely to result in differences in water quality. A comparison of available tap and bottled water quality reports is conducted in the following compliance analysis section.

The complete list of EPA MCLs can be found in Appendix A. FDA allowable levels of contaminants for bottled water are listed in Appendix B.

3.2. Compliance Analysis

Following the comparative analysis of EPA and FDA contaminant regulations and goals (3.1), the compliance records of selected PWS and bottled water are analyzed using publically available water quality reports. Public Water Utilities must publish annual CCRs, as mandated by the EPA. These reports provide information on the quality of the water they supply demonstrating how the water they provide compares to federal and state regulations of maximum contaminant levels. The FDA, however, does not require bottlers to publically publish water quality data. Some bottling companies choose to make a portion of relevant water quality information available on their respective company websites. However, when examined by the author, the data provided on bottlers' websites is problematic. For example, water quality data provided on company websites often do not include information on the location or conditions where the sampling and testing occurred. Unsurprisingly, none of the self-published bottled water data examined in this study cited instances of compromised quality. Because the FDA does not enforce regulation requiring bottlers to comply with public reporting requirements, the legitimacy of the bottlers' self-published data is questionable. Without standardized methods of reporting data, it is impossible to know if the companies truly know their bottled water quality and if instances of compromised quality are intentionally omitted.

In some cases, water quality studies of bottled water have been undertaken by third party organizations including a 2008 study conducted by the Environmental

Working Group titled “Bottled Water Quality Investigation: Test Results: Chemicals in Bottled Water” in which samples of ten bottled water brands from eight states were analyzed [20]. Another study published in 1999 by the NRDC, “Bottled Water: Pure Drink or Pure Hype?” commissioned the independent lab testing of more than 1,000 bottles of 103 bottled water brands from across the country [21]. These studies were not utilized in the compliance analysis of this paper due to the time which has elapsed since their publication.

This paper’s compliance analysis is divided into two sections. Firstly, using the most recent CCRs available online, an analysis of 11 U.S. cities[7] is conducted and the findings explored. Secondly, a 2011 quality study of 60 brands of bottled water conducted by Los Angeles County is examined and the findings explored. This compliance analysis demonstrates differences in water quality between the tap and bottled water sources explored.

3.2.1. 11 City Tap Water Quality Investigation

This analysis utilizes drinking water quality data from the most recent CCRs available for each of the ten largest cities in the U.S. and compares the cities’ reports to EPA MCLs and MCLGs as well as compares the cities to each other. This compliance data for the 19 selected contaminants is then compared to the 2011 study on bottled water quality data. Right-to-know reports, also known as CCRs and mandated by the SDWA, require water suppliers to annually publish reports informing the public of the overall health of their water as well as dangers and noncompliance with EPA MCL limits. For

[7] The 10 largest cities by population were chosen. Milwaukee was also analyzed.

the 19 selected contaminants, the author examined the CCRs of the 10 largest cities in the U.S. by population: New York, Los Angles, Chicago, Houston, Philadelphia, Phoenix, San Antonio, San Diego, Dallas, and San Jose. The City of Milwaukee was also included. The results are listed in Table 3, below.

Table 3. Drinking Water Quality Analysis of 11 US Cities
Source: Author

Pollutant Name	MCL	MCLG	NYC '12	LA '13	CHI '13	Houston '13	Philadelphia '13	Phoenix '13	San Antonio '13	San Diego '12	Dallas '13	San Jose '12	Milwaukee '12
Arsenic (mg/L)	0.010	0	NA	NA	<2	0.025	NA	0.0104	NA	NA	0.00209	NA	NA
Chloride (mg/L)	250	-	9	14	19.8	43	NA	NA	20	149	NA	85	NA
Chromium (total) (mg/L)	0.1	0.1	NA	NA	<2	NA	0.002	0.035	4.2E-06	NA	0.00071	NA	NA
Fluoride (mg/L)	4	4	0.5	0.44	1.13	0.13	0.76	0.7	0.37	1	0.44	0.56	1.35
Mercury (mg/L)	0.002	0.002	NA	NA	<0.2	NA	NA	NA	NA	NA	NA	NA	NA
pH (units)	6.5-8.5	-	7.2	7.85	8.35	8	NA	8.1	7.7	NA	NA	NA	NA
Total Dissolved Solids (mg/L)	500	-	47	677 (2013)	189	270	NA	714 (2012)	269	683 (2012)	NA	650 (2012)	NA
Atrazine (mg/L)	0.003	0.003	NA	NA	NA	0.016	0.0018	NA	NA	NA	0.00018	NA	NA
Benzene (mg/L)	0.005	0	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Haloacetic acids (HAAs) (ug/L)	0.060	NA	47.6667	5	NA	0.145	0.072 (2012)	0.016	0.02	0.012 (2012)	0.0204	0.0798 (2012)	0.0038
Polychlorinated biphenyls (PCBs) (mg/L)	0.00005	0	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total Trihalomethanes (TTHM)	0.08	0.003	0.051	NA (2012)	NA	0.29	0.098 (2012)	0.06	0.106 (2013)	0.09 (2012)	0.02	0.08 (2012)	0.0171

(ug/L)													
Total Coliform Bacteria (MPN/100mL)	5% of monthly samples	0%	0	0 (2000)	NA	NA	0.006	0.005	1.16% (2013)	0.006	4%	0.0069	<1%
Giardia lamblia (0 to 4.5 cysts/50 L)	T.T.	0	57	0	NA	NA	NA	0	NA	NA	NA	NA	NA
Cryptosporidum (100cyst/50L)	T.T.	0	2	0	NA	NA	NA	0	NA	NA	NA	NA	NA
Lead (mg/L)	TT5 Action Level 0.015	0	NA-26	20	<3	0.046	0.058 (2003)	0.003	0.015	16.6667	0.00135	0	0.006
Copper (mg/L)	T.T. action level 1.3	1.3	0.007	20	2.45	0.38	0.32	0.4	0.234	0	0.64	0	0.034
Turbidity (NTU)	T.T. can't exceed 1 NTU *	NA	11 (2012)	17 (2013)	2.5	NA	<MRL	0.3	NA	0.25	NA	0.24 (2012)	0.08
Nitrate (mg/L)	10	10	0.23	35 (2011)	0.377	0.48	3.8	6.9	2.46	NA	1.06	33 (2012)	NA

*T.T. 95% of monthly measurements must be ≤ 0.3 NTU

Notes

NA-Not applicable/Not analyzed
Within MCL regulation
Exceeds MCLG
Violation of MCL

Definitions

- TT-required Treatment Technique to reduce the level of a contaminant
- MRL - Minimum Reporting Limit set by the EPA
- AL-Action Level
- MCLG-Maximum Contaminant Level Goal
- NTU-Nephlometic Turbidity Units

Findings

This evaluation of water quality as measured by compliance for the 19 selected contaminants from 11 U.S. cities found five of the 11 cities were in violation of at least one maximum contaminant level. Three of these five cities were in violation of one contaminant, one city exceeded three maximum contaminant levels, and one city violated four of the 19 maximum contaminant levels. Five cities exceeded MCLGs. Three of these five cities were cited above in violation of one or more MCLs.

A careful examination of each of the 11 city's CCRs demonstrated that pertinent information such as MCL violations were on several occasions buried in the text of the report. For example, in 2012 the City of San Diego violated the total dissolved solids MCL. San Diego's violation is listed within a table of 30 contaminants but not mentioned elsewhere in the report. Only a reader searching for discrepancies would notice this violation, a lie of omission.

3.2.2. Bottled Water Quality Analysis

Independently tested and reported bottled water quality data is exceedingly difficult to locate. This shortage of data is a result of FDA regulation and enforcement which does not result in bottlers making this important information available to the public. A Los Angeles County report entitled "2011 Bottled Water Quality Study"

prepared by the county's Environmental Toxicology Bureau conducted an independent study of 60 bottled water brands available for purchase throughout Los Angeles County [22]. A total of 120 samples representing 60 different brands of bottled water were purchased and tested in this study.

Two samples of each brand were acquired from different locations within the county and tested for presence of bacteria, general physical properties (color, odor, turbidity), total dissolved solids, trace metals (aluminum, arsenic, barium, cadmium, chromium, chromium+6, copper, iron, lead, manganese, mercury, selenium, silver, and zinc), total trihalomethanes, volatile organic chemicals and pesticides [23]. The Los Angeles County report used state or EPA approved testing methods. The findings of this study are provided in Table 4, below.

Table 4. Bottled Water Quality vs. FDA Regulations
Source: Author

Pollutant Name	FDA AL	Samples with Detectable Levels	% with Detectable Level	Remarks
Arsenic (mg/L)	0.01	14	11.70%	None above MCL
Chloride (mg/L)	250	NA		
Chromium (total) (mg/L)	0.1	4	3.30%	None above MCL
Fluoride (mg/L)	Varies	NA		
Mercury (mg/L)	0.002	No samples were found to have detectible concentrations of Mercury		
pH (units)	No standard	NA		
Total Dissolved Solids (mg/L)	500	107	89.20%	None above MCL
Atrazine (mg/L)	0.003	NA		
Benzene (mg/L)	0.005	NA		
Haloacetic acids (HAAs) (ug/L)	0.06	NA		
Polychlorinated biphenyls (PCBs) (mg/L)	0.0005	NA		

Total Trihalomethanes (TTHM) (ug/L)	0.08	13	10.80%	Two above MCL
Total Coliform Bacteria (MPN/100mL)	See below	0	0%	No samples were found to have detectable levels of total coliform in this study
Giardia lamblia (0 to 4.5 cysts/50L)	No standard	NA		
Cryptosporidium (100cyst/50L)	No standard	NA		
Lead (mg/L)	0.005	3	2.50%	None above MCL
Copper (mg/L)	1	3	2.50%	None above MCL
Turbidity (NTU)	5	NA		
Nitrate (mg/L)	10	NA		

Findings

Bottling companies frequently affirm the quality and safety of their product in their advertising campaigns and on the IBWA website [24]. However, FDA regulations and enforcement do not result in bottlers making independent water quality data available to the public. Therefore, the claims of bottlers asserting their bottled product is of higher water quality than tap water is challenging to prove or refute. The 2011 Los Angeles study of 60 types of bottled water for sale in Los Angeles County is a case study providing independent, reliable bottled water quality data for the contaminants analyzed. The notable findings of the study are listed below:

Test Results

- Heterotrophic Plate Count (HPC) bacteria, not regulated by the state or federal government, were at detectable levels in 24 samples (20 percent)
- 20 samples were found to have detectable Total Turbidity (16.7 percent). All were significantly below California state limit of 5 NTU
- All metals were found in concentrations significantly below respective California MCLs
- 13 samples contained detectable amounts of TTHM

- 2 samples were found with TTHM levels exceeding California MCLs though well below federal MCLs
- No samples contained total coliform or E. coli bacteria
- No samples had detectable color or odor
- No samples exceeded MCL for Total Dissolved Solids
- No individual metal was detected exceeding California MCLs
- No samples were found to have detectable levels of volatile organic chemicals or pesticides

The Los Angeles County study found two samples had contaminants in excess of established California bottled water standards for total trihalomethanes (TTHM). California's standard for TTHM in bottled water is 10 parts per billion (ppb) while the federal standard is 80 ppb. The two samples in violation of state regulations were 13.9 and 20.5 ppb. Of the 120 bottled water samples, 13 tested were found to contain limited amounts of TTHM, with concentrations ranging from 0.62 to 20.5 ppb. The violations were reported to the California Department of Public Health.

EPA and FDA regulations of TTHM are both 80 ppb, 0.08 micrograms/liter (mg/L). When compared to the 11 city drinking water quality analysis, one city was in violation of the standard with test results showing a TTHM level of 0.08 mg/L. Nine of the 11 cities were found to contain limited amounts of TTHM. No data was available for two cities. Overall, the 11 city tap water analysis and the California bottled water quality study showed similar records of TTHM contamination levels.

This study demonstrates some of the differences in regulatory regimes and water quality between FDA and EPA drinking water frameworks. The FDA's regulatory framework did not identify these instances of compromised quality before the contaminated bottles entered the marketplace. How much bottled water on the market is

similarly contaminated? As currently regulated and enforced, the FDA framework does not address the type of compromised quality highlighted above. As demonstrated by the contaminates analyzed in this study, there are countless potential contaminants which may be present in drinking water. However, because the FDA does not require and enforce that bottlers provide independently verified water quality information to consumers, the public has no means by which to make informed decisions. The degree to which bottling companies themselves are fully aware of the quality and contaminant levels in their water is questionable. The same is true for the regulating agency, the FDA. Without systematic, comprehensive, independent testing, analysis, and publication of findings, the safety and water quality of bottled water is inadequately understood. The FDA is responsible for protecting public health by assuring that foods are safe, wholesome, sanitary and properly labeled. If the public, the FDA, and likely the bottling companies themselves do not comprehensively test, record, nor publish water quality data, this is a failure of the FDA to fulfil its mandate.

According to the IBWA, “bottled water is a safe, healthy, and convenient packaged food product, which is comprehensively regulated at both the federal and state level” [25]. However, as demonstrated above, bottled water just like all water is vulnerable to contamination. Tap water, however, is systematically regulated thus alerting water managers to potential problems and allowing the problem to be swiftly rectified. Importantly, the EPA’s regulatory framework requires the public to be informed in the event of a contamination of water supply in a timely manner. It is important to note that while some public water suppliers need to strengthen their CCRs by improving readability, listing all contaminant data, and citing contaminant violations, the EPA has a

legally enforceable mechanism for informing the public. The FDA utilizes a self-reporting method for bottlers with little oversight of manufacturer monitoring and compliance. Differences exist in the EPA and FDA drinking water regulatory frameworks likely resulting in differences in water quality.

Bottled water lacks a correspondingly thorough and standardized process. According to Peter Gleick, “bottled water violations are not always reported to the public, or are not reported in a timely manner.” In the cases of bottled water recalls that can be found, such as those listed in the “History of Contamination Recalls and “Field Corrections” [26], we know the companies themselves and discerning consumers are aware of the compromised quality of their product. However, until the FDA’s regulatory framework for bottled water is strengthened and the loopholes closed, the occurrences of contaminated bottled water will continue to make their way to consumers.

4. Analysis & Evidence

Outlined in the previous section, the three-part analysis of evidence, regulatory differences, and compliance analysis is thoroughly explored in this section for both tap and bottled water:

4.1. Evidence

This portion of the analysis identifies and explores the discrepancies between EPA and FDA regulation of tap and bottled water beyond the contaminant regulations and goals examines in section 3.1. Introduced in the project specification (2.2), the differences explored in this category include information on water quality, exemptions, sourcing, testing, and reporting.

- Information on Water Quality: In summary, the FDA does not require bottlers to make independently tested water quality reports available to consumers supporting the thesis that differences exist between EPA and FDA regulation of drinking water.

As demonstrated in this thesis, the FDA does not require bottlers to make independently verified water quality information available to consumers. Without this information, consumers are not equipped to make informed, healthy decisions about the source of their water. Bottled water companies are required by law to include the FDA's standard nutritional label on their product. However, it is impossible for a customer to determine from the label of bottled water if it is safe or of equal, greater, or lesser quality than competing brands or local tap water. The categories of food product nutrition labels include calories, protein, sugar, fiber, and a listing of ingredients. While applicable to food, nutritional labels, as they currently read, do nothing to inform the consumer of water quality.

In March 2014, the FDA proposed amending labeling regulations to include more relevant nutritional information in an effort to assist consumers in making healthy decisions, a significant public health concern in the U.S. [27] First Lady Michelle Obama has been a key proponent of public health initiatives including the FDA's proposed changes. "*You as a parent and a consumer should be able to walk into your local grocery store, pick up an item off the shelf, and be able to tell whether it's good for your family*," said the First Lady [28]. Though the focus of her work is reducing obesity, the point being made is equally relevant for bottled water. As it stands, the regulatory framework governing bottled water does not provide the customer with adequate information in order to make an informed decision as to the quality of the water they choose. The

indicators which determine if water is suitable to drink, as highlighted in the regulatory differences, include testing for the presence of E. coli, cryptosporidium, bacteria and pathogens, etc. Bottled water, and the argument could be extended to other beverages, require a unique nutritional label identifying the indicators useful to determining their safety and quality.

For the prudent consumer, a visit to a bottler's website may in some cases provide information such as bottled water quality reports available on the Nestle website [29] for its 12 brands: Acqua Panna, Arrowhead, Deer Park, Ice Mountain, Nestle Pure Life, Ozarka, Perrier, Poland Spring, Recoaro, Resource, S. Pellegrinno, and Zephyrhills. Nestle's Arrowhead brand December 2012 report provides the MRL, MCL and the level of substances found in its five water types: mountain spring water, drinking water with fluoride, drinking water, distilled water, and sparkling water. It is a step in the right direction that some companies, especially large companies like Nestle, have in recent years begun to make these reports available to the public. However, the data in these reports, like all data, must be critically evaluated.

In contrast, the EPA requires public water suppliers[8] to publish annual CCRs and make them available to the public. These drinking water quality reports including sourcing information, detected contaminants, compliance records for the respective year, and educational information. According to the EPA, these reports are intended to demonstrate the agency's commitment to public health protection and the public's right-

[8] Community water systems are classified by the EPA as serving at least 25 customers year around or at 15 service connections.

to-know about local environmental information. The 11 city analysis is conducted using data from these reports found on the websites of each city's water department.

- Exemptions: In summary, bottled water sold within the state in which it was bottled is exempt from FDA bottled water specific regulation supporting the thesis that differences in EPA and FDA regulation of drinking water result in uncertain bottled water quality.

Loopholes release a large portion of bottled water from the bottled water specific FDA regulation. According to the NRDC, 60-70 percent of bottled water sold in the US is exempt from FDA standards due to this loophole [30]. For example, bottled water for sale within the state in which it was bottled is not required to meet federal FDA bottled water regulations. On the state level, varying levels of oversight is required by 40 states; 10 states report no oversight of the bottling industry. Of the states reporting some level of oversight, the resources dedicated to this task are widely variant.

Food products, including bottled water, introduced or delivered into interstate commerce are regulated by the Federal Food, Drug, and Cosmetic Act (FFDCA). Bottled water bound for interstate commerce is required to comply with the FFDCA's Code of Federal Regulations (21 CFR), specific bottled water regulation with guidance on standard of quality, standard of identity, and current good manufacturing practices (gGMP). Additionally, water bottlers must comply with the FDA's gGMP for food products in regards to processing and bottling.

Carbonated or seltzer water is also exempt from the majority of the FDA bottled water regulations including contaminant regulations. The only requirement for

products of this type is that they meet general sanitation rules and packaging rules. Less than 50 percent of states require carbonated water to meet the bottled water standards of their respective states [31].

In regards to EPA exemptions, as previously noted, EPA drinking water standards do not regulate small water systems, those serving less than 25 residents or 15 connections. Additionally, as noted in the SDWA, states or the EPA have the ability to grant variances for eligible systems to use less costly technology or apply for an extension in the period of time for systems to comply with a new drinking water regulation. Variances may be granted if systems are not able to meet NPDWR due to source water quality or if small systems serving no more than 10,000 residents cannot afford compliance costs. It is crucial to note these exemptions allow eligible systems additional time to meet compliance standards; they do not release water systems from compliance with regulations.

- Sourcing: In summary, bottling companies do not make sourcing information readily available to the public and some bottling companies misrepresent the source of their water thus supporting the thesis that differences exist in EPA and FDA regulatory regimes.

Bottled water companies are sometimes less than forthcoming in reporting the sources of their water. This is to be expected as consumers purchasing bottled water are often surprised and angered to learn bottled water marketed as “naturally spring-sourced” is, in fact, tap water such as in the case of Nestlé’s Ice Mountain Water sold in five gallon jugs. In 2012, a Chicago business sued Nestle for falsely representing its product after learning Nestle had been selling them tap water since 2008. Ice Mountain ads feature

pictures of ice-capped mountains and claim “100% Natural Spring Water”. Some of Nestlé’s bottled water products are spring sourced though its five gallon dispensers are filled with tap water. Nadia Arumugam in the above Forbes article states it best, “Nestle is not being entirely duplicitous. Perhaps you could say that it’s just taking liberties with the truth” [32].

According to FDA sourcing regulations, bottlers are required to provide the source of the water, the volume, and the name of the manufacturer on the product. The source specification regulation is sufficiently vague as to allow companies to list multiple geographic sources. If the consumer wishes to learn more about the quality of a particular bottle of water by looking the information up online or contacting the company at the number provided on the product, it is impossible for the consumer to identify the source of product. This lack of specificity on the source of the water does not fulfill the intent and purpose of the FDA regulation. Additionally, it may hinder product tracing in the event of contamination.

EPA regulations require water systems to provide the source of their water to consumers. In contrast to the FDA sourcing regulation, the EPA regulation is enforced and the sourcing information is available to the public. This information can be found in annual CCRs.

- Testing: In summary, the FDA’s required bottled water testing procedures are less frequent than the EPA’s required tap water testing and the EPA requires independent testing while the FDA does not. These factors support the thesis.

The frequency with which bottlers must test their source water for microbiological contaminants is once a week. The exception to this rule is if the water comes from a municipal source in which case there are no additional tests required.

Municipal water is tested hundreds of times per month for bacterial contaminants according to EPA requirements and for synthetic organic compounds four times per year. The EPA also requires disinfection of water and routine checks for identified pathogens and viruses. Bottlers have no such requirements for testing for pathogens and viruses.

PWS are required to send their water samples to independent labs for quality testing. However, the quality testing of bottled water is done by the companies themselves with little government oversight or accountability. Relying on the bottling industry to self-regulate is placing the health of consumers in the hands of for-profit enterprise. Companies act in their own best interest, sometimes at the expense of the public such as in the case of the American tobacco industry. For example, Pennsylvania sued Philip Morris, Inc. for "concealing and misrepresenting the addictive and harmful nature of tobacco/nicotine, intentionally attracting and addicting children to tobacco products, and targeting African Americans" [33]. The divergent priorities of for-profit companies and public health are precisely why the FDA is important and why it is tasked with protecting the public's health by assuring the safety, efficacy, and security of our nation's food supply as well as drugs and medical devices.

Leaving the quality of bottled water in the hands of bottling companies is irresponsible and dangerous. It is the duty of the FDA to ensure the safety of the public and the FDA's policy of relying on companies to self-regulate is an evasion of responsibility.

- Reporting: In summary, the evidence provided in this thesis demonstrates in some cases bottler reporting is less timely and informative than PWS reporting of violations thus supporting the thesis that differences exist in the regulatory frameworks.

In the event of quality violations, a contaminant exceeding its MCL, PWS must alert the public that receives its water supply within 24 hours of a violation. Bottled water violations are not always reported to the public or not done so in a timely manner. Reports often appear long after the product has been sold and consumed. According to Peter Gleick, the instances when companies report bottled water violations often long after the fact, these violation notices are ineffective at protecting the public from hazardous or mislabeled products [34].

Comprehensive water quality data is initially somewhat difficult to locate for PWS if you don't know where to look. Equivalent quality data for bottled water in many cases does not exist or is not made available to the public. In the instances where quality data is made available to the public, the variance in reporting styles and the data itself makes comparisons difficult.

Public water systems are required by the EPA to publish annual CCRs outlining the sources of their water and extensive water quality data. A google search of the city, "consumer confidence report", and the year in question will produce the relevant report. Bottled water quality information, on the other hand, is much more difficult to locate. In the cases where the data is made available by the bottling companies, the data examined by the author indicated no presence of contaminants or indicated that the levels of contaminants are below MRLs and therefore not reported. Knowing that PWS is the source of approximately 40 percent of bottled water [35] and that CCRs regularly

indicate the presence of contaminants, the spotless bottled water quality data is by definition impossible.

4.2. **Regulatory Differences**

Differences exist in the frameworks of the EPA's regulation of tap water and the FDA's regulation of bottled water. As demonstrated in Table 2. EPA and FDA Regulations and Goals, of the 19 contaminants explored in this thesis, eight contaminants have different regulations. For example, FDA allowable levels for fluoride vary depending on temperatures and other factors. Therefore, comparing the FDA allowable level for fluoride to the EPA's fluoride MCL is problematic. Additional differences in regulation include the pH regulation; the FDA has no required standard for pH while the EPA mandates PWS must be within 6.5-8.5 units. The FDA's total coliform rule differs from the EPA's limit as does the limit for lead, copper, and turbidity making comparisons difficult. Comparing the EPA and FDA regulations for giardia lamblia and cryptosporidium is a straightforward process. The EPA has mandatory treatment techniques in the event of positive test results for either contaminant while the FDA does not require testing for either of the contaminants.

Using selective quality data and FDA regulations, bottlers claim their product is of equal and even superior quality to tap water. Municipal water providers tasked with providing water in compliance with EPA regulations are not in the business of selling their product to the public. By and large, public water providers do not challenge the assertions of the bottling industry though non-profit and watchdog organizations such as the NRDC and the Food & Water Watch have challenged the legitimacy of bottled water quality claims as well as the externalized costs of the industry. These two organizations

in particular have provided a good deal of information about the problems associated with bottled water. For example, the NRDC published a report entitled “Bottled water: Pure Drink or Pure Hype”. The following table is an example of the work undertaken by these organizations to make these somewhat convoluted topics accessible to the public and drive policy change.

Table 5. Differences Between EPA Tap Water and FDA Bottled Water Rules [36]
Source: Natural Resources Defense Council. (2013). Bottled Water: pure drink or pure hype? from http://www.nrdc.org/water/drinking/bw/chap4.asp#table6

Key Differences Between EPA Tap Water and FDA Bottled Water Rules

Water Type	Disinfection Required?	Confirmed *E. Coli* & Fecal Coliform Banned?	Testing Frequency for Bacteria?	Must Filter to Remove Pathogens, or Have Strictly Protected Source?	Must Test for *Cryptosporidium, Giardia,* Viruses?	Testing Frequency for Most Synthetic Organic Chemicals?
Bottled Water	No	No	1/week	No[a]	No	1/year
Carbonated or Seltzer Water	No	No	None	No	No	None
Big City[b] Tap Water (using surface water)	Yes	Yes	Hundreds/ month	Yes	Yes	1/quarter (limited waivers available if clean source)
Small Town[d] Tap Water (using a well)	No (though new rule in 2002 will require if needed)	Yes	20/month	No (unless subject to surface contamination)	No	1/quarter (waivers available if clean source)

4.3. **Compliance Analysis**

The regulatory differences between EPA and FDA frameworks are likely to result in differences in water quality. This compliance analysis, introduced in 4.2, examines the water quality data from the CCRs of 11 U.S. cities and the water quality data from a 2011 Los Angeles County water quality study of 120 bottles of water for sale. The findings of the 11 city analysis are highlighted by city below.

New York [37]: The CCR analyzed for NYC included citywide data for some contaminants while data for other contaminants were only provided for subsets of the

service area. Of the 19 contaminants examined in this survey, the New York Environmental Protection CCR violated one MCL: turbidity. No contaminant levels exceeded MCLGs. Six contaminants were not reported. This CCR highlighted and bolded values which exceeded MCLs.

Violation details: High turbidity levels were measured on April 19, 2012 following maintenance on sampling equipment. However, the sample was judged to be non-representative due to the maintenance and therefore accurate turbidity levels do not exist for the 4 hour time period in question. On April 27, the public was notified of this missed sample and in May an After Action Reported was submitted to the state to help prevent future such instances. On October 29, 2012, NTU units excited the allowable 5 NTU. The highest recorded value was 11 NTU before measurements showed turbidity having returned to below 5 NTU.

Los Angeles [38]: The Castaic Lake Water Agency serves a number of water districts including Los Angeles County Waterworks District #36. The 2013 Santa Clarita Valley CCR reported three violations of MCLs: total dissolved solids, turbidity, and nitrate. In Newhall County Water District – Newhall, nitrate levels exceeded the EPA MCL (10 mg/L) reporting a maximum level of 35 mg/L. It is interesting to note the CCR listed the MCL (AL) – Allowable Limit (45 mg/L) instead of the MCL. By not listing the MCL, it appears the provider is within the limit while in reality they violated the EPA standard. TDS exceeded the MCL of 500 mg/L reporting a typical level of 677 mg/L in Newhall County Water District - Pinetree. Two contaminants exceeded MCLGs: TTHMs and total coliform bacteria. Six contaminants were not reported.

Violation Details: On March 23, 2012 a sample from Castaic Lake Water Agency showed turbidity levels exceeding 1 turbidity unit and continued for 8 hours. During the month of March, approximately 17 percent of turbidity measurements were over 0.20 turbidity units while the standard allows no more than 5 percent of samples to exceed 0.20 turbidity units per month. According to CCR, users were notified of the violation which was due to equipment failures and errors by treatment operators. Turbidity has no health effects but high turbidity levels are an indicator of the filtration system and may indicate undesirable organisms such as bacteria and parasites in the water.

Chicago [39]: Chicago's Bureau of Water supply provides water to Chicago and neighboring suburban communities. Chicago's Department of Water Management was the least user friendly CCR presenting eight pages of testing result spreadsheets. No MCL violations or instances where concentrations exceeded MCLGs were found. Information was not provided for eight contaminants.

Houston [40]: Houston is located within Harris County and served by a number of regional water districts. In this study, County Municipal Utility District No. 208 which supplies drinking water to Northwest Houston was analyzed. According to the CCR, no MCL violations or MCLGs were exceeded. No information was provided for eight contaminants.

Philadelphia [41]: The Philadelphia Water Department serves the greater Philadelphia region. The PWD 2012 CCR indicates the system-wide range includes no violations of contaminant MCLs. Three contaminants exceeded MCLGs. No information was provided for nine contaminants.

Details: HAAs range from 1-72 ppb. Because the EPA's MCL's regulation sets the highest level allowed in a one year average at 60 ppb, Philadelphia's 72 ppb level does not qualify as a violation. However, this number is high and is cause for concern. A similar situation in Philadelphia is reported for total trihalomethanes (TTHMs). The highest level allowed per the EPA's MCL is a one year average of 80 ppb while the highest system-wide range of results exceeds the MCL at 98 ppb. Again, it is important to note this is not a violation as the MCL is the annual average while the result is the maximum of the system-wide range.

Phoenix [42]: The City of Phoenix Water Services Department serves approximately 1.5 million residents. The 2012 CCR claims on its front page that it "met or surpassed all federal and state drinking water standards" [43]. However, examining the CCR closely, the highest detected TDS levels of 714 ppm violated the MCL of 500 mg/L.[9]

The Total Dissolved Solids (TDS) rate as provided in the 2012 CCR lists its highest detected level at 714 ppm while the EPA MCL is 500 ppm. Though clearly a violation of the EPA's MCL, the CCR does not point out to the reader that it as a violation. Unless the reader knows the MCL level specific for TDS, the reader would likely read over this information without comprehending its significance.

San Antonio [44]: The San Antonio Water System serves more than 1.6 million people. The SAWS 2013 CCR was the easiest of the 11 reports to interpret. Significantly, it was the most forthcoming with its information, even data which showed its water quality to

[9] Parts per million (ppm) is equal to milligrams/liter mg/L.

be lacking in some cases. SAWS did not violate any MCLs. In two instances the MCLGs were exceeded for TTHMs and total coliform bacteria.

Details: The report listed all of the relevant information to put the reporting data in perspective of the MCLs. For example, for coliform bacteria, the report listed the maximum contaminant level goal (0), the total coliform maximum contaminant level (5 percent of monthly samples are positive), and the highest number of positive (highest monthly percent of positive samples: 1.16 percent). Many CCRs provide only a portion of the relevant information making understanding the data difficult for everyone except an individual well-versed in U.S. water quality regulations.

San Diego [45]: The City of San Diego Public Utilities Department imports approximately 85% of its water from the Metropolitan Water District of Southern California (MWD). It claims on its webpage to meet all federal and state health standards [46]. Examining the 2012 CCR, TDS levels are in violation of the MCL. The EPA MCL is 500 mg/L and San Diego reports 683 ppm as a maximum range at the Alvarado treatment plant. HAAs and TTHMs exceed MCLGs.

Dallas [47**]:** Dallas Water Utilities claims in its CCR to meet or exceed all state and federal requirements for water quality and it does based on the 19 contaminant analysis in this study. No contaminants are in violation of MCLs nor exceed MCLGs. No information is available for nine of the contaminants.

San Jose [48]: The San Jose Water Company on the last page of its CCR states, “as you can see, in 2012, as in years past, your tap water met all USEPA and State primary drinking water health standards.” In direct contradiction, the CCR demonstrated four contaminants were in violation of MCLs: TDS, HAAs, TTHMs, and nitrate. Maximum

TDS rates were 650 ppm, well above the MCL of 500 mg/L. No information was provided for nine contaminants: arsenic, chromium, mercury, pH, atrazine, benzene, polychlorinated biphenyls, giardia lamblia, and cryptosporidium.

Milwaukee [49]: The Milwaukee Water Works CCR did report violations for any of the 19 MCLs. The CCR did not report instances where contaminants exceeded MCLGs. No information was provided for 12 contaminants: arsenic, chloride, chromium, mercury, pH, total dissolved solids, atrazine, benzene, polychlorinated biphenyls, giardia lablia, cryptosporidium, and nitrate.

The International Bottled Water Association (IBWA) was founded as a lobby organization by bottling companies in the 1950s. The IBWA lobbies for the industry on the state and federal levels. The IBWA published the IBWA Model Bottled Water Regulation known as the Model Code which provides voluntary guidance to bottlers on water quality protections beyond those required by the FDA. However, as previously noted, the standards are voluntary and compliance with the Code does not translate into clear information for the consumer to make an informed decision. The third-party annual inspection of bottling facilities though complying with FDA and state regulations by reviewing monitoring, labeling, and Good Manufacturing Practices does not require any physical testing of water quality.

Benefits As demonstrated through the analysis of water quality reports, water supply is vulnerable to contamination. Bottled water is important in times when PWS is unavailable or contaminated. For example, extreme weather events sometimes disrupt the delivery of public water supply. In the United States, the right of the individual is highly

valued. For this reason, consumers should continue to have the choice to buy bottled water. However, consumers must be able to make an informed decision based on reliable, accessible information. Through the establishment and enforcement of adequate regulation, the government is responsible for ensuring the safety of consumer products and the availability of pertinent information so that the consumer is capable of making an informed decision.

5. *Secondary Discussion of Bottled Water*

Beyond the focus of this paper, a number of other concerns regarding the bottled water industry are worthy of consideration. This secondary discussion explores the public perception and externalized costs of the bottled water industry, issues which are pertinent to conversations about the U.S. bottled water industry. Limitations of this study are also noted in this section.

Public Perception: As a result of the FDA's regulatory standards of reporting and oversight, there is a general lack of reliable information about bottled water quality available to regulators and consumers. For-profit companies exploit this lack of information by deliberately creating misinformation and distrust of public water supplies. Compliance with the FDA's regulation of bottled water is cited by bottlers as evidence of the safety and superiority of their product. According to the IBWA website, "the FDA regulations governing the safety and quality of bottled water must be as stringent as the EPA regulations which govern tap water. To suggest in any way that bottled water is less stringently regulated than tap water is simply not true" [50]. However, as demonstrated by this paper, the above claims are often unsubstantiated and in some cases blatantly

false. Bottlers' statements citing the FDA serve to confuse and mislead the consumer in regards to the quality of the product.

In some cases, bottled water companies intentionally disparage PWS in an effort to win over customers and promote bottled water sales. Oftentimes, the false claims of superiority made by the bottling industry go unchallenged. However, in this famous case, a nasty add by Fiji Water ran the headline "The Label Says Fiji Because It's Not Bottled in Cleveland". Cleveland responded by running water quality tests on Fiji water and publishing their lab's test results which showed that while both Fiji Water and Cleveland's tap water met all federal standards, Fiji Water contained: volatile plastic compounds, 40 times more bacteria than found in well-run municipal water systems, and 6.3 micrograms per liter of arsenic. Cleveland's tap water had no measurable levels of arsenic [51].

Figure 1. The label says Fiji because it's not bottled in Cleveland [52]

Source: Water, water everywhere... Retrieved March 20, 2014, from http://thinkoutsidethecliche.files.wordpress.com/2012/11/figi-water.jpg

Human psychology plays a key role in the success of the water bottling industry and marketing has been a critical component in the ever growing popularity of this luxury product. As demonstrated in the case of Fiji Water disparaging Cleveland's tap water, intentional undermining of public confidence in tap water is a technique employed by bottlers. Health, convenience, style, and taste are reasons commonly cited by consumers for their purchasing motivation. Dr. Peter Gleick argues fear, fear of sickness and contamination, is also a central component to the success of the bottling industry. The bottlers' marking campaigns both overtly and covertly undermine the public's trust of tap water. "If we can be made to fear our tap water, the market for bottled water skyrockets," says Gleick [53]. Paying up to 1900 times [54] more for bottled water than tap water per gallon, the willingness of consumers to exercise their purchasing power for a commodity available to them for free is remarkable. Fear no doubt plays into the ability of the bottling industry to win customers.

Table 6. U.S. Bottled Water Market: Volume and Producer Revenues [55]
Source: Beverage Marketing Corporation

U.S. BOTTLED WATER MARKET
Volume and Producer Revenues
2002 – 2012

Year	Millions of Gallons	Annual % Change	Millions of Dollars	Annual % Change
2002	5,795.6	--	$7,901.4	--
2003	6,269.8	8.2%	8,526.4	7.9%
2004	6,806.7	8.6%	9,169.5	7.5%
2005	7,538.9	10.8%	10,007.5	9.1%
2006	8,255.0	9.5%	10,857.8	8.5%
2007	8,753.8	6.0%	11,551.5	6.4%
2008	8,666.7	-1.0%	11,178.5	-3.2%
2009	8,453.1	-2.5%	10,601.3	-5.2%
2010	8,756.3	3.6%	10,686.4	0.8%
2011	9,107.4	4.0%	11,072.4	3.6%
2012	9,674.3	6.2%	11,815.9	6.7%

Source: Beverage Marketing Corporation

In the 1970s, bottled water captured the minds and hearts of American consumers through marking campaigns such as the $5 million Perrier campaign. Since that time, the bottled water industry has enjoyed sustained growth and profits. The industry not only capitalizes on the fears of consumers but is also involved in efforts to reduce and in some cases eliminate the availability of tap water in restaurants, sports stadiums, schools, and other public venues. In 2007, the newly constructed University of Central Florida Knights football stadium was built without a single drinking water fountain. The only source of water for the 45,000 fans was from concession stands or taps in the bathroom sinks. On a scorching day at the first home game in the new stadium, bottled water sold out. That day eighteen people were taken to local hospitals and sixty more were treated for heat-related illnesses. Student activism and ensuing media attention resulted in the school's installation of 50 water fountains [56].

Externalized Costs: In addition to the financial cost to the consumer, bottled water has significant, externalized costs. Three common methods in holistically evaluating costs are the life-cycle assessment, triple bottom line, and environmental full cost accounting. As relates to bottled water, the production, manufacture, distribution, use and disposal must be taken into account.

The environmental and energy costs of bottled water are the most costly and strongest arguments against this luxury product. The environmental costs of bottled water like most products and services in the U.S. are neither recognized nor passed on to the consumer but instead the costs are shifted resulting in environmental degradation. The environmental costs of bottled water include the energy for the pumping the water from the ground, the petroleum to produce the plastic bottles as well as the harmful emissions

from initial refining, bottle manufacturing, and decomposing bottles, the carbon/energy costs of transporting the bottles around the country and sometimes the world, the energy used in the refrigeration of the bottles, and, finally, the cost of recycling the single-use plastic bottles. It is important to note at this point that the vast majority of water bottles are not recycled but instead end up in landfills and scattered across our landscape.

According to a study published in IOP Science entitled "Energy implications of bottled water", it is estimated that in 2007 U.S. bottled water consumption "required an energy input equivalent to between 32 and 54 million barrels of oil or a third of a per cent of total US primary energy consumption" [57].

Limitations: A significant portion of this analysis is determining the limitations of information available to consumers regarding the differences in regulatory standards and water quality of tap versus bottled water.

Several potential limitations exist to this study. One limitation is the size of the public water systems analyzed in the 11 city water quality analysis. The cities were selected due to their large service populations. Analyzing the largest cities in the U.S. will theoretically provide water quality data for a large portion of the nation's population. However, a potential drawback is that the larger the system, the larger the funding for the utility. Smaller public water systems with fewer funds may have a more difficulty meeting EPA standards and thus have lower quality drinking water than larger systems. However, trends are identified as weaknesses in the quality analysis of the largest, best-funded PWS, will likely be experienced to some degree by smaller systems.

6. *Policy Implications & Conclusions*

This study endeavors to unpack the complex system of drinking water regulation in the United States. One of the contributions of this work is identifying gaps and weaknesses in the available information. Without good information it is difficult to make sound policy decisions. Though limited in some respects as explored above, a number of key policy recommendations can effectively be made from the findings of this study.

The primary conclusion is that bottled and tap water should regulated by the same agency and held to the same standards of regulation including comprehensive quality testing, monitoring, reporting, and faster procedures for correcting violations. Until the time when drinking water regulation, both tap and bottled sources, in the U.S. is standardized and regulated by the same agency, nine key recommendations are provided below:

1. FDA should set strict limits on contaminants currently unregulated including arsenic, hetrotrophic-plate-count bacteria, E. coli, and other parasites and pathogens. At minimum, FDA regulations on the above contaminants should match EPA regulations.

2. FDA should enforce existing regulations, specifically on sourcing, treatment, and water quality, and if necessary strengthen regulations requiring bottling companies to be transparent in their operations and advertising. At minimum, FDA regulations on sourcing, treatment, and water quality should be enforced and strengthened to match EPA regulations.

3. FDA should implement a policy requiring bottlers to inform the public of quality violations in a timely manner. At minimum, FDA regulations on informing the public should match EPA regulations.

4. FDA regulations should apply to all bottled water regardless of whether it enters into interstate commerce or if it is carbonated. FDA regulations should pertain to all bottled water on the market.

5. FDA should monitor the quality of bottled water for sale across the country and make their findings available to the public. FDA regulations should be increased to match the EPA regulations on the requirement for independently confirmed, consumer reporting of water quality.

6. EPA drinking water standards should be strengthened to include regulation of emerging contaminants which threaten public health, reflect advancements in scientific knowledge, and incorporate domestic and international best practices. Future research is needed on the impacts of emerging contaminants on human health.

7. The EPA should enforce existing regulations of reporting data and reducing violations.

8. Externalities of bottled water, or the full cost, should be factored into price of product. One way this could be implemented is though implementing a bottled water tax, a method commonly used to curve negative externalities. The tax collected from bottled water sales could be used to improve water infrastructure, a public service from which all will benefit equally.

Increased prices may mean that people without the means to afford bottled water won't be able to access the product. However, bottled water is a luxury product and

safe, clean, tap water is accessible at a reasonable rate. Increasing the cost of bottled water may result in bottled water becoming less affordable for those whose tap water is not available such as those affected by natural disasters. However, in the case of emergencies, the government provides clean water.

9. Government departments and agencies at the federal, state, and local levels should ban the purchase of bottled water with public funds. Supporting the private bottling industry using public funds is a conflict of interest as bottled water is competing with public water systems. Additionally, bottled water companies use their profits to intentionally disparage and undermine public water sources.

Future work needs to be done in two key areas: research and action. Further research needs to be done on bottled water quality data. Action needs to be taken to correct differences in regulations, discrepancies in quality, and public misperceptions. An example of bold action is Ban The Bottle campaigns. Over 50 colleges and university in the United States and Canada have banned the sale of bottled water on their campuses [58]. Additionally, 12 U.S. national parks have banned the sale of bottled water. Disposable plastic bottles comprise an estimated 20% of the Grand Canyon's waste stream and 30% of the park's recyclables [59]. Three cities have banned the sale of bottled water including Concord, Massachusetts and San Francisco, California. A 2007 ordinance prohibits city funds to be used for the purchase of bottled water saving San Francisco $500,000 annually. San Francisco has undertaken a campaign educating citizens about the quality of their tap water and installing outdoor water bottle refilling stations around the city. The city encourages conserving natural resources and reducing waste from single-use plastic water bottles. The utility's website provides a link to a

mobile application called “TapIt” which helps users identify refill stations around the city and encourages users “the next time while you are out and about in the City, remember to bring your reusable container and refill your bottle at any of our tap stations” [60]. More cities and organizations could contribute to moving away from bottled water consumption by banning the purchase and/or sale of bottled water in their respective locations.

Future research opportunities include the collection of better data and reporting on the quality of bottled water. Due to the lack of available data on bottled water quality and the effectiveness of bottlers at creating and manipulating consumer perceptions, people are being tricked into purchasing bottled water thinking it is a healthier choice than tap water. Bottlers use the pricing mechanism to signal their product is of high quality. In fact, bottled water is the same product as tap water but perceived differently. To move the discussion forward, we need better water quality data. In conclusion, all drinking water sources ought to be regulated by the same agency and held to the same standards of regulation. It is the duty of our government to protect the health of the public by ensuring the quality of drinking water is reliable and of consistent quality regardless of whether the source is tap water or bottled water.

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Appendix A. EPA Regulations of Public Water Supply

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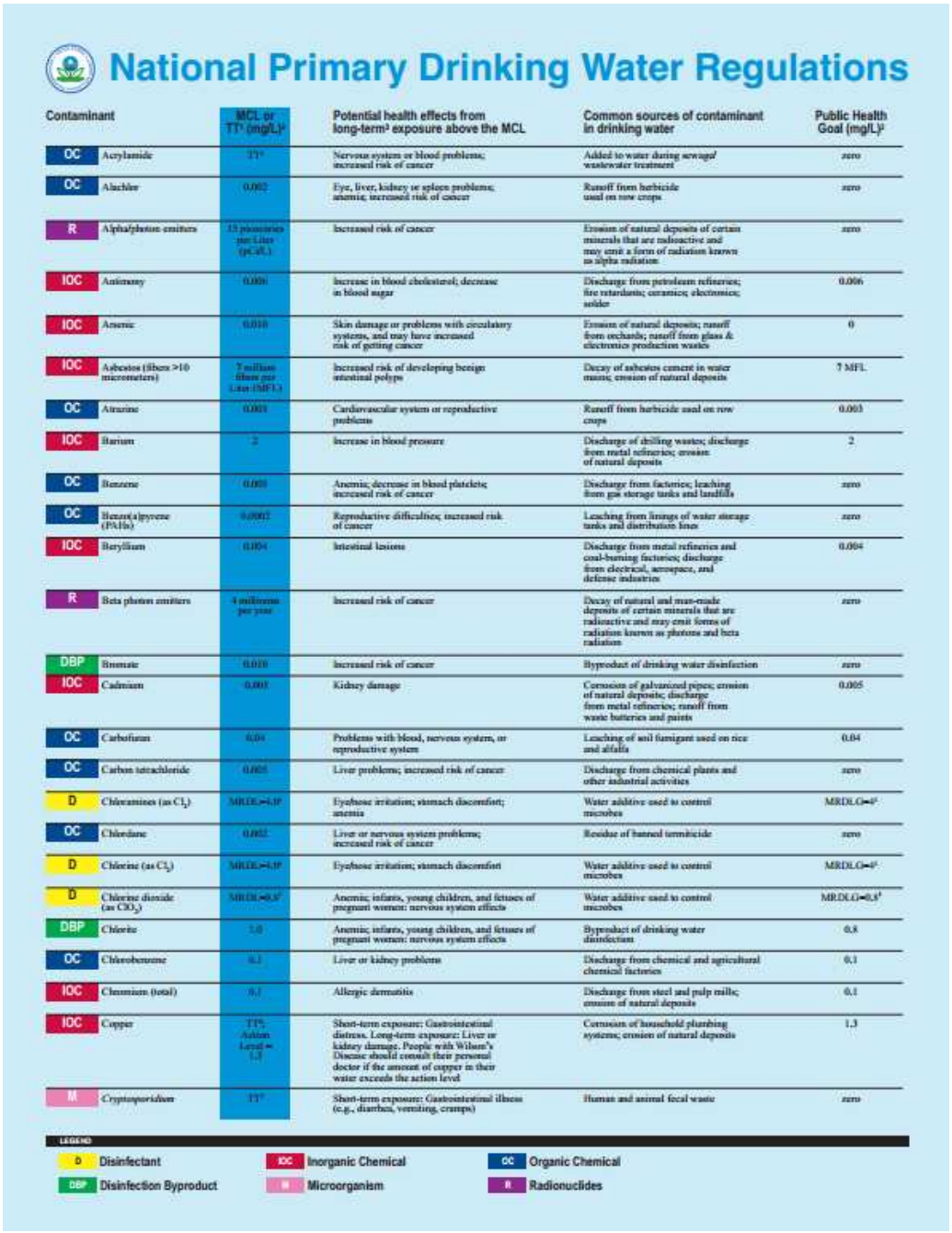


National Primary Drinking Water Regulations

Contaminant	MCL or TT[1] (mg/L)[2]	Potential health effects from long-term[3] exposure above the MCL	Common sources of contaminant in drinking water	Public Health Goal (mg/L)[2]
OC Acrylamide	TT[4]	Nervous system or blood problems; increased risk of cancer	Added to water during sewage/ wastewater treatment	zero
OC Alachlor	0.002	Eye, liver, kidney or spleen problems; anemia; increased risk of cancer	Runoff from herbicide used on row crops	zero
R Alpha/photon emitters	15 picocuries per Liter (pCi/L)	Increased risk of cancer	Erosion of natural deposits of certain minerals that are radioactive and may emit a form of radiation known as alpha radiation	zero
IOC Antimony	0.006	Increase in blood cholesterol; decrease in blood sugar	Discharge from petroleum refineries; fire retardants; ceramics; electronics; solder	0.006
IOC Arsenic	0.010	Skin damage or problems with circulatory systems, and may have increased risk of getting cancer	Erosion of natural deposits; runoff from orchards; runoff from glass & electronics production wastes	0
IOC Asbestos (fibers >10 micrometers)	7 million fibers per Liter (MFL)	Increased risk of developing benign intestinal polyps	Decay of asbestos cement in water mains; erosion of natural deposits	7 MFL
OC Atrazine	0.003	Cardiovascular system or reproductive problems	Runoff from herbicide used on row crops	0.003
IOC Barium	2	Increase in blood pressure	Discharge of drilling wastes; discharge from metal refineries; erosion of natural deposits	2
OC Benzene	0.005	Anemia; decrease in blood platelets; increased risk of cancer	Discharge from factories; leaching from gas storage tanks and landfills	zero
OC Benzo(a)pyrene (PAHs)	0.0002	Reproductive difficulties; increased risk of cancer	Leaching from linings of water storage tanks and distribution lines	zero
IOC Beryllium	0.004	Intestinal lesions	Discharge from metal refineries and coal-burning factories; discharge from electrical, aerospace, and defense industries	0.004
R Beta photon emitters	4 millirems per year	Increased risk of cancer	Decay of natural and man-made deposits of certain minerals that are radioactive and may emit forms of radiation known as photons and beta radiation	zero
DBP Bromate	0.010	Increased risk of cancer	Byproduct of drinking water disinfection	zero
IOC Cadmium	0.005	Kidney damage	Corrosion of galvanized pipes; erosion of natural deposits; discharge from metal refineries; runoff from waste batteries and paints	0.005
OC Carbofuran	0.04	Problems with blood, nervous system, or reproductive system	Leaching of soil fumigant used on rice and alfalfa	0.04
OC Carbon tetrachloride	0.005	Liver problems; increased risk of cancer	Discharge from chemical plants and other industrial activities	zero
D Chloramines (as Cl_2)	MRDL=4.0[5]	Eye/nose irritation; stomach discomfort; anemia	Water additive used to control microbes	MRDLG=4[5]
OC Chlordane	0.002	Liver or nervous system problems; increased risk of cancer	Residue of banned termiticide	zero
D Chlorine (as Cl_2)	MRDL=4.0[5]	Eye/nose irritation; stomach discomfort	Water additive used to control microbes	MRDLG=4[5]
D Chlorine dioxide (as ClO_2)	MRDL=0.8[5]	Anemia; infants, young children, and fetuses of pregnant women: nervous system effects	Water additive used to control microbes	MRDLG=0.8[5]
DBP Chlorite	1.0	Anemia; infants, young children, and fetuses of pregnant women: nervous system effects	Byproduct of drinking water disinfection	0.8
OC Chlorobenzene	0.1	Liver or kidney problems	Discharge from chemical and agricultural chemical factories	0.1
IOC Chromium (total)	0.1	Allergic dermatitis	Discharge from steel and pulp mills; erosion of natural deposits	0.1
IOC Copper	TT; Action Level = 1.3	Short-term exposure: Gastrointestinal distress. Long-term exposure: Liver or kidney damage. People with Wilson's Disease should consult their personal doctor if the amount of copper in their water exceeds the action level	Corrosion of household plumbing systems; erosion of natural deposits	1.3
M *Cryptosporidium*	TT[4]	Short-term exposure: Gastrointestinal illness (e.g., diarrhea, vomiting, cramps)	Human and animal fecal waste	zero

LEGEND

D Disinfectant | DBP Disinfection Byproduct | IOC Inorganic Chemical | M Microorganism | OC Organic Chemical | R Radionuclides

Contaminant		MCL or TT[1] (mg/L)[2]	Potential health effects from long-term[3] exposure above the MCL	Common sources of contaminant in drinking water	Public Health Goal (mg/L)[2]
IOC	Cyanide (as free cyanide)	0.2	Nerve damage or thyroid problems	Discharge from steel/metal factories; discharge from plastic and fertilizer factories	0.2
OC	2,4-D	0.07	Kidney, liver, or adrenal gland problems	Runoff from herbicide used on row crops	0.07
OC	Dalapon	0.2	Minor kidney changes	Runoff from herbicide used on rights of way	0.2
OC	1,2-Dibromo-3-chloropropane (DBCP)	0.0002	Reproductive difficulties; increased risk of cancer	Runoff/leaching from soil fumigant used on soybeans, cotton, pineapples, and orchards	zero
OC	o-Dichlorobenzene	0.6	Liver, kidney, or circulatory system problems	Discharge from industrial chemical factories	0.6
OC	p-Dichlorobenzene	0.075	Anemia; liver, kidney or spleen damage; changes in blood	Discharge from industrial chemical factories	0.075
OC	1,2-Dichloroethane	0.005	Increased risk of cancer	Discharge from industrial chemical factories	zero
OC	1,1-Dichloroethylene	0.007	Liver problems	Discharge from industrial chemical factories	0.007
OC	cis-1,2-Dichloroethylene	0.07	Liver problems	Discharge from industrial chemical factories	0.07
OC	trans-1,2-Dichloroethylene	0.1	Liver problems	Discharge from industrial chemical factories	0.1
OC	Dichloromethane	0.005	Liver problems; increased risk of cancer	Discharge from drug and chemical factories	zero
OC	1,2-Dichloropropane	0.005	Increased risk of cancer	Discharge from industrial chemical factories	zero
OC	Di(2-ethylhexyl) adipate	0.4	Weight loss, liver problems, or possible reproductive difficulties	Discharge from chemical factories	0.4
OC	Di(2-ethylhexyl) phthalate	0.006	Reproductive difficulties; liver problems; increased risk of cancer	Discharge from rubber and chemical factories	zero
OC	Dinoseb	0.007	Reproductive difficulties	Runoff from herbicide used on soybeans and vegetables	0.007
OC	Dioxin (2,3,7,8-TCDD)	0.00000003	Reproductive difficulties; increased risk of cancer	Emissions from waste incineration and other combustion; discharge from chemical factories	zero
OC	Diquat	0.02	Cataracts	Runoff from herbicide use	0.02
OC	Endothall	0.1	Stomach and intestinal problems	Runoff from herbicide use	0.1
OC	Endrin	0.002	Liver problems	Residue of banned insecticide	0.002
OC	Epichlorohydrin	TT[4]	Increased cancer risk; stomach problems	Discharge from industrial chemical factories; an impurity of some water treatment chemicals	zero
OC	Ethylbenzene	0.7	Liver or kidney problems	Discharge from petroleum refineries	0.7
OC	Ethylene dibromide	0.00005	Problems with liver, stomach, reproductive system, or kidneys; increased risk of cancer	Discharge from petroleum refineries	zero
M	Fecal coliform and *E. coli*	MCL[5]	Fecal coliforms and *E. coli* are bacteria whose presence indicates that the water may be contaminated with human or animal wastes. Microbes in these wastes may cause short term effects, such as diarrhea, cramps, nausea, headaches, or other symptoms. They may pose a special health risk for infants, young children, and people with severely compromised immune systems.	Human and animal fecal waste	zero[6]
IOC	Fluoride	4.0	Bone disease (pain and tenderness of the bones); children may get mottled teeth	Water additive which promotes strong teeth; erosion of natural deposits; discharge from fertilizer and aluminum factories	4.0
M	*Giardia lamblia*	TT[4]	Short-term exposure: Gastrointestinal illness (e.g., diarrhea, vomiting, cramps)	Human and animal fecal waste	zero
OC	Glyphosate	0.7	Kidney problems; reproductive difficulties	Runoff from herbicide use	0.7
DBP	Haloacetic acids (HAA5)	0.060	Increased risk of cancer	Byproduct of drinking water disinfection	n/a[9]
OC	Heptachlor	0.0004	Liver damage; increased risk of cancer	Residue of banned termiticide	zero
OC	Heptachlor epoxide	0.0002	Liver damage; increased risk of cancer	Breakdown of heptachlor	zero
M	Heterotrophic plate count (HPC)	TT[4]	HPC has no health effects; it is an analytic method used to measure the variety of bacteria that are common in water. The lower the concentration of bacteria in drinking water, the better maintained the water system is.	HPC measures a range of bacteria that are naturally present in the environment	n/a

LEGEND

D Disinfectant — IOC Inorganic Chemical — OC Organic Chemical

DBP Disinfection Byproduct — M Microorganism — R Radionuclides

Contaminant		MCL or TT[1] (mg/L)[2]	Potential health effects from long-term[3] exposure above the MCL	Common sources of contaminant in drinking water	Public Health Goal (mg/L)[2]
OC	Hexachlorobenzene	0.001	Liver or kidney problems; reproductive difficulties; increased risk of cancer	Discharge from metal refineries and agricultural chemical factories	zero
OC	Hexachlorocyclopentadiene	0.05	Kidney or stomach problems	Discharge from chemical factories	0.05
IOC	Lead	TT[4]; Action Level=0.015	Infants and children: Delays in physical or mental development; children could show slight deficits in attention span and learning abilities; Adults: Kidney problems; high blood pressure	Corrosion of household plumbing systems; erosion of natural deposits	zero
M	*Legionella*	TT[4]	Legionnaire's Disease, a type of pneumonia	Found naturally in water; multiplies in heating systems	zero
OC	Lindane	0.0002	Liver or kidney problems	Runoff/leaching from insecticide used on cattle, lumber, gardens	0.0002
IOC	Mercury (inorganic)	0.002	Kidney damage	Erosion of natural deposits; discharge from refineries and factories; runoff from landfills and croplands	0.002
OC	Methoxychlor	0.04	Reproductive difficulties	Runoff/leaching from insecticide used on fruits, vegetables, alfalfa, livestock	0.04
IOC	Nitrate (measured as Nitrogen)	10	Infants below the age of six months who drink water containing nitrate in excess of the MCL could become seriously ill and, if untreated, may die. Symptoms include shortness of breath and blue-baby syndrome.	Runoff from fertilizer use; leaching from septic tanks, sewage; erosion of natural deposits	10
IOC	Nitrite (measured as Nitrogen)	1	Infants below the age of six months who drink water containing nitrite in excess of the MCL could become seriously ill and, if untreated, may die. Symptoms include shortness of breath and blue-baby syndrome.	Runoff from fertilizer use; leaching from septic tanks, sewage; erosion of natural deposits	1
OC	Oxamyl (Vydate)	0.2	Slight nervous system effects	Runoff/leaching from insecticide used on apples, potatoes, and tomatoes	0.2
OC	Pentachlorophenol	0.001	Liver or kidney problems; increased cancer risk	Discharge from wood-preserving factories	zero
OC	Picloram	0.5	Liver problems	Herbicide runoff	0.5
OC	Polychlorinated biphenyls (PCBs)	0.0005	Skin changes; thymus gland problems; immune deficiencies; reproductive or nervous system difficulties; increased risk of cancer	Runoff from landfills; discharge of waste chemicals	zero
R	Radium 226 and Radium 228 (combined)	5 pCi/L	Increased risk of cancer	Erosion of natural deposits	zero
IOC	Selenium	0.05	Hair or fingernail loss; numbness in fingers or toes; circulatory problems	Discharge from petroleum and metal refineries; erosion of natural deposits; discharge from mines	0.05
OC	Simazine	0.004	Problems with blood	Herbicide runoff	0.004
OC	Styrene	0.1	Liver, kidney, or circulatory system problems	Discharge from rubber and plastic factories; leaching from landfills	0.1
OC	Tetrachloroethylene	0.005	Liver problems; increased risk of cancer	Discharge from factories and dry cleaners	zero
IOC	Thallium	0.002	Hair loss; changes in blood; kidney, intestine, or liver problems	Leaching from ore-processing sites; discharge from electronics, glass, and drug factories	0.0005
OC	Toluene	1	Nervous system, kidney, or liver problems	Discharge from petroleum factories	1
M	Total Coliforms	5.0 percent[5]	Coliforms are bacteria that indicate that other, potentially harmful bacteria may be present. See fecal coliforms and *E. coli*	Naturally present in the environment	zero
DBP	Total Trihalomethanes (TTHMs)	0.080	Liver, kidney or central nervous system problems; increased risk of cancer	Byproduct of drinking water disinfection	n/a[6]
OC	Toxaphene	0.003	Kidney, liver, or thyroid problems; increased risk of cancer	Runoff/leaching from insecticide used on cotton and cattle	zero
OC	2,4,5-TP (Silvex)	0.05	Liver problems	Residue of banned herbicide	0.05
OC	1,2,4-Trichlorobenzene	0.07	Changes in adrenal glands	Discharge from textile finishing factories	0.07
OC	1,1,1-Trichloroethane	0.2	Liver, nervous system, or circulatory problems	Discharge from metal degreasing sites and other factories	0.2
OC	1,1,2-Trichloroethane	0.003	Liver, kidney, or immune system problems	Discharge from industrial chemical factories	0.003
OC	Trichloroethylene	0.005	Liver problems; increased risk of cancer	Discharge from metal degreasing sites and other factories	zero

LEGEND

D Disinfectant
DBP Disinfection Byproduct
IOC Inorganic Chemical
M Microorganism
OC Organic Chemical
R Radionuclides

Contaminant		MCL or TT[1] (mg/L)[2]	Potential health effects from long-term[3] exposure above the MCL	Common sources of contaminant in drinking water	Public Health Goal (mg/L)[3]
M	Turbidity	TT[7]	Turbidity is a measure of the cloudiness of water. It is used to indicate water quality and filtration effectiveness (e.g., whether disease-causing organisms are present). Higher turbidity levels are often associated with higher levels of disease-causing microorganisms such as viruses, parasites and some bacteria. These organisms can cause short term symptoms such as nausea, cramps, diarrhea, and associated headaches.	Soil runoff	n/a
R	Uranium	30 µg/L	Increased risk of cancer, kidney toxicity	Erosion of natural deposits	zero
OC	Vinyl chloride	0.002	Increased risk of cancer	Leaching from PVC pipes; discharge from plastic factories	zero
M	Viruses (enteric)	TT[7]	Short-term exposure: Gastrointestinal illness (e.g., diarrhea, vomiting, cramps)	Human and animal fecal waste	zero
OC	Xylenes (total)	10	Nervous system damage	Discharge from petroleum factories; discharge from chemical factories	10

National Secondary Drinking Water Regulation

National Secondary Drinking Water Regulations are non-enforceable guidelines regarding contaminants that may cause cosmetic effects (such as skin or tooth discoloration) or aesthetic effects (such as taste, odor, or color) in drinking water. EPA recommends secondary standards to water systems but does not require systems to comply. However, some states may choose to adopt them as enforceable standards.

Contaminant	Secondary Maximum Contaminant Level
Aluminum	0.05 to 0.2 mg/L
Chloride	250 mg/L
Color	15 (color units)
Copper	1.0 mg/L
Corrosivity	noncorrosive
Fluoride	2.0 mg/L
Foaming Agents	0.5 mg/L
Iron	0.3 mg/L
Manganese	0.05 mg/L
Odor	3 threshold odor number
pH	6.5-8.5
Silver	0.10 mg/L
Sulfate	250 mg/L
Total Dissolved Solids	500 mg/L
Zinc	5 mg/L

For More Information

EPA's Safe Drinking Water Web site:
http://www.epa.gov/safewater/

EPA's Safe Drinking Water Hotline:
(800) 426-4791

To order additional posters or other ground water and drinking water publications, please contact the National Service Center for Environmental Publications at :
(800) 490-9198, or
email: nscep@bps-lmit.com.

NOTES

1 Definitions
- Maximum Contaminant Level Goal (MCLG)—The level of a contaminant in drinking water below which there is no known or expected risk to health. MCLGs allow for a margin of safety and are non-enforceable public health goals.
- Maximum Contaminant Level (MCL)—The highest level of a contaminant that is allowed in drinking water. MCLs are set as close to MCLGs as feasible using the best available treatment technology and taking cost into consideration. MCLs are enforceable standards.
- Maximum Residual Disinfectant Level Goal (MRDLG)—The level of a drinking water disinfectant below which there is no known or expected risk to health. MRDLGs do not reflect the benefits of the use of disinfectants to control microbial contaminants.
- Maximum Residual Disinfectant Level (MRDL)—The highest level of a disinfectant allowed in drinking water. There is convincing evidence that addition of a disinfectant is necessary for control of microbial contaminants.
- Treatment Technique (TT)—A required process intended to reduce the level of a contaminant in drinking water.

2 Units are in milligrams per liter (mg/L) unless otherwise noted. Milligrams per liter are equivalent to parts per million (ppm).

3 Health effects are from long-term exposure unless specified as short-term exposure.

4 Each water system must certify annually, in writing, to the state (using third-party or manufacturers certification) that when it uses acrylamide and/or epichlorohydrin to treat water, the combination (or product) of dose and monomer level does not exceed the levels specified, as follows: Acrylamide = 0.05 percent dosed at 1 mg/L (or equivalent); Epichlorohydrin = 0.01 percent dosed at 20 mg/L (or equivalent).

5 Lead and copper are regulated by a Treatment Technique that requires systems to control the corrosiveness of their water. If more than 10 percent of tap water samples exceed the action level, water systems must take additional steps. For copper, the action level is 1.3 mg/L, and for lead is 0.015 mg/L.

6 A routine sample that is fecal coliform-positive or *E. coli*-positive triggers repeat samples—if any repeat sample is total coliform-positive, the system has an acute MCL violation. A routine sample that is total coliform-positive and fecal coliform-negative or *E. coli*-negative triggers repeat samples—if any repeat sample is fecal coliform-positive or *E. coli*-positive, the system has an acute MCL violation. See also Total Coliforms.

7 EPA's surface water treatment rules require systems using surface water or ground water under the direct influence of surface water to (1) disinfect their water, and (2) filter their water or meet criteria for avoiding filtration so that the following contaminants are controlled at the following levels:
- Cryptosporidium: 99 percent removal for systems that filter. Unfiltered systems are required to include Cryptosporidium in their existing watershed control provisions.
- Giardia lamblia: 99.9 percent removal/inactivation
- Viruses: 99.99 percent removal/inactivation
- *Legionella*: No limit, but EPA believes that if Giardia and viruses are removed/inactivated according to the treatment techniques in the surface water treatment rule, *Legionella* will also be controlled.
- Turbidity: For systems that use conventional or direct filtration, at no time can turbidity (cloudiness of water) go higher than 1 nephelometric turbidity unit (NTU), and samples for turbidity must be less than or equal to 0.3 NTU in at least 95 percent of the samples in any month. Systems that use filtration other than conventional or direct filtration must follow state limits, which must include turbidity at no time exceeding 5 NTU.
- HPC: No more than 500 bacterial colonies per milliliter
- Long Term 1 Enhanced Surface Water Treatment: Surface water systems or ground water systems under the direct influence of surface water serving fewer than 10,000 people must comply with the applicable Long Term 1 Enhanced Surface Water Treatment Rule provisions (e.g. turbidity standards, individual filter monitoring, Cryptosporidium removal requirements, updated watershed control requirements for unfiltered systems).
- Long Term 2 Enhanced Surface Water Treatment: This rule applies to all surface water systems or ground water systems under the direct influence of surface water. The rule targets additional Cryptosporidium treatment requirements for higher risk systems and includes provisions to reduce risks from uncovered finished water storages facilities and to ensure that the systems maintain microbial protection as they take steps to reduce the formation of disinfection byproducts. (Monitoring start dates are staggered by system size. The largest systems (serving at least 100,000 people) will begin monitoring in October 2006 and the smallest systems (serving fewer than 10,000 people) will not begin monitoring until October 2008. After completing monitoring and determining their treatment bin, systems generally have three years to comply with any additional treatment requirements.)
- Filter Backwash Recycling: The Filter Backwash Recycling Rule requires systems that recycle to return specific recycle flows through all processes of the system's existing conventional or direct filtration system or at an alternate location approved by the state.

8 No more than 5.0 percent samples total coliform-positive in a month. (For water systems that collect fewer than 40 routine samples per month, no more than one sample can be total coliform-positive per month.) Every sample that has total coliform must be analyzed for either fecal coliforms or *E. coli*. If two consecutive TC-positive samples, and one is also positive for *E. coli* or fecal coliforms, system has an acute MCL violation.

9 Although there is no collective MCLG for this contaminant group, there are individual MCLGs for some of the individual contaminants:
- Haloacetic acids: dichloroacetic acid (zero); trichloroacetic acid (0.3 mg/L)
- Trihalomethanes: bromodichloromethane (zero); bromoform (zero); dibromochloromethane (0.06 mg/L)

Appendix B. FDA Regulations of Bottled Water

Title 21: Food and Drugs of The Code of Federal Regulations has two pertaining to bottled water: 21 CFR Part 129 – Processing and Bottling of Bottled Drinking Water and 21 CFR Part 165.110 – Bottled Water. The codes are too lengthy to include in this report.

21 CFR Part 129 includes subpart A – General Provisions, Subpart B – Buildings and Facilities, Subpart C – Equipment, Subpart D – Reserved, and Subpart E – Production and Process Controls.

21 CFR Part 165.110 includes definitions, contaminant concentration limits, and measuring methods.

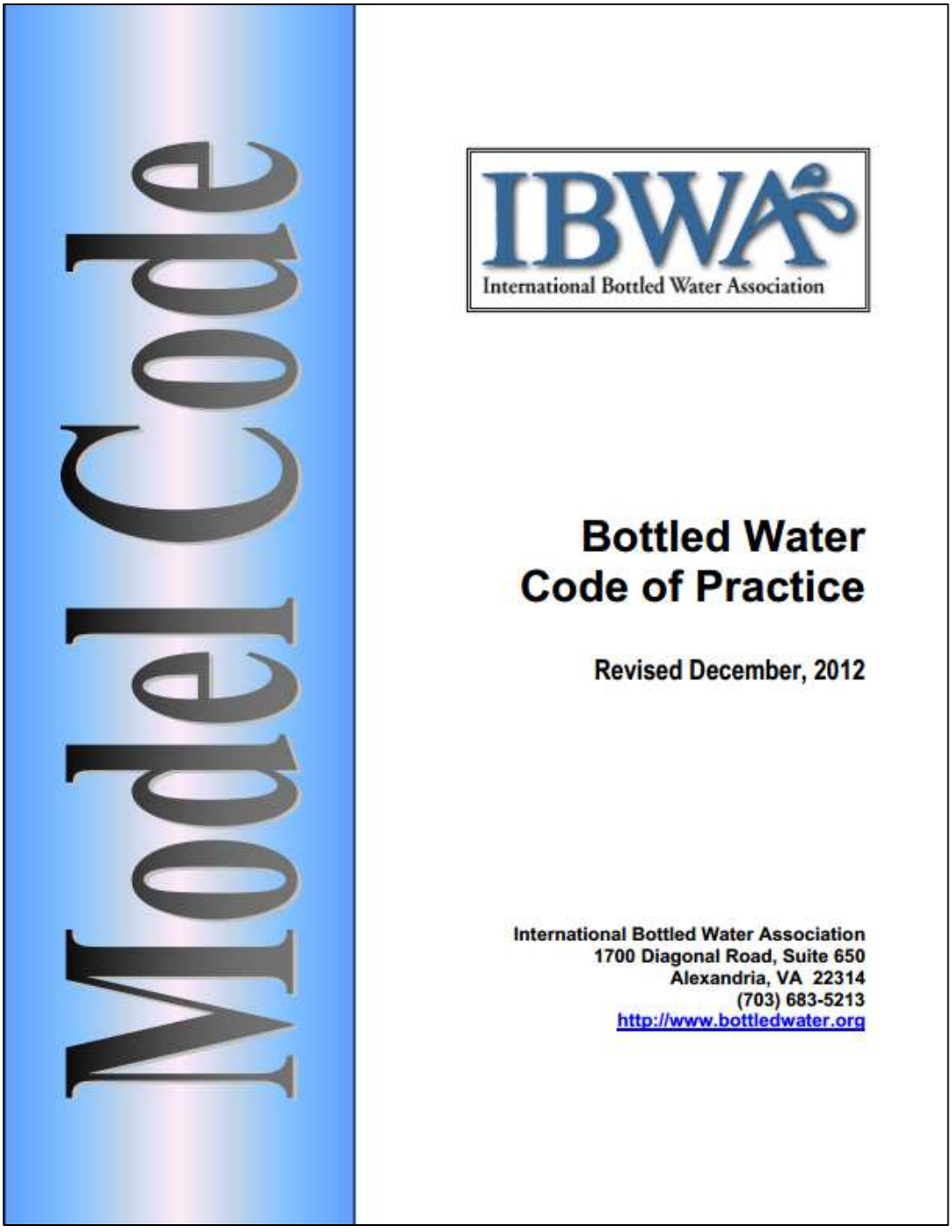
The full documents can be accessed on the FDA website.

http://www.fda.gov/Food/GuidanceRegulation/GuidanceDocumentsRegulatoryInformation/BottledWaterCarbonatedSoftDrinks/default.htm

Appendix C. IBWA Model Code Monitoring Requirements

International Bottled Water Association. (2014). Bottled water. Retrieved March 15, 2014,
from http://www.bottledwater.org/files/IBWA_MODEL_CODE_2012_1212_FINAL_0.pdf#overlay-context=education/codes-of-practice

The first three of 30 pages are included below. For the full document, visit the IBWA website.


Model Code
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International Bottled Water Association
Bottled Water
Code of Practice
Revised December, 2012
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INTERNATIONAL BOTTLED WATER ASSOCIATION
Bottled Water Code of Practice
(revised December, 2012)

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This Code of Practice for Bottled Water has been prepared by the International Bottled Water Association, its membership, Board of Directors, Government Relations Committee, and Technical Committee. For questions about the Model Code contact: International Bottled Water Association, 1700 Diagonal Road, Suite 650, Alexandria, VA 22314. (703) 683-5213.

INTERNATIONAL BOTTLED WATER ASSOCIATION
Bottled Water Code of Practice

Foreword

The IBWA Model Bottled Water Regulation, known as the "Model Code," was first published in 1982. At that time, the U.S. Food and Drug Administration's regulations for bottled water were limited in scope. IBWA developed a set of standards that could be used as minimum standards to which association members would subscribe and to encourage state agencies to adopt it as a model for their own bottled water regulations.

IBWA has continued to advance the Model Code in the 1980s, 1990s, and up to the present day. In November 13, 1995, FDA published a standard of identity and quality for bottled water at 21 C.F.R. §165.110. The Model Code was revised to adopt the provisions that FDA had promulgated, but it was still considered a document that could be used to raise the standards for bottled water and distinguish IBWA bottlers from others in the industry. This was done partly by adopting industry and regulatory requirements that were sometimes more stringent than FDA, primarily in the area of good manufacturing practices (GMPs). In 2000, IBWA adopted the Hazard Analysis of Critical Control Points (HACCP) system into the Model Code. This was a significant advance for the industry since HACCP was not mandated for bottled water at either the federal or state levels of government. The association felt it was important to adopt HACCP.

The IBWA Model Code has adopted many of the state requirements for bottled water. However, there are some instances where an individual state requirement may not be included in the Model Code, such as source and finished product monitoring requirements for certain substances, and bulk water hauling regulations. If a bottler sells in a particular state, they must ensure they comply with the state bottled water regulations. IBWA bottler members are encouraged to use the contact list of state regulatory agencies, included in this Model Code at Appendix D, for ready access to state bottled water regulations.

In recent years, with improved FDA and state regulations in place, IBWA's focus began to shift from providing a regulatory model to the following set of principles:

The IBWA Model Code is a set of self-regulating industry standards.

The Model Code establishes a comprehensive set of standards for bottler members to ensure product safety and quality.

The Model Code provides specific guidance to current IBWA members.

The Model Code is a reference document that provides, in one place, information members need regarding government and industry standards.

The Model Code provides valuable guidance to "startup" companies, who are prospective members of IBWA.

For companies who seek to enter the bottled water industry, the Model Code is a valuable resource to educate them on our industry's technical and regulatory requirements and provides a framework within which they can establish their facilities.