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The Role of Regulatory Agencies in the Frequency and Occurrence of Health-Based Violations at Public Water Systems in the United States

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By

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Abstract

The Safe Drinking Water Act (SDWA) was implemented in the United States (U.S.) in 1974 for the purpose of protecting consumers from water contaminants. The Federal government gave the Environmental Protection Agency (EPA) the authority to delegate the responsibility of ensuring that States, Sovereign Nations and U.S. territories meet specific requirements upon being granted primacy to regulate all public water systems (PWSs) in their jurisdiction. An examination of seven years (2013-2019) of SDWA compliance data from all PWSs in the U.S. revealed trends within various categories of regulating agencies that could create disparities in how water systems are regulated. Analyses of variance (ANOVA) showed correlations between the number of violations and population as well as the rate of increase in violations and population. Results show that on average, a high percentage of health-based (HB) violations occurred at the least populated states, regions and U.S. territories. Also, EPA regulated PWSs (mostly American Indian Tribal) and PWSs located in U.S Territories reported higher numbers than State regulated PWSs. American Samoa with one of the lowest populations served had the highest average number of health-based violations, while Washington, D.C., with substantially more people had the lowest average number of health-based violations. The rate at which these HB violations increased from year to year was fastest in American Samoa as well, but lowest in EPA Region 7. These trends reveal disparities between systems regulated by different agencies and in relation to the populations served.

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Introduction

Water is a resource that all living things need for survival. Access to clean and safe drinking water should be a right for all, but unfortunately it is not the case for many. Although over 70% of the earth's surface is made up of water, 97% of this is saltwater, while only 3% is freshwater. The World Health Organization (WHO) notes that although 91% of the world's population had access to an improved drinking-water source in 2015, 785 million people still lack a basic drinking-water service (WHO, 2016) and by 2025, half of the world's population will be water-stressed. In the United States (U.S.), water demand is increasingly unsustainable, and it is estimated that over 35% of the country will face water shortages by mid-century because of climate change (Tech et al., 2010). This is especially critical in arid and semi-arid areas of the U.S., such as the Southwest, that are most impacted by climate change and lack adequate freshwater resources (Gonzalez et al., 2018).

Although freshwater availability throughout the country is not even, the U.S is among the nations most blessed with abundant freshwater. According to the Food and Agriculture Organization (FAO) of the United Nations, the U.S. is ranked 7th in total freshwater resources among world nations with 2071 km^3 a year (FAO, 2003). However, even in the U.S., the ready availability of freshwater resources does not always equate to access to a product that is safe for human consumption. For that reason, the U.S. has invested heavily in terms of effort and resources to provide safe drinking water to its population. To that end, two major developments have had major and significant impact on the safety and availability of drinking water in the U.S. in the 20^{th} century: disinfection and regulation.

Disinfection refers to the killing or inactivation of pathogens in drinking water to make it safe for human consumption. Disinfection became necessary as a result of water borne disease outbreaks associated with the rapid urbanization and population increases in major U.S cities in the 19^{th} century. Authorities realized that there was a need to ensure the supply of drinking water to

these urban communities and, to a lesser extent, rural communities were not only reliable, but also safe (McGuire, 2006). Early advances therefore stemmed from health concerns, and in 1908, chlorine disinfection of drinking water was introduced in the U.S (CDC.gov). Chlorination was found to curb the increase in water borne diseases such as typhoid fever and cholera, which had become prevalent in urban areas. The disinfection of municipal water supplies led to significant declines in waterborne diseases, especially in large U.S. cities (CDC.gov).

According to McGuire, 2006, this major revolution in water treatment required a general understanding that bacteria and other microorganisms in water could cause disease in humans. This concept was bitterly contested amongst scientists, until the acceptance in the mid-20th century of the "germ theory" (Romano, 2001). Thereafter, water borne diseases reduced drastically during the first half of the 20th century to be virtually insignificant (Figure 1), and by the end of the 20th century, deaths from waterborne illnesses became less prevalent in the U.S.

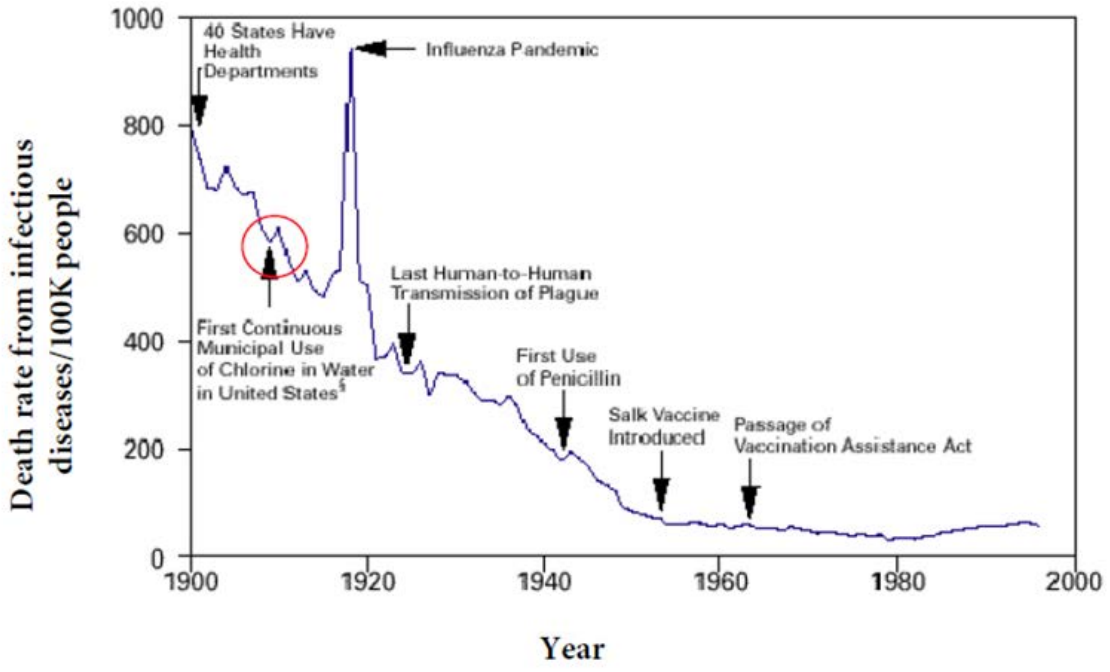


Figure 1: Decline in death rate from infectious diseases in the U.S. following the Introduction of water disinfection using chlorine (Modified from CDC.gov)

The next major innovation in the U.S. drinking water supply system - regulation - became necessary as a means for ensuring a safe product to the public. Although the introduction of chlorine disinfection had made drinking water safe for consumption, lack of proper standards and guidelines meant that there was no way of telling if safe practices were being followed and if the appropriate and safe dose was being applied by water systems across the country. Scientists were aware that, if not done correctly, water disinfection could cause other public health concerns, such as chemical poisoning or inadequate treatment (AWWA, 2000).

To address these concerns, The U.S. Congress enacted the Safe Drinking Water Act (SDWA) in 1974 with the purpose of protecting public health from natural and man-made contaminants in drinking water. The Act required that all Public Water Systems (PWSs) adhere to the Environmental Protection Agency's (EPA) regulations for limiting harmful contaminants in public water supplies. Under this Act, all drinking water suppliers were obligated to follow SDWA Common Rules and any other rules legally enacted by regulatory agencies. The SDWA established different regulatory agencies (of which there are currently 65 throughout the nation) to implement and to enforce these common Rules.

Research Questions

The current study examines the potential impact of U.S. regulatory agencies in the reported number of health-based violations, the types of violations, and the frequency of occurrences of these violations at U.S PWSs. Specifically, the study examines whether the rules are being implemented in a consistent manner across all water systems and whether there are factors affecting their proper implementation across jurisdictional boundaries. In other words, do primacy agencies affect the rate of increases in health-based violations at PWSs? And are there any characteristics of primacy agencies, such as size of population, number of systems regulated, that impact the reported number of

health-based violations? A comparison of violations in different PWSs regulated by different agencies in different states, regions and tribal communities could shed a light on differences, and therefore help explain any disparities in existence.

The study is prompted by the fact that some violations at PWSs can be an indicator of water quality and how well these systems are managed to comply with SDWA regulations. However, PWSs don't operate in a vacuum: Regulatory agencies play an important role in ensuring that SDWA regulations are followed. The goal is to highlight any factors that may be contributing to disparities in compliance that may affect the provision of clean, safe water to consumers. Any disparities based on population size, characteristics of the served population (such as racial breakdowns), size of water system, location, and the type of regulating agency are highlighted and suggestions made on how to address the disparity in order to ensure the provision of safe drinking water to all consumers.

Background

The first public water system was instituted in the US in 1755 in Bethlehem, Pennsylvania (Choice Reviews, 2003). By 1860, following an increase in the U.S. urban population, more than 400 water systems (private and public) had been formed to serve major cities and towns. By 1900, the number of water systems had increased rapidly to more than 3,000, with most of the systems categorized as public water systems (Figure 2). By 2019, there were over 146,000 PWSs in the U.S., of which 951 (1%) are categorized as American Indian Tribal owned systems. (USEPA, 2017).

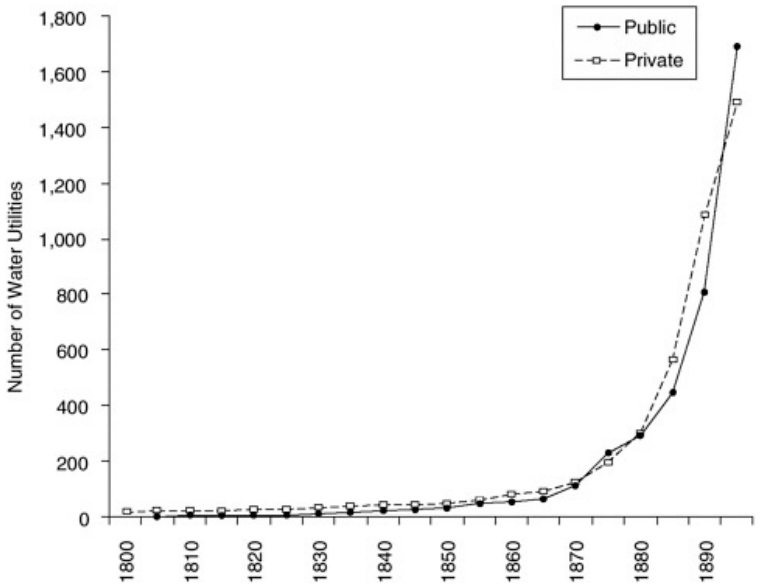


Figure 2: Historical emergence of water systems in the U.S.

(Source: Privatization of Water Services in the United States; An Assessment of Issues and Experience (2002; pg. 34)

The SDWA affects only PWSs and not private wells. For purposes of the SDWA, a PWS is defined as a water system serving at least 25 people for at least 60 days of the year, or a system with 15 service connections serving water for at least 60 days of the year. Private systems (mostly wells) that serve fewer than 25 people are not regulated by the SDWA and are not subject to the same rules governing public water systems. Approximately 99% of the U.S. population is served by a PWS (USEPA, 2017). It is important to note that the term ‘public’ does not refer to the ownership or governance of the water system. A PWS simply refers to the size of and the number of people it serves. In fact, in 2019, a majority of PWSs in the U.S were owned by private entities and the public sector owned approximately 30% of all systems (Figure 3)

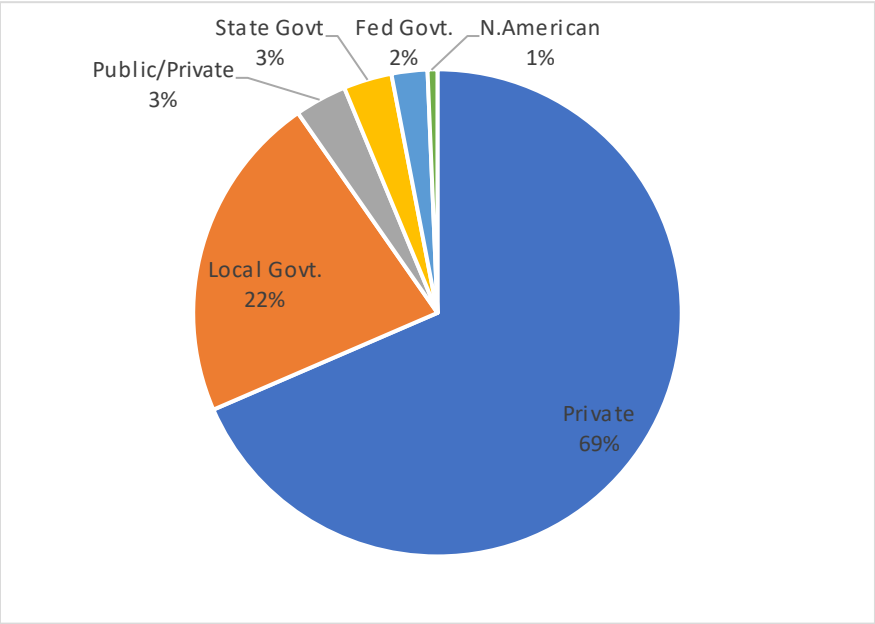


Figure 3: Ownership of PWSs breakdown in the U. S (EPA.gov[3])

Regulation of PWSs in the U.S

Beginning in 1974, SDWA gave EPA the authority to delegate the primary responsibility for enforcing drinking water regulations to States, Territories or American Indian Tribes, with the requirement that they all meet specific standards (USEPA, 2017). Groups with this responsibility are commonly referred to as having 'primacy'. The SDWA authorized EPA to provide grants to these groups to administer programs under the Public Water System Supervision (PWSS) programs (EPA.gov[6]). All States (except the state of Wyoming), Territories, and the Navajo Nation have assumed primacy and hence receive grants from the EPA to help fund the oversight of water systems and other program responsibilities in their localities.

Primacy is exercised in several ways. Wyoming is the only state not granted primacy, so EPA directly regulates all water utilities in that state. The EPA Region 8 has primary enforcement authority for all SDWA regulatory programs in Wyoming except the Operator Certification and

Capacity Development Programs (DEQ.Wyoming.gov). The District of Columbia (D.C.) is regulated by EPA Region 3.

The Federal Register shows that the Navajo Nation is the only tribal nation in the U.S. that was granted primacy in October 2000 to regulate public water systems on the Navajo Nation (65 Fed. Register 66, 541, Nov 6, 2000). Save for the Navajo Nation's special case, EPA generally regulates American Indian Tribal systems and States regulate all other systems. There are a few exceptions where some Tribal utilities, for reasons beyond the scope of this study, are regulated by states. The EPA directly regulates only tribal nations that are federally recognized and receive funding from the federal government for various programs, including drinking water. According to data from the 2018 Bureau of Indian Affairs, 574 tribes in the contiguous U.S are federally recognized (NCAI.org), while an additional 66 are recognized by their respective states only, but not by the federal government (Koenig & Stein, 2011). Currently, Alaska has the largest number of federally recognized Alaskan native tribes in the U.S. with 229 (Figure 4a). Most of the American Indian tribes are distributed heavily in the western half of the U.S. (Figure 4b).

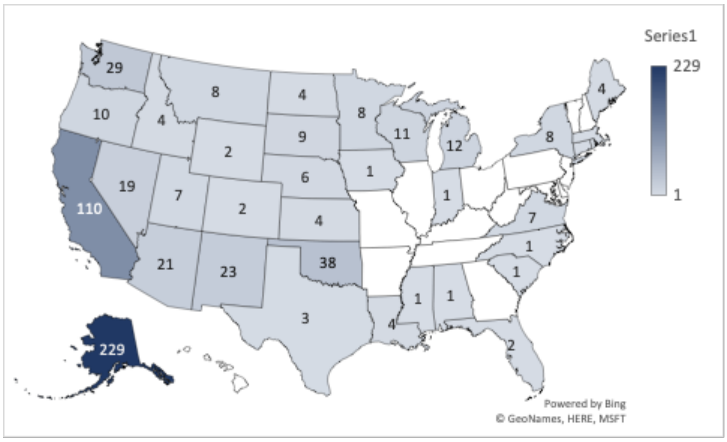


Figure 4a: Number of federally recognized American Indian and Alaska Native Tribes in the U.S (Data from BIA.gov)

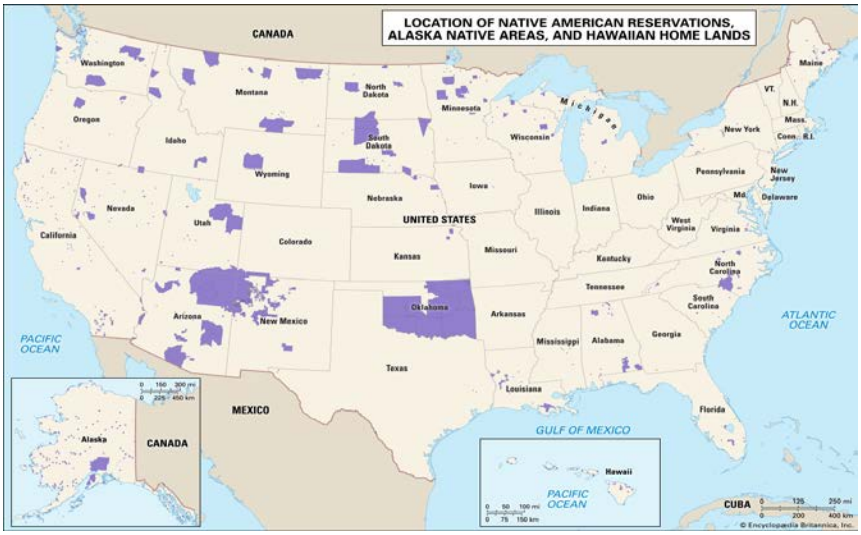


Figure 4b: Location of U.S federally recognized American Indian tribes (BIA.gov)

PWS Types

There are three main types of PWS classifications: Community Water Systems (CWS), Non-Transient Non-Community (NTNC) water systems and Transient Non-Community (TNC) systems. CWSs are the most regulated systems as they serve a big percentage of the U.S. population (310 million; Figure 5b). NTNC systems are moderately regulated and serve a non-transient population (for example schools, office buildings). NTNC systems are the fewest in number countrywide and serve the least number of people cumulatively (7 million). The least regulated types of systems are the TNC systems. Overall, TNC systems have the largest number of water systems, but serve a cumulative population of only 12 million people (Figures 5a & 5b). Therefore, although a majority of PWSs in the U.S. are classified as TNC, the largest population of consumers is served by CWSs. In total, in 2019 about 329 million people were served by a PWS, which is approximately 99% of the total U.S. population.

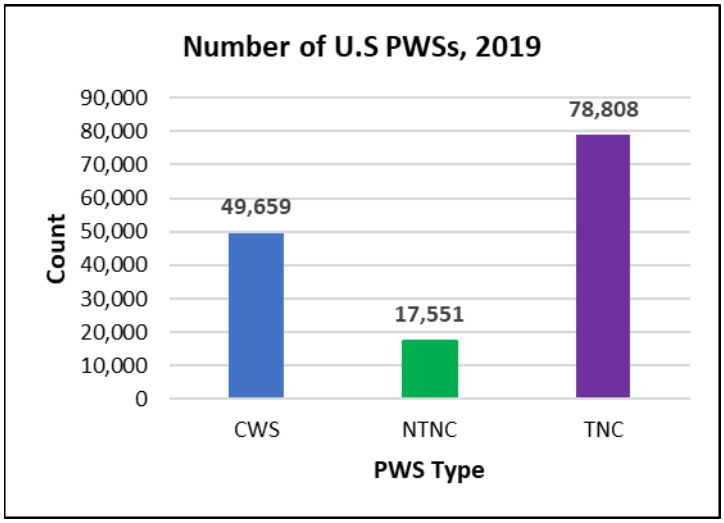


Figure 5a: Number of U.S PWSs in 2019

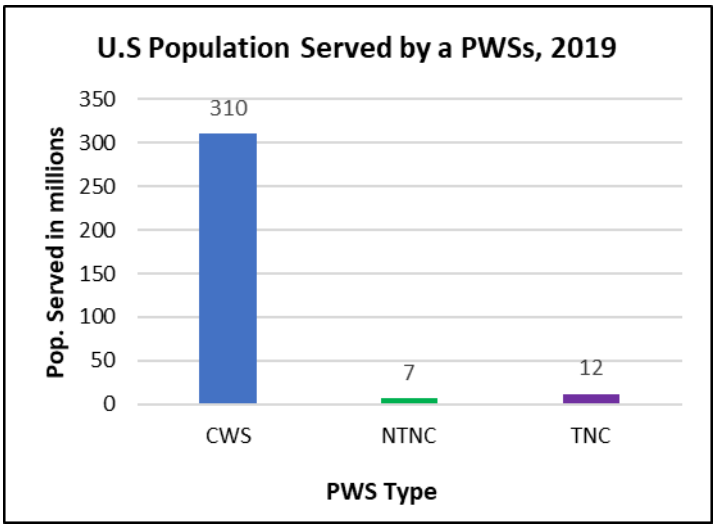


Figure 5b: U.S population served by a PWSs in 2019

Violations of the National Primary Drinking Water Regulations (NPDWR)

According to a 2017 *New York Times* article, a large percentage of Americans are exposed to drinking water contaminants, but there is not enough reporting and/or accountability from water utilities or from EPA (Fortin, 2017). Given the respectability of the publication and the seriousness of the allegations, it is important to understand the nature of the violations that result from water

contamination and other issues arising at water utilities. Allaire et al., 2018 and Tiermann, 2015 note that violation incidences occur in rural areas at a substantially higher rate than in urbanized areas. Therefore, an examination of factors that might be leading to this trend is necessary.

As part of the SDWA, PWSs are required to follow rules and regulations set by the EPA and regulating agencies. Overall, EPA oversees all systems in the U.S. and sets baseline compliance standards that must be implemented by regulating agencies. These agencies may set standards that are more stringent than EPA standards. Water systems are required to follow the set standards, hence failure to follow SDWA regulations results in violation of the National Primary Drinking Water Regulations (NPDWR), which are legally enforceable (EPA.gov[1]).

Violation Types

There are three main types of drinking water violations: Maximum Contaminant Level (MCL), Treatment Technique (TT) and Monitoring and Reporting (M&R) Violations. Both MCL and TT violations are further categorized as health-based (HB) violations, while M&R violations are categorized as non-health based (Figure 6). HB violations have the potential to impact public health in the short or long-term, while M&R violations do not have a direct impact on human health but are related to water systems operation and management.

The determination of violations can and do vary from regulator to regulator. The ways in which something is classified as a violation is to a large extent determined by the regulator, therefore variations are bound to happen. For example, one regulator might determine a given deficiency to be a violation, while a different regulator might not make the same determination for an identical deficiency. This aspect should be taken into consideration as we examine the number of violations at different systems.

Health-Based Violations

HB violations are very serious because they have the potential to impact public health in the short or long-term. Depending on the severity of their impact, they are further categorized below into:

Maximum Contaminant Level (MCL) violations: MCL violations occur when water quality lab test results indicate that the level of a contaminant in treated water is above the EPA or state legal limit. These violations indicate a potential health risk to human consumers. The health threat may be acute (immediate) or chronic (long term). An example of an acute MCL violation is the presence of *E. coli* or fecal coliform bacteria in drinking water which, if detected, requires immediate action from the system as well as immediate public notice such as a boil water advisory (BWA). Although *E. coli* by itself is not necessarily harmful, it provides an indication that other harmful strains of water-borne pathogens may be present in the water. If ingested, these other pathogens may have the potential to make someone ill.

Treatment Technique (TT) violations: TT Violations occur when a PWS fails to treat its water in the manner prescribed by EPA or the state, in order to remove a given contaminant from drinking water or reduce it to non-harmful levels. For example, failure to filter surface water to remove viruses and cysts can result in a TT violation. Like MCL violations, TT violations indicate a potential health risk to the consuming public.

Non-Health Based Violations

Non-HB violations are related to water systems' operation and management, which can, in turn affect water treatment and handling and therefore have an indirect impact on human health. These are categorized as:

Monitoring and Reporting (M&R) violations: M & R violations occur when a PWS fails to test its drinking water for certain contaminants or fails to report test results in a timely manner to the regulating agency or to its consumers. Lack of water monitoring poses a risk to consumers because changes in water quality cannot be identified immediately and therefore a public health emergency may not be averted.

Other: Violations that do not fall under the above three descriptions fall under the "Other" category. Examples include failure to generate annual water quality reports that are required for all community water systems or failure to provide public notices for violations of a NPDWR regulation.

Groundwater Rule (GWR) Violations

The Groundwater Rule was implemented in 2010 for the purpose of improving the quality of drinking water by ensuring that ground water sources do not harbor harmful bacteria and viruses that could impact public health (EPA.gov[5]). Provisions of this Rule require that all water systems must be inspected by their respective regulating agencies at least once every 3 years for CWSs and once every 5 years for non-CWSs. During these inspections, deficiencies identified at the water system must be fixed over an agreed timeline. If a water system does not fix the issues highlighted from an inspection, a violation may be issued. Violations of the Groundwater Rule fall under either health-based or non-health-based category depending on the type and the severity of the deficiency (Figure 6).

Determination of GWR violations

Determination of GWR violations is not always a clear-cut decision. These violations stem from field inspections and include deficiencies identified by the inspector. With the GWR there is

no set standard for determining violations across the regulatory agencies, hence deficiencies tend to be subjective in nature and might vary from one regulator to the next. For example, a stricter regulator may categorize a given deficiency as a severe HB violation, while a different regulator may categorize the exact same deficiency as less severe or may not even classify it as a deficiency. In such cases, variations in the number and type of violations across the different regulating agencies are likely to occur.

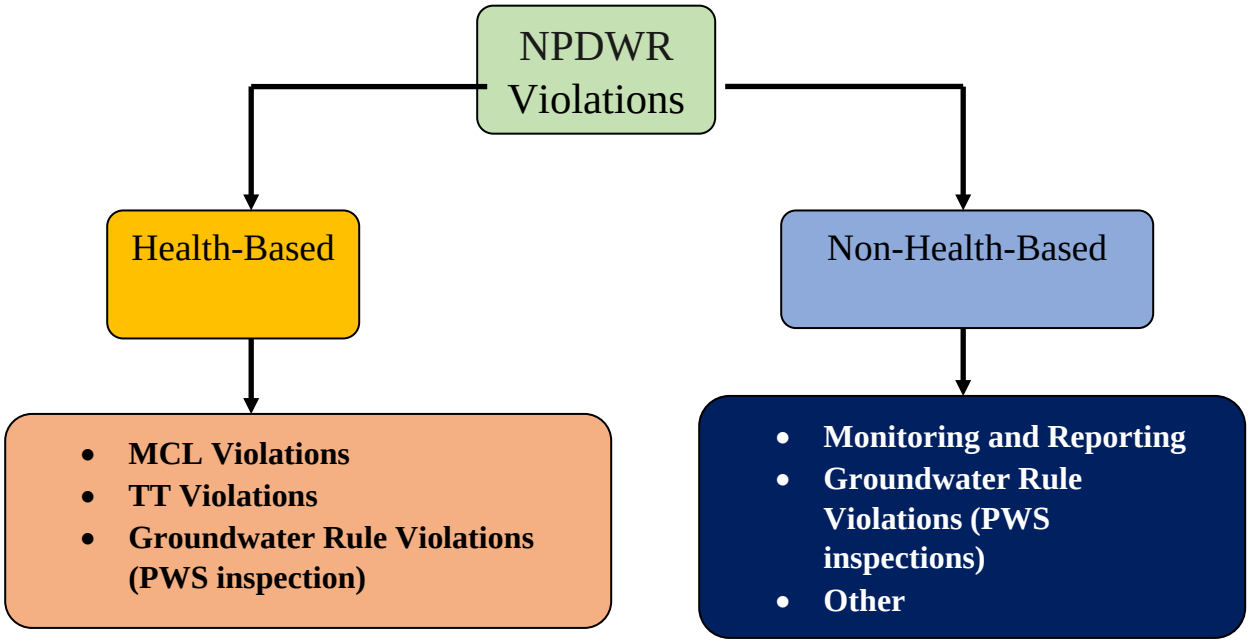


Figure 6: Breakdown of NPDWR Violations

Methodology

This study examined the trends in drinking water violations in the U.S. during the federal fiscal years 2013 to 2019 to find out if regulating agencies had any impact on the number or increases in reported SDWA violations at PWSs. Data and information were obtained from EPA's

Safe Drinking Water Information System (SDWIS) online database and the Enforcement and Compliance History Online (ECHO) database. Both databases contain drinking water information from all PWSs in the U.S. and its territories. The information includes PWSs inventory, water source types, PWS type, ownership type, drinking water monitoring test results, occurrences of drinking water violations, and much more. HB violations have a direct impact on human health, therefore population served was used to reflect the percentage of the public realistically or potentially affected by the reported violations.

Data was gathered by running different filters within the SDWIS database, the ECHO databases and the Government Performance and Results Act tool (EPA.gov[3]) to obtain the same information for all the 65 regulating agencies. To eliminate bias, the data was gathered in the same manner, using the same filters for all PWSs that fall under the different regulators. The same was repeated for each of the seven fiscal years from 2013 to 2019, with each year comprising of data from October of a given year to September of the next year. Once raw data was obtained, it was processed into graphs and tables to highlight trends that may exist. Analysis of variance (ANOVA) was done on components of this data to determine the significance of any noted trends.

For comparison purposes, State regulated systems were grouped together, as were EPA regulated systems (Tribal, D.C. and Wyoming), while a third category classified as 'Other' consisted of U.S. Territories and the Navajo Nation. The population served for each group was obtained during the same period for all the 65 agencies for each year. Data obtained on violations was normalized based on the population served for that year to obtain violations per 1000 people for each group. The increases in violations per 1000 people was graphed in Microsoft Excel and trendlines of the seven years of values was obtained for every group. The slope of each trendline was used as an indicator of how fast or how slow the violations increased over the 7-year period for each group. Further, a comparison was made between the five largest states and the five smallest

states population wise to find out if population played a role in the rate of increases. A comparison was made between HB and non-HB violations to highlight the variables across the groups. Other factors considered in this research were type of water system, funding availability and characteristics of the regulator.

Limitations of the Study

This study only considered data from 2013 to 2019 which was specifically filtered to obtain a specified result of the required data. However, different filters can be applied to the same data to obtain different outcomes. Data in these databases is not static and often change as updates are made. SDWIS data accuracy is the responsibility of the regulator in ensuring that incorrect data is corrected, and new changes are added as they happen. The data used in this study is accurate up to the end of the study period of 9/30/2019, and when it was gathered in October of 2019. However, if a regulatory agency corrected any of the data after the date of the data download, these changes would not be reflected in this study. In that respect, if the regulator does not diligently perform these tasks, the data in SDWIS and ECHO will reflect what is available at that given time, whether accurate or not. The figures for population served were also based on estimates by the PWSs and not outside sources. These figures may therefore be different from other population data such as the U.S. Census data. It is important to consider that there could be discrepancies in data based on several factors that may not affect all PWSs and all regulators equally.

Results

Violations Based on PWS Types

All violations were analyzed cumulatively from Tribal water systems (including the Navajo Nation), from State regulated systems, and from Territories. Results showed that for Tribal water systems, more violations were reported at CWSs and significantly fewer violations were reported at

Non CWSs. (Figure 7a). For States regulated water systems, most violations were also reported at CWSs, but the fewest violations happened at NTNC systems (Figure 7b). For Territories, a similar trend to Tribal systems was observed, with most violations happening at CWSs, and the fewest at TNC systems (Figure 7c).

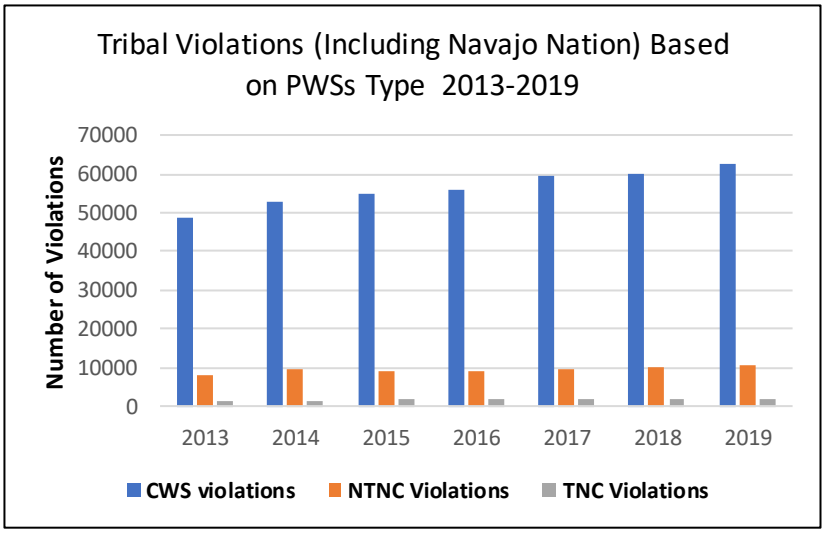


Figure 7a: Tribal Violations based on PWS type

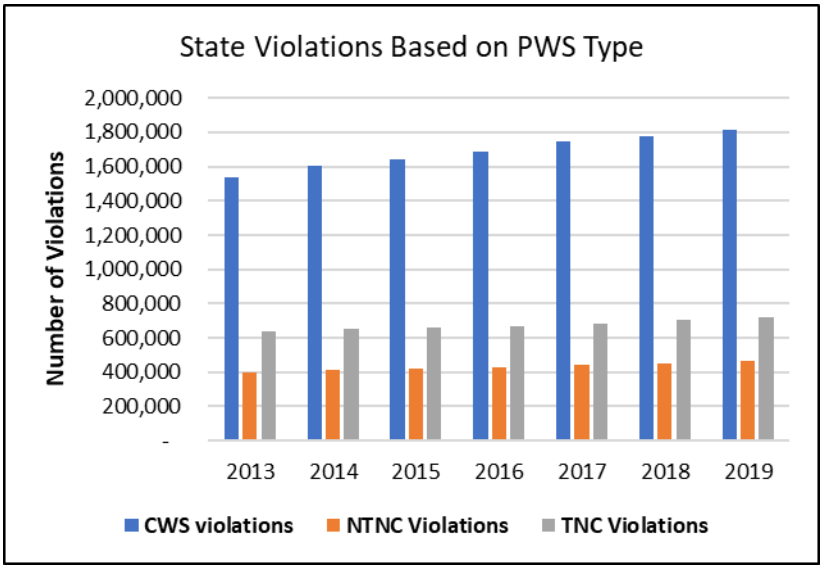


Figure 7b. States violations based on PWS type

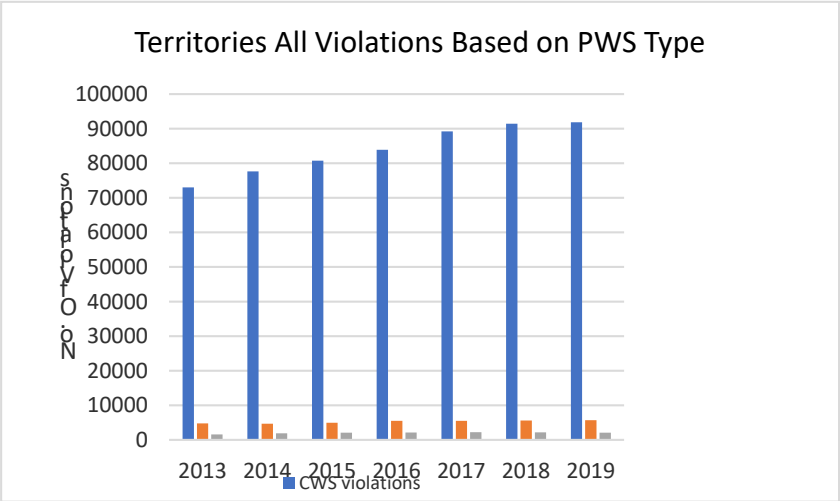


Figure 7c. Territories violations based on PWS type

All Violations

An overall comparison of all violations from all regulating agencies showed that American Samoa had the highest average of all violations—HB and non-HB violations combined. Washington D.C. had the lowest average number of violations. The ratio of HB to non-HB violations vary from regulator to regulator with some groups reporting larger percentages of HB violations. For example, Hawaii had the highest percentage of HB violations (60%) in relation to non-HB (40%), while EPA Region 10 had the lowest percentage of HB violations (1%) in relation to Non-HB violations (99%). In general, data from all regulating agencies show a trend of higher occurrences of non-HB violations than HB violations, with only 6% of the regulators reporting more HB violations than Non-HB violations which is a favorable trend on a public health perspective (Figure 8).

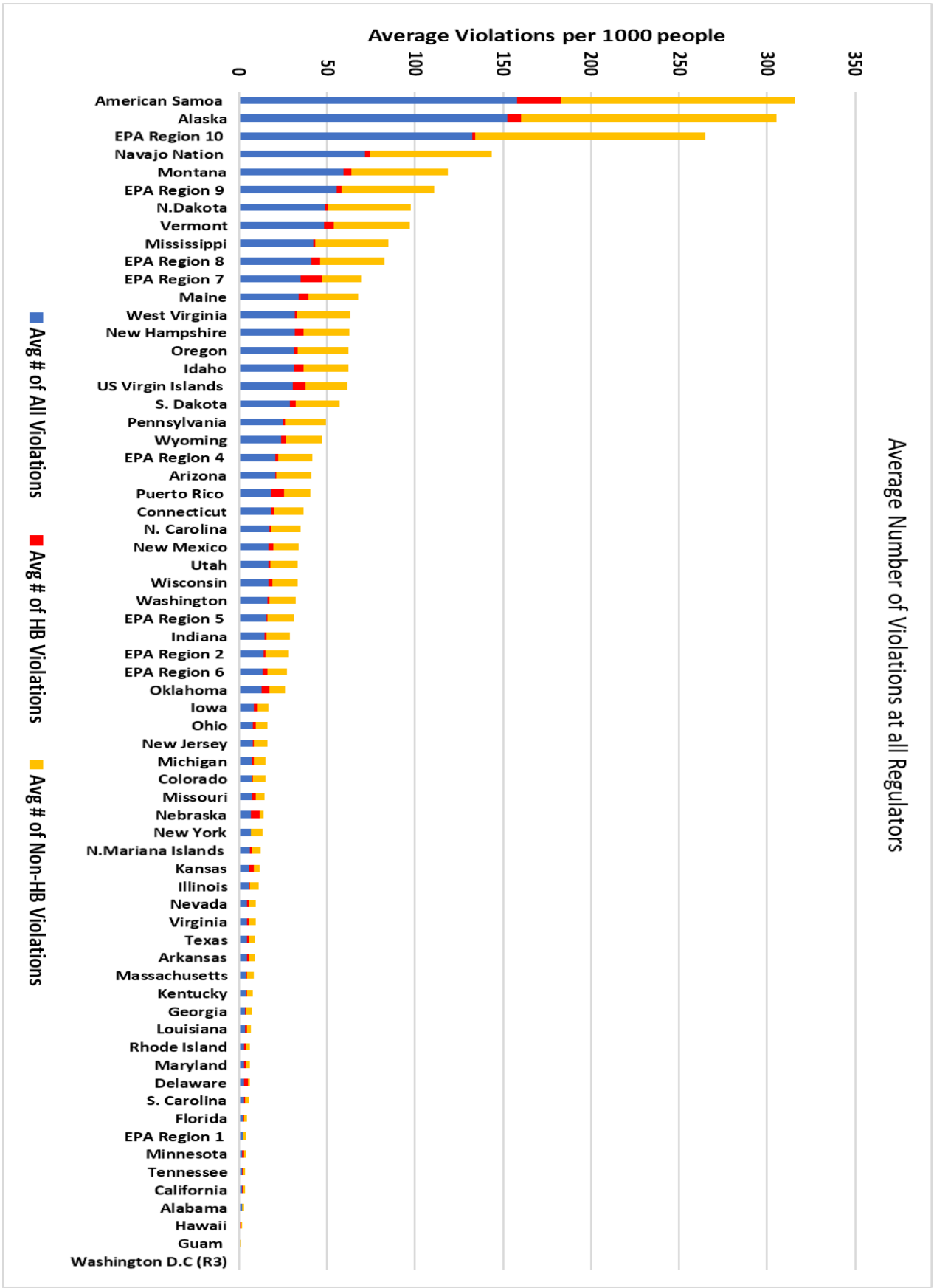


Figure 8. Breakdown of all violations at all regulating agency groups

Health-Based Violations

Average Number of HB Violations

Data from all regulating agencies combined showed that, as noted previously, American Samoa had the highest number of health-based violations with an average of 25.2violations per 1000 people, while Washington D.C had the lowest average with 0.04 violations per 1000 people (Table 1). This data was normalized to report the average number of violations per 1000 people due to the different scale of the various regulating agencies in terms of population served. The normalization was done to enable a fair and accurate comparison of extreme groups of regulators with very high or very low number of violations or population served.

Health-based violations are one of the biggest indicators of water quality at PWSs because they are directly related to contaminants in drinking water as well as the effectiveness of water treatment processes in place. MCL violations, TT violations and some GWR violations fall under this category. However, some non-HB violations can indirectly jeopardize water quality and consequently affect public health.

Table 1: Ranking of Average Number of HB Violations/1000 people in comparison to Non-HB and Total violations

(Ranked from highest to lowest average violations per 1000 values under HB category)

Regulating Agency	Avg # of HB Violations/1000 people	Avg # of Non-HB Violations/1000 people	Avg # of Total Violations/1000 people
American Samoa	25.21	132.6	157.8
EPA Region 7	12.18	22.6	34.8
Alaska	7.70	144.9	152.6
US Virgin Islands	7.08	23.7	30.8
Idaho	5.75	14.9	18.5
Vermont	5.67	25.2	31.0
Maine	5.58	42.9	48.4
New Hampshire	5.20	28.1	33.8
EPA Region 8	5.00	26.3	31.4
Nebraska	4.60	36.3	41.3
Montana	4.48	2.4	7.0
Oklahoma	4.29	54.9	59.4
Puerto Rico	3.55	8.7	13.0
South Dakota	3.33	25.4	28.7
EPA Region 9	3.07	52.3	55.4
Wyoming	2.90	20.8	23.7
EPA Region 6	2.87	10.7	13.5
New Mexico	2.76	14.1	16.9
Navajo Nation	2.52	69.2	71.7
Kansas	2.32	3.5	5.8
Wisconsin	2.27	14.3	16.5
Oregon	2.13	29.1	31.2
Missouri	1.99	5.4	7.4
Delaware	1.99	1.1	3.1
Iowa	1.96	6.5	8.4
Connecticut	1.83	16.6	18.4
EPA Region 4	1.67	19.1	20.8
EPA Region 10	1.52	131.0	132.5
Arkansas	1.51	2.8	4.3
Northern Mariana	1.48	47.3	48.8
North Dakota	1.44	4.6	6.0
Indiana	1.33	13.1	14.4
Ohio	1.31	6.7	8.0
Washington	1.28	14.7	16.0
Louisiana	1.26	2.1	3.3
Pennsylvania	1.19	23.5	24.8
West Virginia	1.14	30.3	31.6
Maryland	1.13	2.0	3.1
Minnesota	1.11	0.8	1.9
North Carolina	1.03	16.3	17.4
Rhode Island	1.02	2.0	3.1
EPA Region 2	0.90	13.2	14.1
Texas	0.89	3.6	4.5
Michigan	0.89	6.7	7.6
Virginia	0.87	3.8	4.7
Utah	0.85	15.9	16.8
Mississippi	0.81	41.5	42.3
EPA Region 5	0.80	14.7	15.5
Illinois	0.72	4.9	5.7
Arizona	0.68	20.0	20.7
Colorado	0.62	6.8	7.5
Nevada	0.58	4.2	4.8
South Carolina	0.57	2.3	2.9
California	0.56	1.1	1.6
New Jersey	0.54	7.4	8.0
Kentucky	0.51	3.4	3.9
Hawaii	0.50	0.3	0.8
Massachusetts	0.42	4.0	4.0
Florida	0.39	2.0	2.4
Georgia	0.35	3.3	3.6
Tennessee	0.35	1.4	1.7
EPA Region 1	0.34	1.8	2.1
New York	0.32	6.2	6.6
Alabama	0.17	1.3	1.5
Guam	0.13	0.3	0.4
Washington D.C	0.04	0.1	0.1

Rate of Increase in HB Violations: All regulators

A comparison of all regulating agencies showed that American Samoa had the fastest rate of increase in HB violations with a rate of 0.47 violations per 1000 people and EPA Region 7 had the slowest rate of increase in violations (an actual decrease) of -1.7 violations per 1000 people. The national average in increases in HB violations was 0.03 violations per 1000 people (Figure 10). EPA Region 7 reported a decrease in violations due to a rapid increase in the total population served by the region over a short period of time, therefore significantly reducing the number of violations per 1000 people (Table 2, Figure 9).

Table 2: EPA Region R7 showing a rapid increase in population from 2014 - 2016

Year	HB Violations	Non-HB Violations	All Violations	Population Served	HB Violations per 1000 people
2013	120	207	327	6,789	17.7
2014	124	245	369	6,699	18.5
2015	131	246	377	10,252	12.8
2016	139	255	394	15,826	8.8
2017	144	255	399	15,951	9.0
2018	146	258	404	15,926	9.2
2019	148	303	451	15,926	9.3

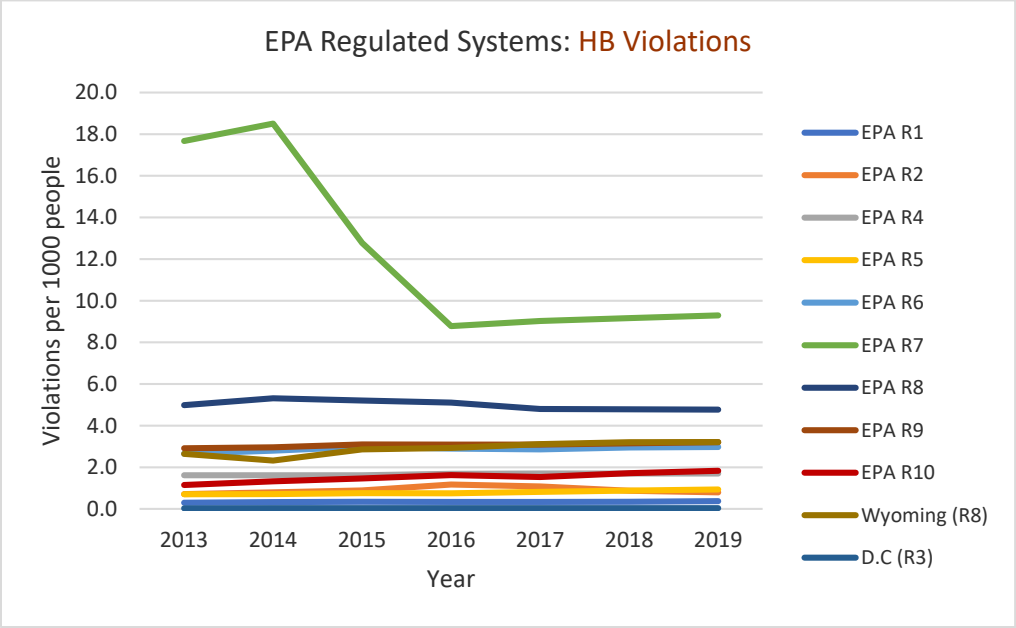


Figure 9: EPA Region 7 reported a rapid decline in the number of violations per 1000

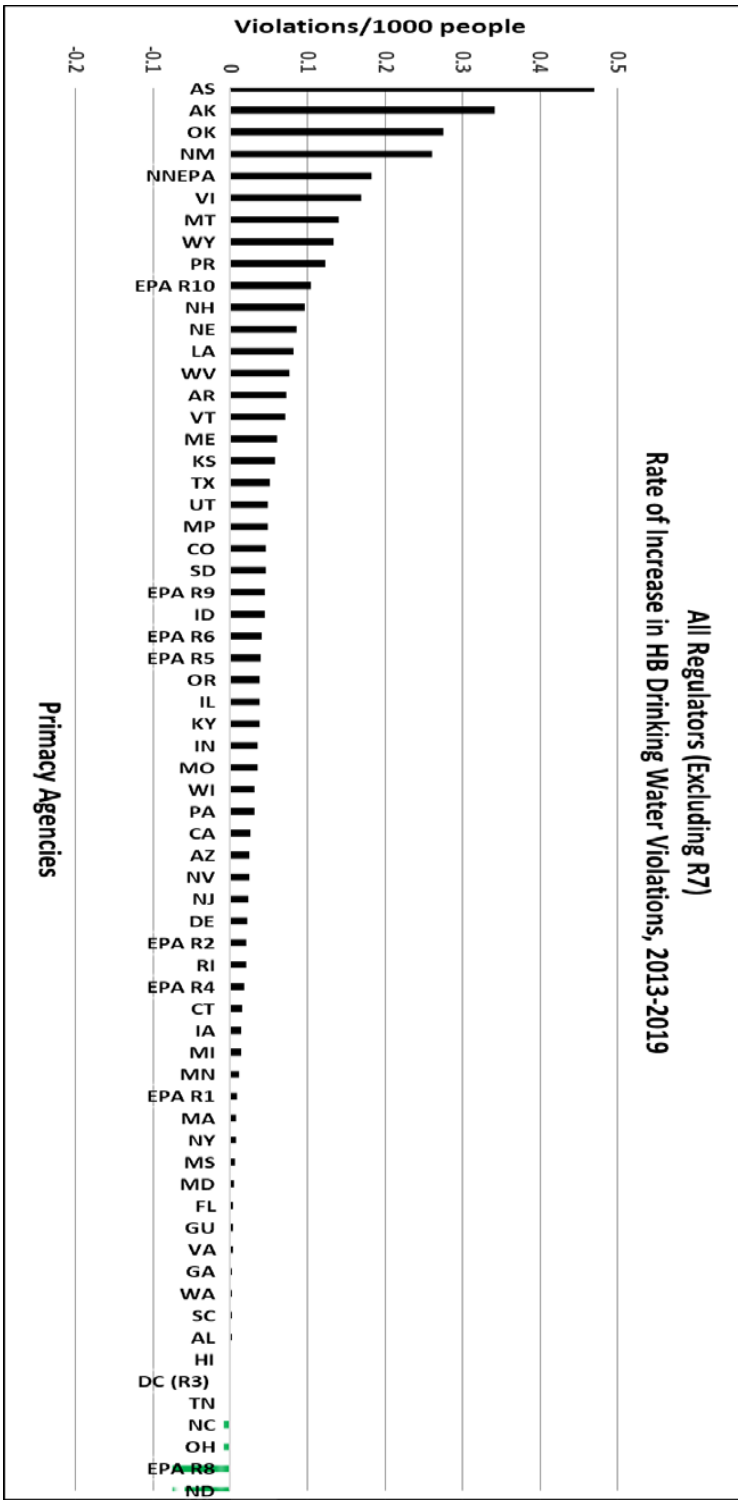


Figure 10. Breakdown of all violations at all regulating Agency groups. EPA Region 7 (-1.7) is excluded in the above graph to allow a display of the other groups)

HB Increases Categorized by Groups

A comparison of State regulated systems showed that the fastest increases in HB violations occurred in the State of Alaska with 0.34 violations per 1000 people and the slowest increases (decrease in violations) occurred in the State of North Dakota with -0.08 violations per 1000. Under the EPA regulated systems, the fastest increase occurred in the state of Wyoming with 0.13 violations, while the slowest rate (decrease) occurred in EPA Region 7 with -1.7 violations. In the third category of 'Other', the fastest increase occurred in American Samoa with 0.47 violations per 1000 people, and the slowest rate occurred in Guam which reported a slight increase in violations of 0.003 violations per 1000 people (Table 3).

Table 3: Increases in health-based violations; All regulatory Agencies 2013-2019

EPA Regulated Systems	
Primacy Agency	Increase in HB violations per 1000 people
Wyoming (R8)	0.13
EPA Region 9	0.11
EPA Region 10	0.11
EPA Region 6	0.04
EPA Region 5	0.04
EPA Region 2	0.02
EPA Region 4	0.02
EPA Region 1	0.01
Washington	0.00
EPA Region 8	(0.07)
EPA Region 7	(1.70)

State Regulated Systems	
Primacy Agency	Increase in HB violations per 1000 people
Alaska	0.34
Oklahoma	0.28
New Mexico	0.26
Montana	0.14
N. Hampshire	0.10
Nebraska	0.09
Louisiana	0.08
West Virginia	0.08
Arkansas	0.07
Vermont	0.07
Maine	0.06
Kansas	0.06
Texas	0.05
Utah	0.05
Colorado	0.05
S. Dakota	0.05
Idaho	0.04
Oregon	0.04
Illinois	0.04
Kentucky	0.04
Indiana	0.04
Missouri	0.04
Wisconsin	0.03
Pennsylvania	0.03
California	0.03
Arizona	0.02
Nevada	0.02
New jersey	0.02
Delaware	0.02
Rhode Island	0.02
Connecticut	0.02
Iowa	0.01
Michigan	0.01
Minnesota	0.01
New York	0.01
Massachusetts	0.01
Mississippi	0.01
Maryland	0.00
Florida	0.00
Virginia	0.00
Georgia	0.00
Washington	0.00
South Carolina	0.00
Alabama	0.00
Hawaii	0.00
Tennessee	(0.00)
N. Carolina	(0.01)
Ohio	(0.01)
N. Dakota	(0.08)

Other Regulated Systems (NN & Territories)	
Primacy Agency	Increase in HB violations per 1000 people
American Samoa	0.47
Navajo Nation	0.18
US Virgin Islands	0.17
Puerto Rico	0.12
N. Mariana Islands	0.05
Guam	0.003

Under the States category, a comparison of the five most populated states—California, Texas, New York, Florida, and Pennsylvania—showed that none of these five states ranked in the top 10 overall fastest rates of increases in HB violations Pennsylvania had the highest number of HB violations and New York had the least. However, the fastest increase rate was reported in Texas and the least in Florida (Table 4 & Figure 11).

Table 4: Top five most populated states – Ranking in Heath-based Violations Increases

U.S. State Regulated PWSs - HB Violations Increases Ranking of Five Highest Pop. Served			
State	Population Served	Rate of health-based violations Increases	State Ranking
California	41.0M	0.03	25
Texas	28.4M	0.05	13
New York	21.3M	0.01	35
Florida	20.7M	0.00	39
Pennsylvania	12.7M	0.03	24

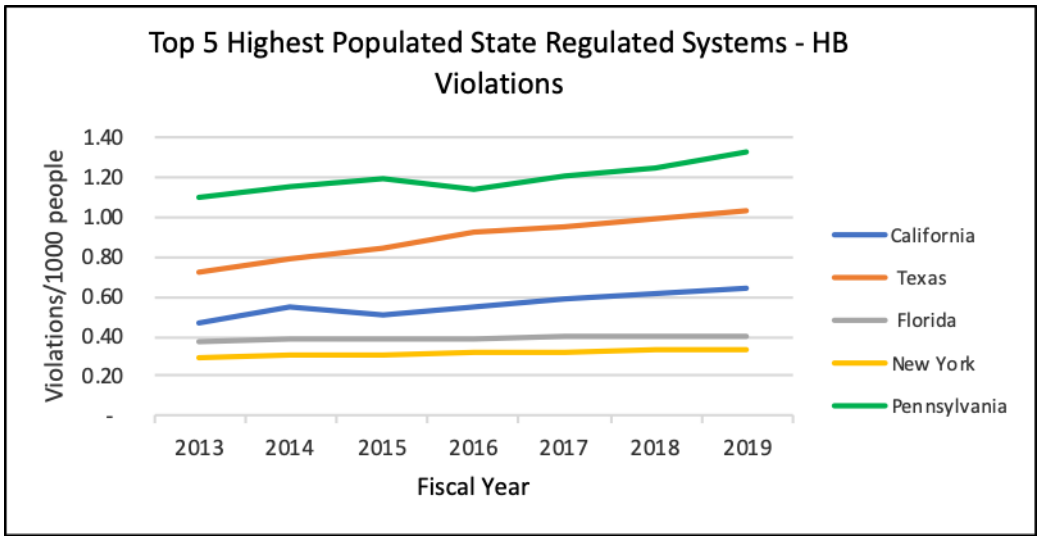


Figure 11: Top 5 most populated states – Number of health-based violations

In the five least populated states – Nebraska, West Virginia, Hawaii, Idaho and New Hampshire, three of these five states ranked in the top 10 fastest increases in health-based violations. New Hampshire had the fastest rate of increase and Hawaii had the slowest (Table 5 & Figure 12). Additional comparative figures of various groups are available in Figures 24 to 35.

Table 5: Top five least populated states – Ranking in Health-based Violations Increases

U.S. State Regulated PWSs – HB Violations Increases Ranking of Five Least Pop. Served			
State	Population Served	Rate of health-based violations Increases	State Ranking
N. Hampshire	1.2	0.10	5
Nebraska	1.7	0.09	6
West Virginia	1.6	0.08	8
Idaho	1.5	0.04	17
Hawaii	1.5	0.00	45

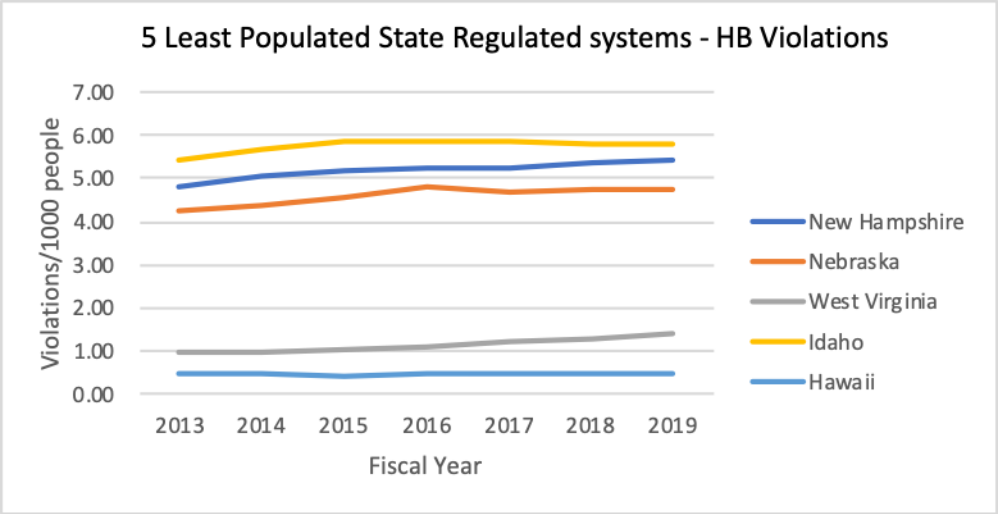


Figure 12: Five smallest states – Number of health-based violations

Under EPA regulated systems, Wyoming had the fastest rates of increases in HB violations with 0.13 violations per 1000, and EPA Region 7 had the lowest rates of -1.7. Data from Region 7

showed a drastic increase in population served over short period of time, resulting in a drastic decrease in violations per 1000 people from 2014-2016. (Table 2 & Figure 9).

Under the Other category, American Samoa (pop. 0.06 million) had the highest increase in HB violations and Guam (pop. 0.2 million) had the lowest increase. This trend mirrors the trend observed at States systems whereby the least populated states had the highest increases, and the highest populated states had the lowest increases. Puerto Rico is the largest territory (pop. 3.8 million), followed by Guam (0.2 million) and the third is Navajo Nation (0.18 million). From this data, we can conclude that larger populated states/territories tend to have fewer increases in HB violations than less populated ones (Table 2 & Figure 13).

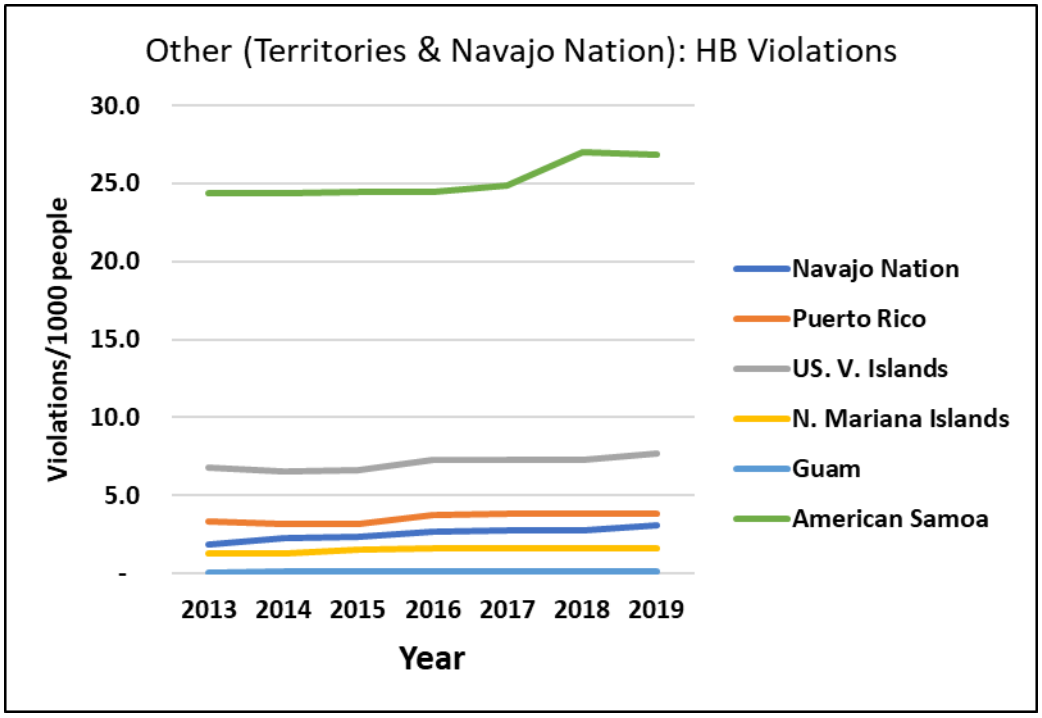


Figure 13: Other – Number of and increases in HB violations

MCL and TT Violations

Data was analyzed to examine the breakdown of violations at Tribal water systems and at Territories. Due to data limitations, the same type of data could not be obtained for state regulated systems. Results gathered cumulatively from Tribal water systems showed that most violations that occurred during this period were non-HB (Figures 14 a & 14b). In addition, most of the HB violations were MCL as opposed to TT which averaged about 16% of the HB violations. Similarly, data from systems in U.S. Territories showed that most of the violations were non-HB, but that TT violations averaged 45% of the HB violations (Figures 15a &15b).

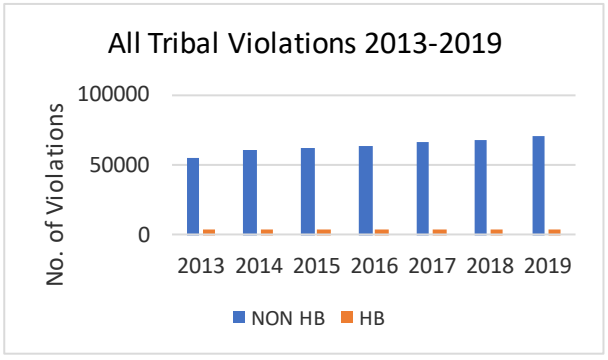


Figure 14a: HB vs Non-HB violations at Tribal systems

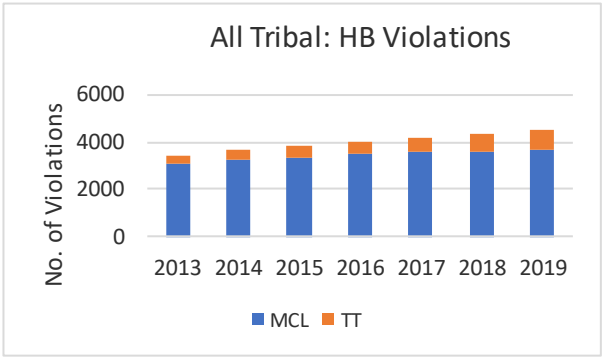
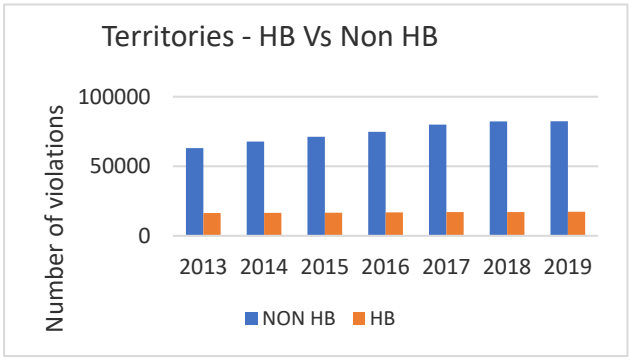
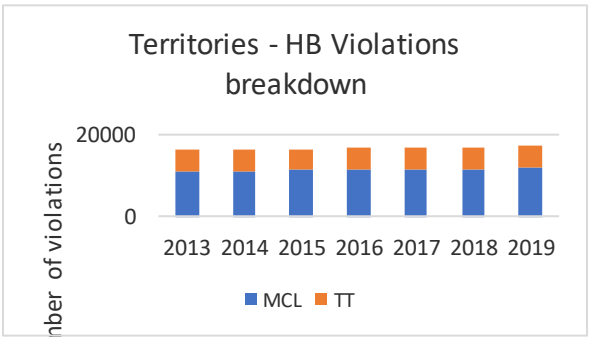


Figure 14b: MCL and TT violations at Tribal systems



15a: HB vs Non-HB violations in U.S. Territories



15b: MCL and TT violations in U.S. Territories

Discussion

Trends Based on Population

Various trends were observed from the data obtained. The first trend seemed to suggest a disproportionate number of violations occurring in low populated groups than in higher populated areas. American Samoa had the overall highest average number of health-based violations per 1000 people and Washington, D.C. had the overall lowest average (Table 1). Washington, D.C. is a mainland district that houses the U.S. capital, while American Samoa is an isolated island in the Pacific Ocean within EPA Region 9 jurisdiction. The two groups have completely different characteristics in population served, the number of water systems, and the type of water systems under their jurisdictions. Systems in D.C. serve a total population of 665,000 via only six water systems. Each of the six systems serve over 250 people, and only two of the systems serve less than 1000 people. In contrast, American Samoan systems serve a total population of 59,400 via 112 systems. Eighty-five percent of these systems are small systems, serving 100 people or less. In both cases, characteristics of the regulating agency, the population served, and the type of water systems seem to play a role in the average number of heath-based violations. Clearly, there exists a big difference in the two groups' average violations. With such a big difference, a further examination might be necessary to determine if other not so clear disparities may be contributing to American Samoa having the highest average number of HB violations per 1000 people in the entire nation. A statistical analysis of variance between population and number of violations resulted in an R^2 of 0.088 (9%), meaning that there does exist a correlation between the two variables (Figures 16a)

Figure 16b shows that 60% of the EPA regulated systems (most of which are tribal), 80% of the systems in U.S territories, and the Navajo Nation as a whole, ranked in the higher 50^{th} percentile for the average total number of violations per 1000 people. 43% of the State regulated systems ranked in the same category. This trend seems to suggest that more violations are occurring at tribal water systems and territories than at state regulated systems. It is an important observation to note

because American Indian and other minority communities are often impacted by social injustices that may not be obvious (Galway, 2016; Baird et al., 2015), such as lack of access to clean drinking water.

Take for example the Navajo Nation, spanning the states of Arizona, Utah and New Mexico. It is estimated that about 35% of Navajo Nation lacks access to piped water in homes, forcing residents to haul water from outside sources for domestic use (EPA.gov[4]). Moreover, from the data analyzed in this study, the available piped and regulated water shows that there is an average of 71.7 total violations per 1000 people of which 2.5 violations per 1000 people are health based. From 2013 to 2020, the highest percentage increase in HB violations for Navajo Nation occurred under the Arsenic Rule which reported an increase of 72%. The lowest increases occurred under the Volatile Organic Compounds (VOCs) Rule. The Navajo Nation continues to deal with cleanup of contamination from abandoned mines, including 500 abandoned uranium mines. Exposure to high levels of uranium and other radionuclides are detrimental to human health. Recent studies show elevated autoimmunity in residents living close to abandoned mines on Navajo Nation in New Mexico, who have had chronic exposure to metal mixtures from uranium mine wastes and in drinking water supplies (Erdei, et al., 2019). During this study period, there was a 5% increase in the number of radionuclides MCL violations cumulatively from Navajo Nation PWSs. Future studies should be done to examine the existence of disparities in the provision of drinking water to areas populated by minority groups based on race, income, geographic locations etc. across the U.S. Current numbers and distribution of various U.S racial groups are available in Figures 36 to 40.

The various American Indian tribal communities have different capacities for managing their water systems. Based on available resources, communities with greater capacities and access to adequate funding and trained professionals may report fewer violations in comparison to tribal communities with fewer resources. For example, tribal communities with more capacity may be able to charge rates to their water consumers and collect revenue that can then be channeled back

towards SDWA compliance. A PWS with enough revenue may be able to hire adequately trained and certified water personnel to manage their utility's daily operations. This means important tasks, including maintaining and monitoring the water treatment process and addressing any issues that arise (e.g., to repair water main breaks or troubleshoot and repair a malfunctioning treatment process), collecting compliance samples is done in a timely manner, helping ensure water safety and a reduction in both HB and Non HB violations. The utility may also be able to afford costs associated with collecting required water samples and sending them to the labs, and to invest in improved water treatment processes to remove or reduce contaminants. Some water treatment processes, including the removal of dissolved contaminants such as arsenic, nitrates and radionuclides, can be complex and expensive (Sorg et al., 2015). Systems without the capacity to install adequate treatment procedures risk violating health-based water quality standards and, therefore, may report more violations

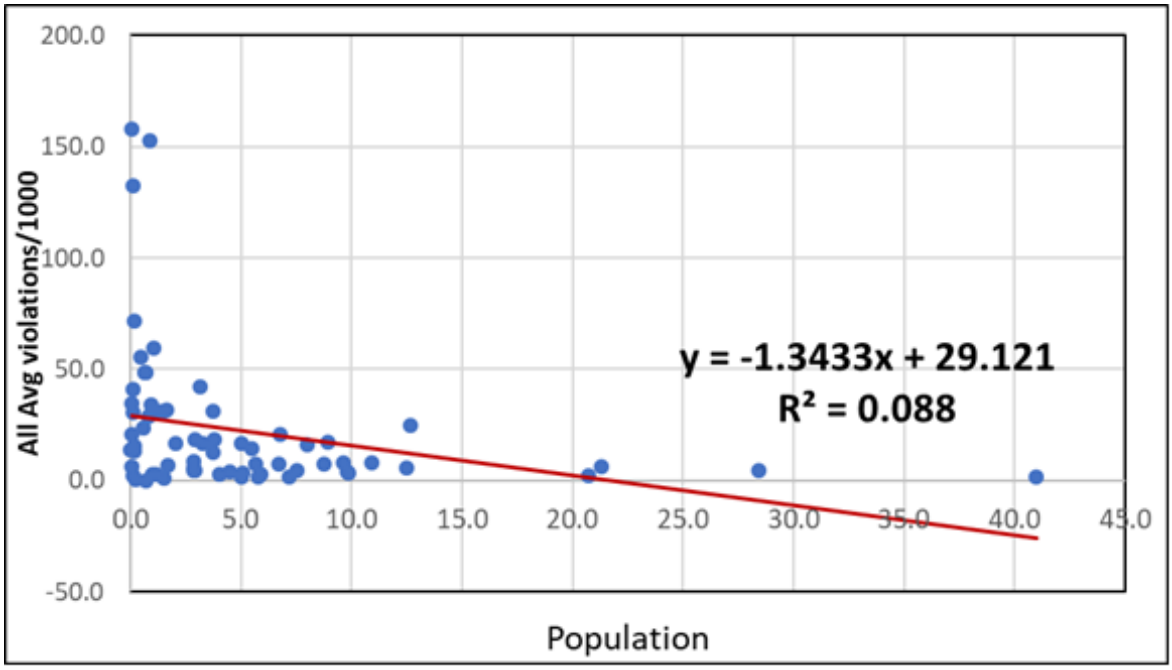


Figure 16a: All regulators, ANOVA, average number of HB violations in the U.S. There exists a 9% ($R^2 = 0.088$) correlation relationship between average violations and population served

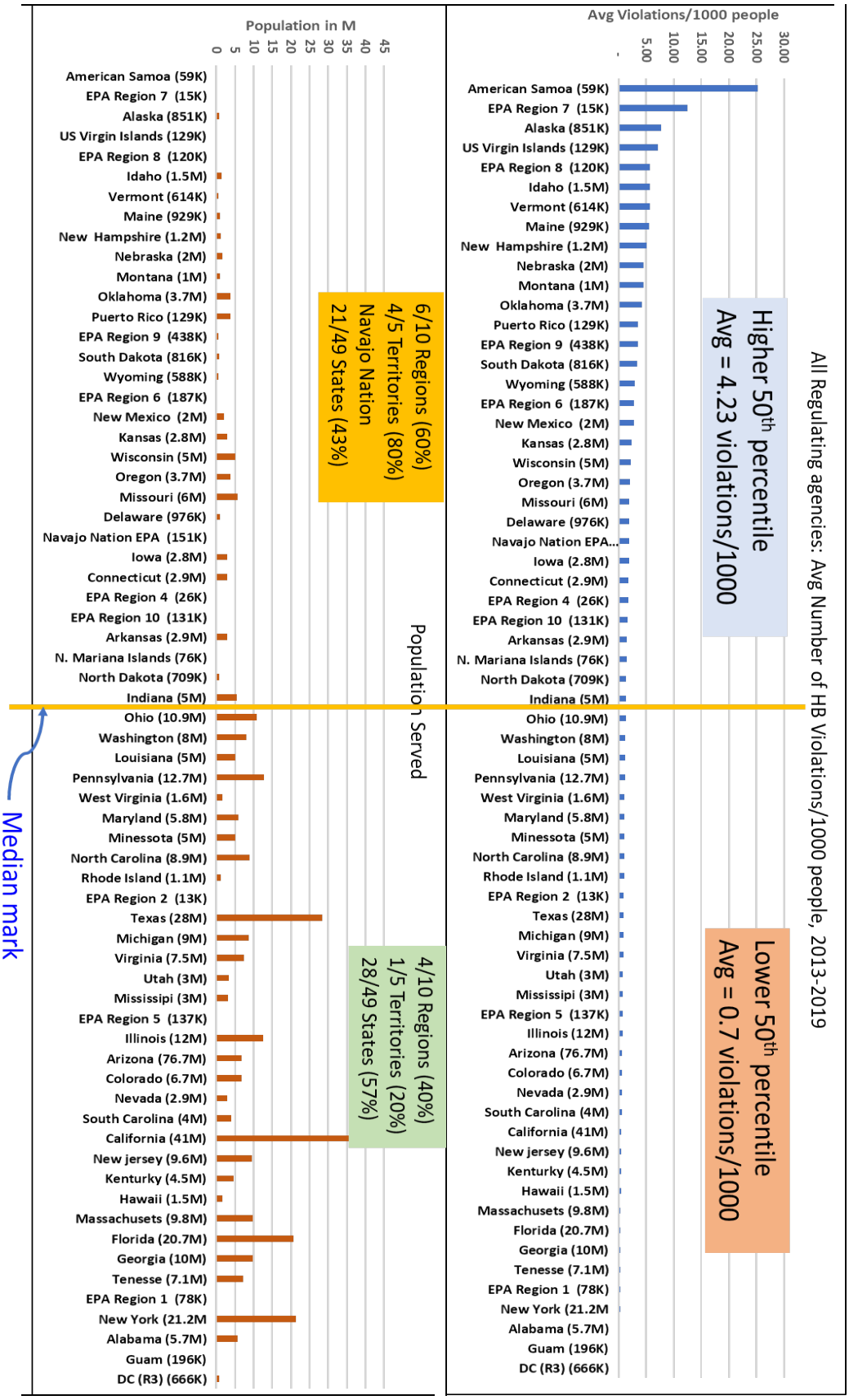


Figure 16b: All regulators, average number of HB violations in the U.S. compared to population served

It is one thing to have the highest average number of violations, and another to have those violations increasing from year to year at a high rate. A group with high average violations, but practically no increases in violations year to year may show a positive image. Even though violations might have happened in the past, the utility may have put in place a system that ensures no more new violations occur or may be in the process of correcting those past violations. A system that has a low average number of violations, but a very high rate of occurrence of new violations year to year may be signaling more or larger problems –a trend that is not positive or desirable. In this study, the rates of increase in health-based violations was noticeably higher in states and regions with smaller populations.

Three of the least populated states–New Hampshire (1.2 million people), Nebraska (1.7 million people) and West Virginia (1.6 million people)— ranked in the top 10 out of 49 states overall with the steepest climbs in health-based violations. Amongst the five largest states, only Texas (28.4 million) placed in the top 20 (it ranked 13th). A statistical analysis of variance between population and rate of violations increases resulted in an R^2 value of 0.0467 (5%), meaning that there exists a slight correlation between the two variables (Figures 17 a & b). This suggests that the size of the population served under a regulating agency may play a role in the occurrences of violations at the water systems they serve even if to a small extent.

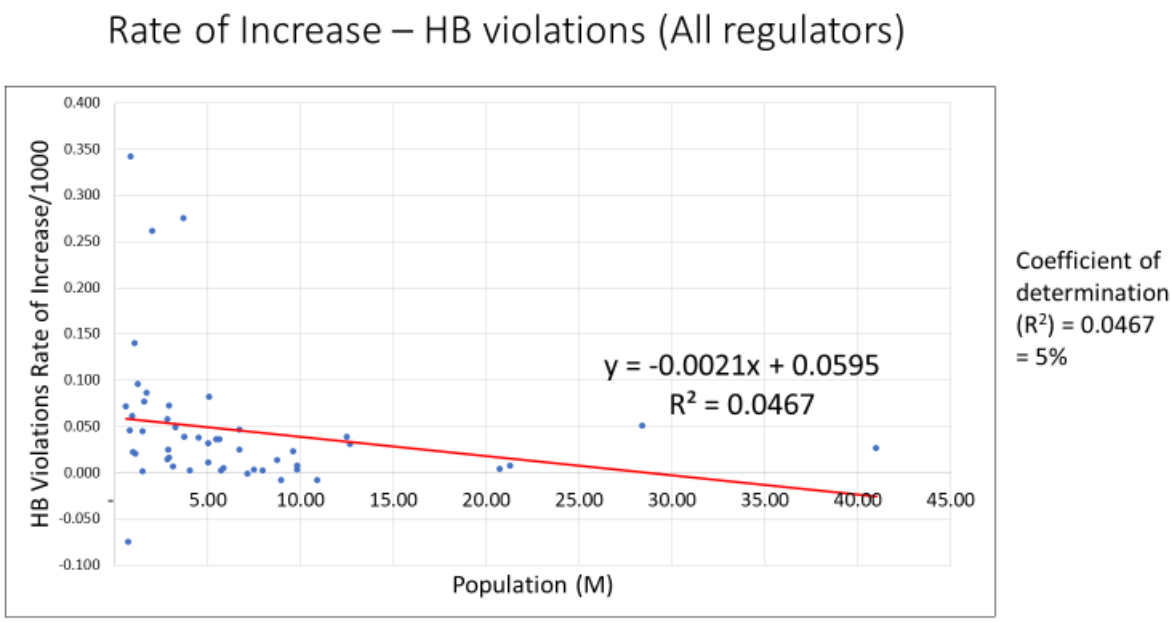


Figure 17a: All regulators, average number of health-based violations in the U.S. There exists a 5% correlation relationship between increases in HB violations and population served

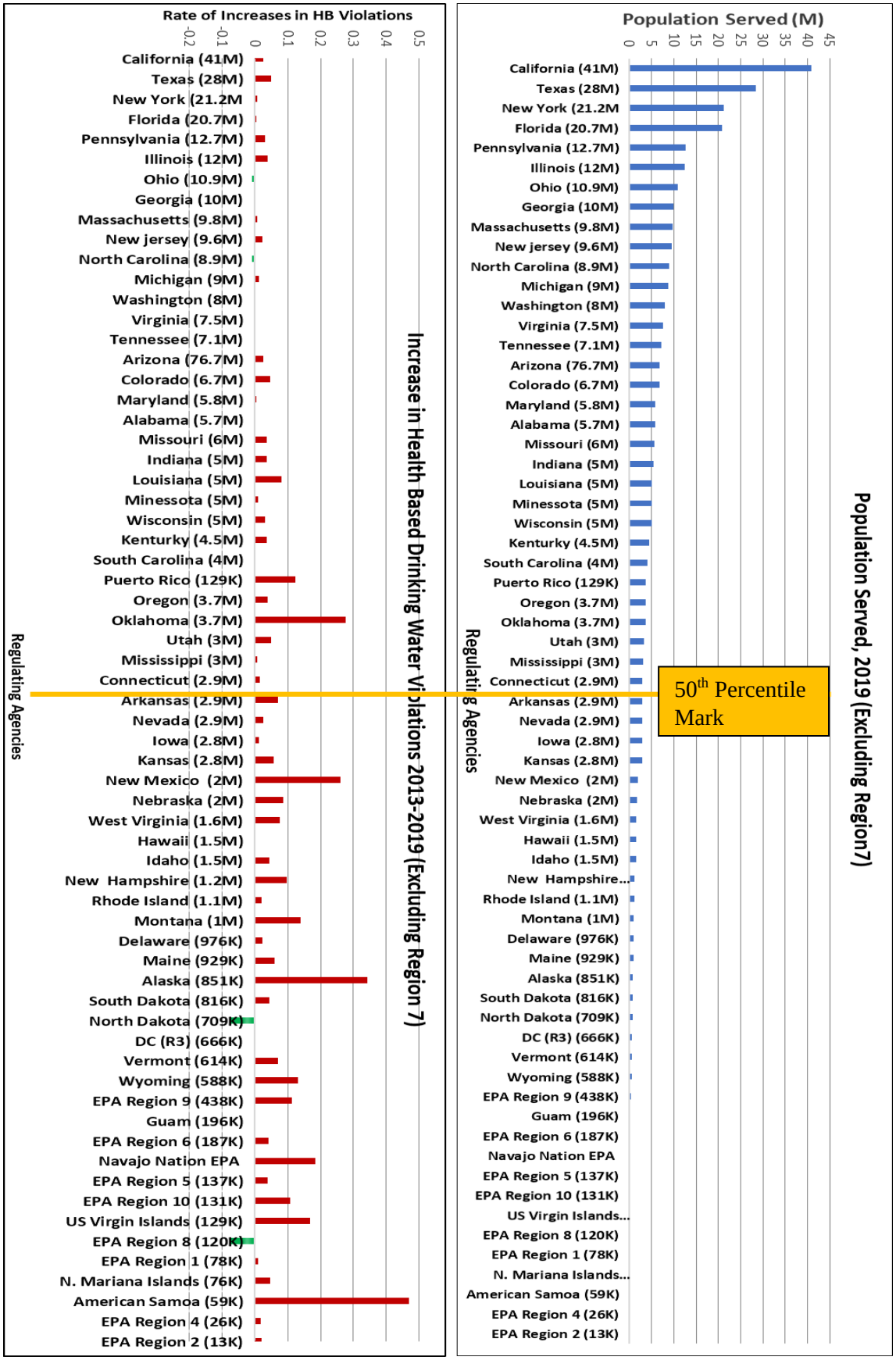


Figure 17b: All regulators, Increases in number of health-based violations in the U.S.

Trends Based on Federal Funding Availability

There are various possible contributing reasons for the noted differences in violations amongst various groups. A major factor is funding. Larger population groups may have access to more federal funding under the PWSS program to support compliance programs at water utilities, because funding is partially based on population served (EPA.gov[5;] Figures 18, 19 & 20). Availability of funding and funding opportunities may allow utilities to channel those funds to programs that are linked to drinking water quality (such as source water protection programs), leading to lower levels of contaminants in source water and, therefore, reducing the occurrences of MCL violations.

More funding may also lead to utilities being able to build capacity and to install the latest water treatment facilities and techniques, again leading to fewer contaminants in drinking water. The larger population states tend to have more revenue from other sources such as taxes (as opposed to federal funding) that can improve their capacity to support SDWA programs (such as the Utility Operator Certification) that ensure that personnel are adequately trained to operate the drinking water facilities. Such capacity and training reduce the occurrence of both health based and non-health-based violations. Moreover, states, regions or territories that experience an increased need for funding based on special circumstances may receive additional federal funding to address the need. For example, the state of Michigan received an additional $95 million on top of their regular funding during FY 2018 to address the issue of lead contamination in the City of Flint (USEPA, 2019; Abernethy et al. 2018).

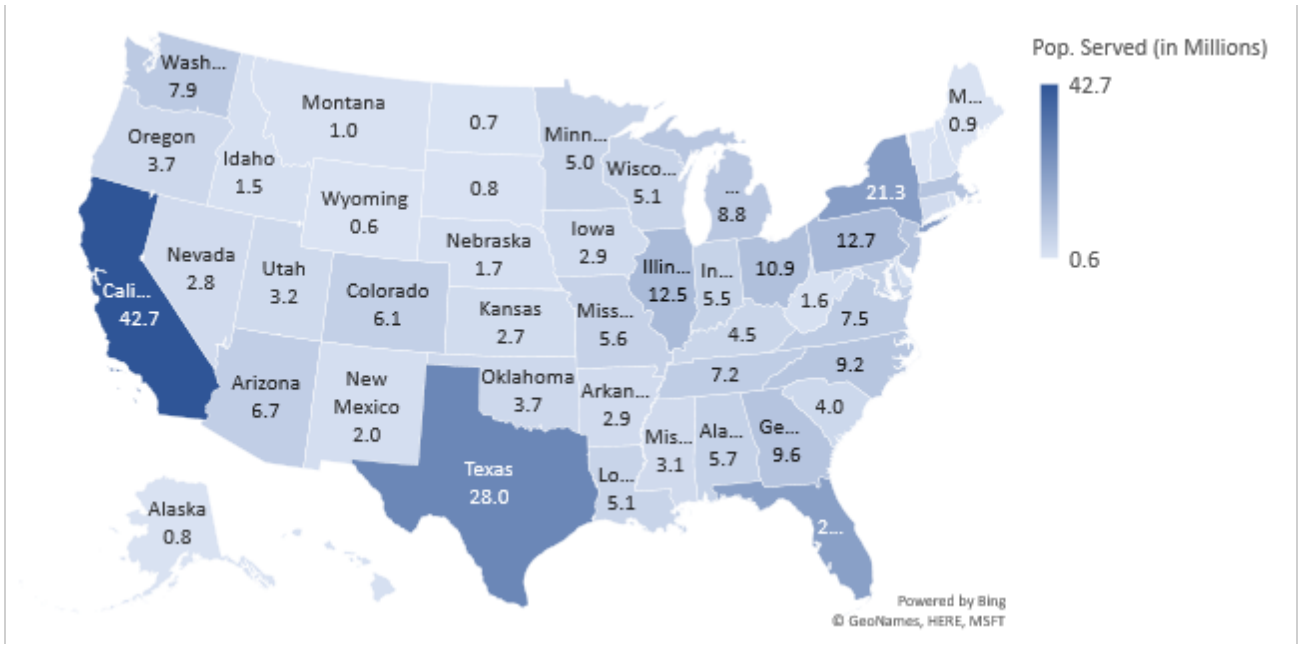


Figure 18: 2019 SDWIS data showing the state of California with the largest population served by PWSs in the U.S.

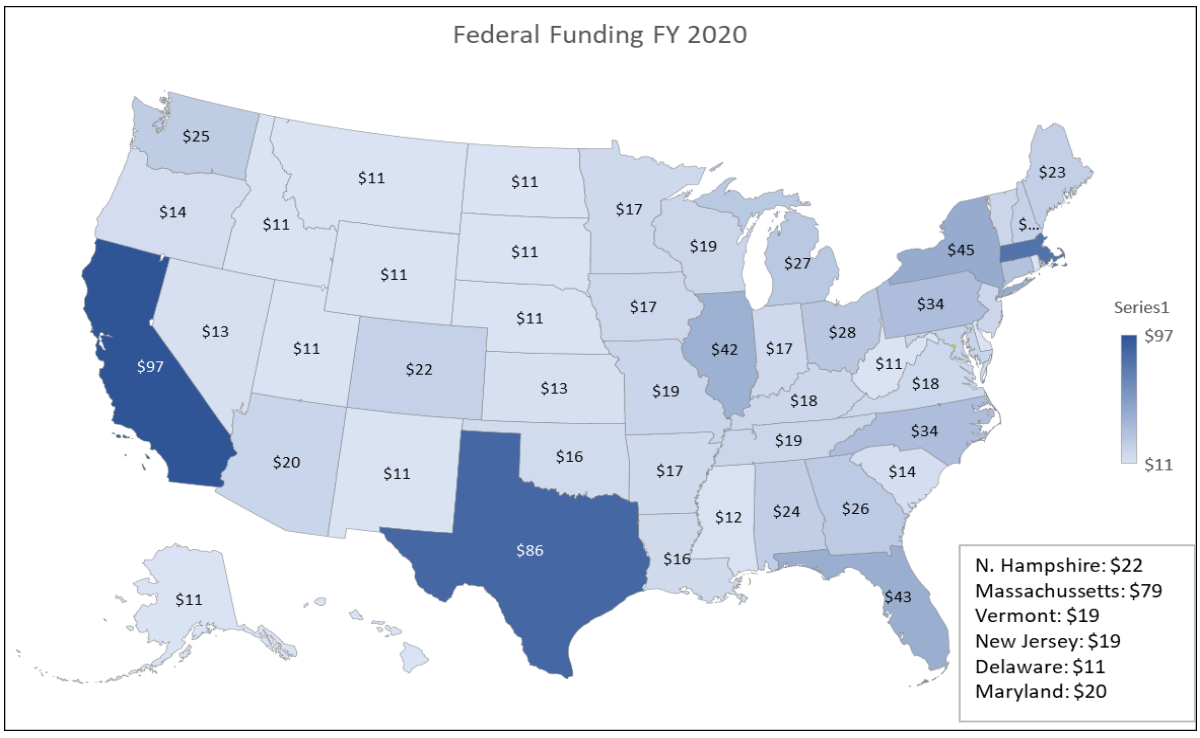


Figure 19: FY 20 federal funding received by states. Six States (MA, CT, ME, NH, RI & VT) received an additional $200 million to upgrade DW infrastructure (EPA, 2019[2])

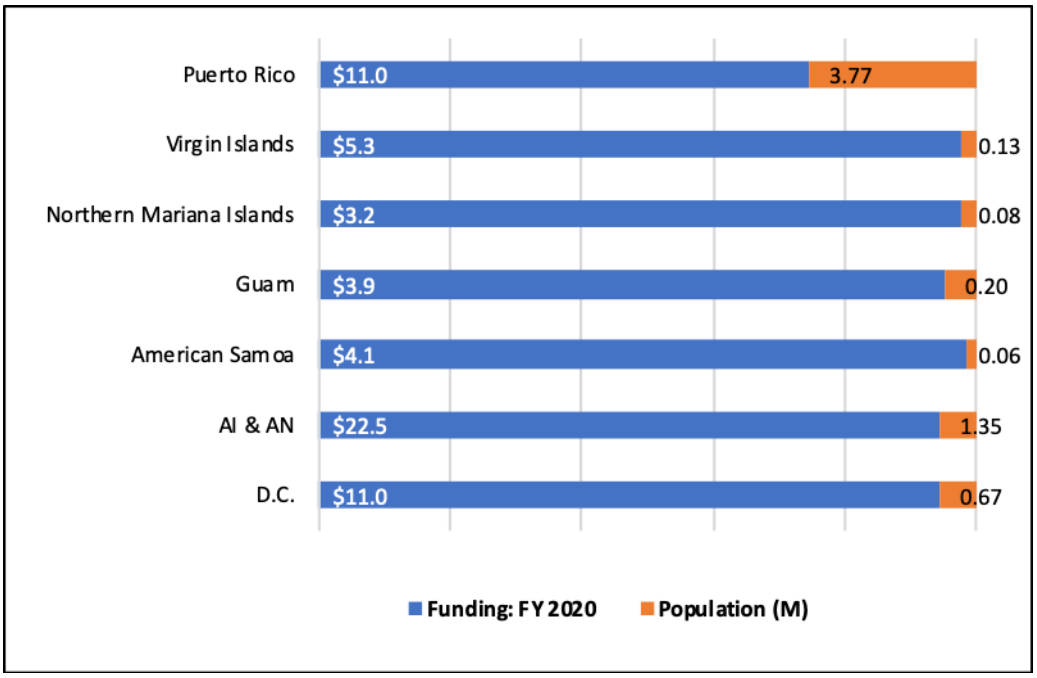


Figure 20: FY 20 federal funding received by Tribes, Territories and D.C

Trends Based on Number of Water Systems

According to 2019 SDWIS data, the state of Wisconsin had the highest number of water systems per capita in the U.S. with 11,400 water systems (Figure 21) serving only 5.1 million people. In contrast, California had 7.5K systems serving the largest population of 42.7 million people (Figure 17). This statistic shows that the number of water systems within a region or state is not directly related to the size of population served. A state may have a large population served by only a few water systems, while another may have a high number of water systems but serve a small population. Nevertheless, population served is an indicator for evaluating the portion of a population in a state or region potentially affected by issues related to drinking water quality.

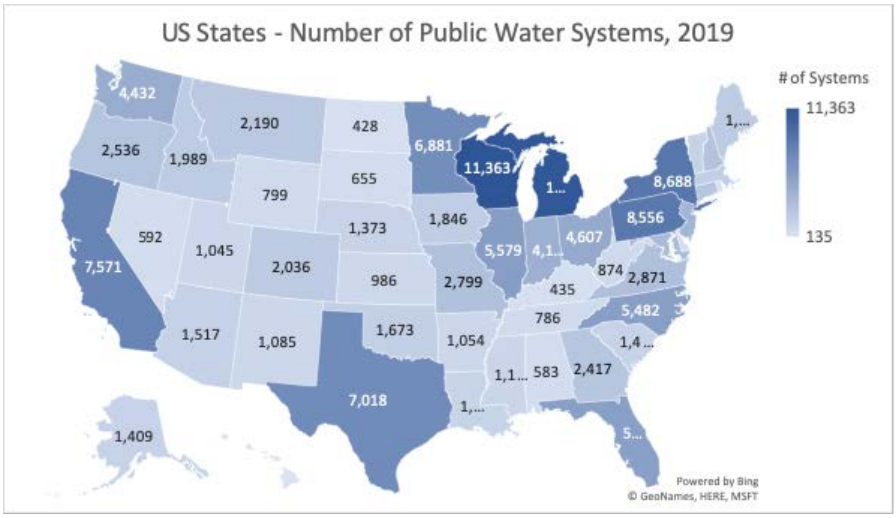
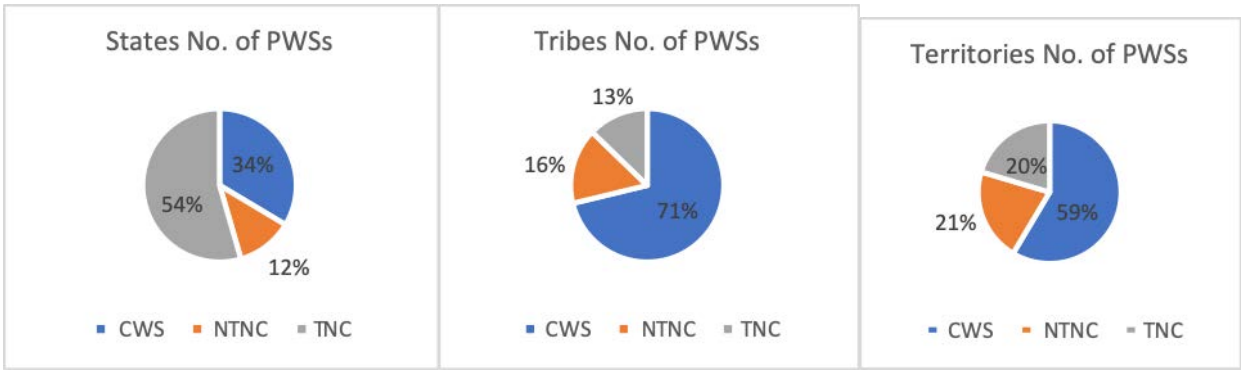


Figure 21: States, Number of PWSs

Trends Based on System Types

As noted earlier, most violations (HB and non-HB) countrywide occurred at CWSs under all regulating agencies (Figures 22a, b & c). CWSs are the most regulated water systems amongst the three categories. Therefore, it is expected that more violations will be reported at these types of systems. However, there occurred more violations at NTNC and TNC water systems under state regulated systems than at tribal and territorial PWSs. This trend may not be related to the regulating agency, but rather to the general characteristics of the population served. A majority of the tribal and territorial PWSs tend to be CWSs due to the nature of their populations. In contrast, states tend to have more non-CWSs (NTNC & TNC) as well as a larger population served by the same. It is for this reason that the states, with largely non CWSs systems, tend to report more violations than the Tribal areas and territories, which have largely CWSs.



(22a) (22b) (22c)

Figures 22a, b & c: States have a higher percentage of non-CWSs in comparison to Tribes and Territories

Trends Based on Regulating Agency

Characteristics of regulating agencies may play a role in the number of violations at PWSs. State regulated systems are supervised by the state in which the system is located. The regulating agencies are therefore located within the same state boundaries as their systems. Geographically, they have closer proximity to their systems and are able to pay closer attention to systems experiencing problems. State systems are required to follow the set federal rules and guidelines, as well as additional specific state guidelines related to public water systems.

In contrast to state regulated systems, EPA regulated systems are normally located in different states, but all are regulated under one regional office, usually in a given state (Figure 23). These systems may experience a disconnect with their regulating agency, especially if the regulating agency is in a different state. Without assistance providers – usually separate entities from EPA– to provide closer one-on-one help to systems, they may find it challenging to comply with some SDWA regulations. Furthermore, if present, assistance providers require extra funding to be able to provide their services to utilities and that funding may be limited or may be specific for

certain types of assistance but not others. Sometimes, EPA regulated systems may be required to comply with additional states regulations which vary from state to state, and this can create confusion and may result in more violations.

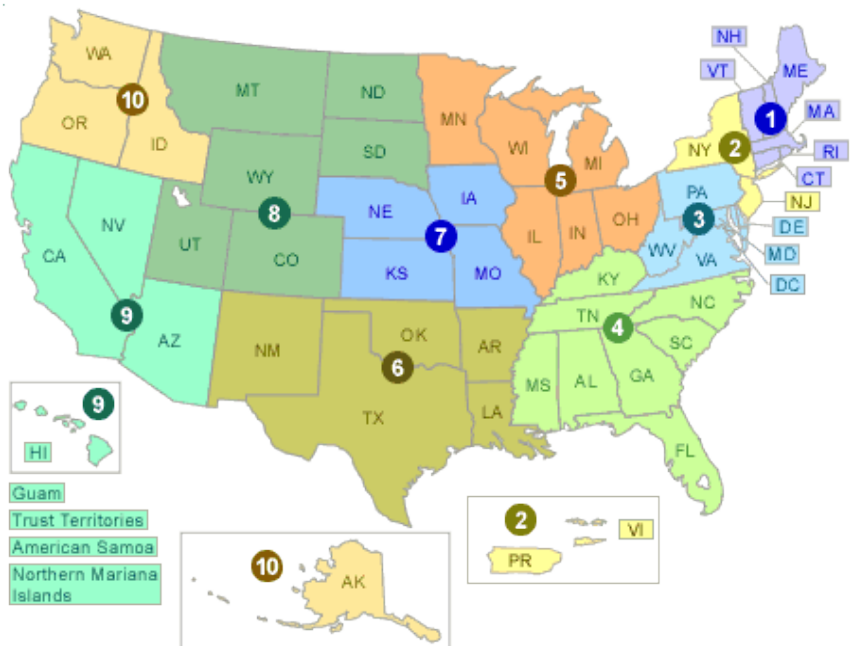


Figure 23: U.S Regions and States (modified from: epa.gov)

Although the SDWA and its governing Rules affect all PWSs alike, the Rules can be enforced differently by the various primacy agencies. A PWS showing a high number of health-based violations (MCL based) in SDWIS could mean that 1) the data is correct or 2) the data is incorrect. If the data is correct, it could mean that the regulating agency is diligent in overseeing the PWS and making sure that all the data is correctly reported. Follow up action for the regulatory agency would include assigning violations as they happen; ensuring that a PWS completes corrective action as required and returning the PWSs to compliance once the issue(s) have been corrected. If the data is incorrect, the lack of proper oversight could mean that erroneous data reported into SDWIS may go unnoticed, impacting the generation of an MCL violation, and

subsequently affecting the number of health-based violations at the system. Once validated, violations need to be tracked, and once corrected, the system may be returned to compliance. Failure to track and close out corrected violations, could inflate the number of violations at a system, making the system seem overly out of compliance. Sometimes, fewer reported violations at a PWS might not be an indicator of SDWA compliance but rather a lack of reporting and/or lack of results for the system. It could also mean that the regulating agency is not very vigilant at identifying and issuing valid violations.

Different regulating agencies may categorize violations differently. This is common with the groundwater SDWA rule, implemented in 2010 with the aim of protecting underground water sources (wells) from *E. coli* contamination (epa.gov[7]). Under this rule, inspections identify significant health-based deficiencies that could impact public health. The SDWA does not offer a standard guidance that regulating agencies must follow to uniformly determine deficiencies (and subsequently HB violations if uncorrected). For example, one regulating agency may categorize an observed failure as a major deficiency that must be corrected, while a different regulating agency may categorize the same failure as a minor deficiency and make a recommendation for action that may or may not be carried out. It is obvious therefore that PWSs regulated by more stringent regulators in this situation may report more violations in comparison to those regulated by lax regulators.

Data Caveats

The data analyzed represents data that is available to the general public as part of the Freedom of Information Act (FOIA) which was established in 1967 to keep citizens informed about their government. With this publicly available information, the public can get a glance at, amongst other aspects, the quality of their drinking water and gauge how utilities, water providers, and regulating agencies are doing in terms of keeping drinking water safe. This data however has some

caveats that sometimes affect the information that the public has access to. Utilities are supposed to regularly update details about the characteristics of their water systems, such as population, number of facilities and treatment processes in place. However, this is not always the case, so the data and information that the public sees—and was used in this study—might not be current or accurate.

When details such as population are included in the database, the figures given are usually rough estimates of the actual numbers. This can result in some numbers being overestimated, underestimated or the demographics (for example, type of population served) not correctly captured. Inaccurate population count can impact several aspects of how a system is regulated and even the federal funding it receives. It is therefore important for regulators to be proactive in gathering and updating this information in the SDWIS database, which will then accurately reflect the correct information. A good example is reflected in the data from EPA Region 7, which shows that population served almost tripled within a 3-year period from 2014-2016. There were very few new systems that were activated in that 3-year period that could have contributed to this increase. A closer look at the inventory for that region shows a significant increase in population served for some PWSs, for example, Pony Express-Bago, PWSs ID# 070000020 (NTNC), which served a population of 30 people in 2014 and 1080 in 2015. Similarly, Winnavegas Casino, PWS # 070000014 (NTNC) recorded a pop of 625 in 2014 and 1625 in 2015. While it is possible to see such drastic changes in a population over a year, a more likely explanation is that the apparent large changes were the result of clerical and/or recording and reporting errors. Columbia PWS# VA 2065120, the only American Indian owned PWSs in EPA Region 3, that is regulated by the state of Virginia, was categorized as Native American Owned in 2017. However, according to information in Virginia's Drinking Water Watch public access portal, it has been active since 1979 and had previously been classified as a privately-owned system (DWW.org). Such changes in ownership type can give inaccurate or confusing results depending on the time and period that data is accessed.

Results Reporting

Lack of reporting of sample results within the required time limits might constitute an MR violation in one region, while the same scenario might not generate a violation under a different regulator. The regulating agency that is diligent in ensuring all regulations are followed and enforced will tend to issue more violations than lax regulators. It is therefore possible that PWSs that appear to comply, and have fewer violations, aren't really in compliance at all.

Corrected but Open Violations

Once violations have been corrected by PWSs as required by SDWA, it is upon the regulators to close out the violation and to return the water system to compliance. Once such violations are closed out, they should not appear as open violations. However, some regulators, for unknown reasons, do not always do so. As a result, one may find that a violation that occurred 10 years ago and has long since been corrected, is still listed as a valid and open violation. Such violations will be included in any data acquired from SDWIS for open violations, therefore contaminating the data.

Conclusion

It is imperative that the information available to the public reflects an accurate picture of the reality of the situation at our public water systems. The public depends on the water utilities, regulators, and the federal government to provide not just safe drinking water, but also to provide accurate information related to it. This study examined and highlighted some factors that could be contributing to the occurrence of health-based violations in some areas appearing more normal than at others. The study found that lower populated regions of the U.S seem to be reporting higher average violations in comparison to higher populated areas, which is counter to expectation. The

less populated areas of the U.S tend to be remote and isolated and often have pre-dominantly minority groups and populations (e.g. tribal communities). It is not obvious why this difference exists, but it warrants a closer look to find and eliminate any underlying causes of the disparities.

The study also found differences in the occurrence of violations based on the characteristics of the regulating agencies overseeing these systems. More violations are reported at EPA regulated systems (which are mostly tribal systems) than at state regulated systems. As noted in the discussion, fewer violations do not always equate to safer drinking water. It could mean, in fact, that some violations were not determined or were not reported as violations despite their occurrence. This is a major flaw in the reporting system for violations that needs to be investigated and corrected. All regulating agencies should have a standard way of determining and issuing violations regardless of the characteristics of the populations and/or the systems they regulate. For instance, states regulate more PWSs than EPA, but might be restricted by available resources. Therefore, even though we see fewer violations at state regulated PWSs, public health might nevertheless be compromised despite the rosier picture owing to lack of determination or lax reporting of violations. It may also be necessary to re-assess how federal funding is distributed take into account other characteristics of the community served rather than rely solely on the population numbers, as is currently the case.

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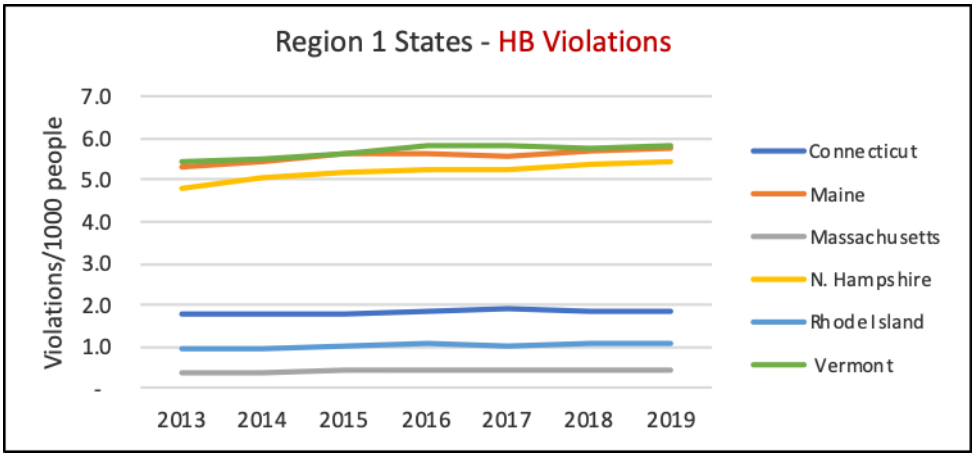
Additional Figures and Graphs

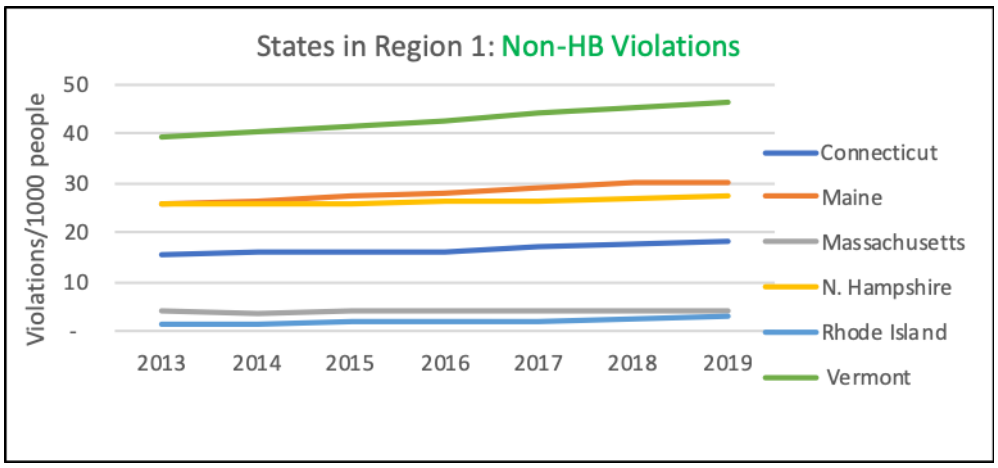
State Regulated PWSs (Categorized by EPA Regions): Health-based vs Non-health-based violations, 2013 – 2019

State Regulated PWSs

State Regulated PWSs in EPA Region 1



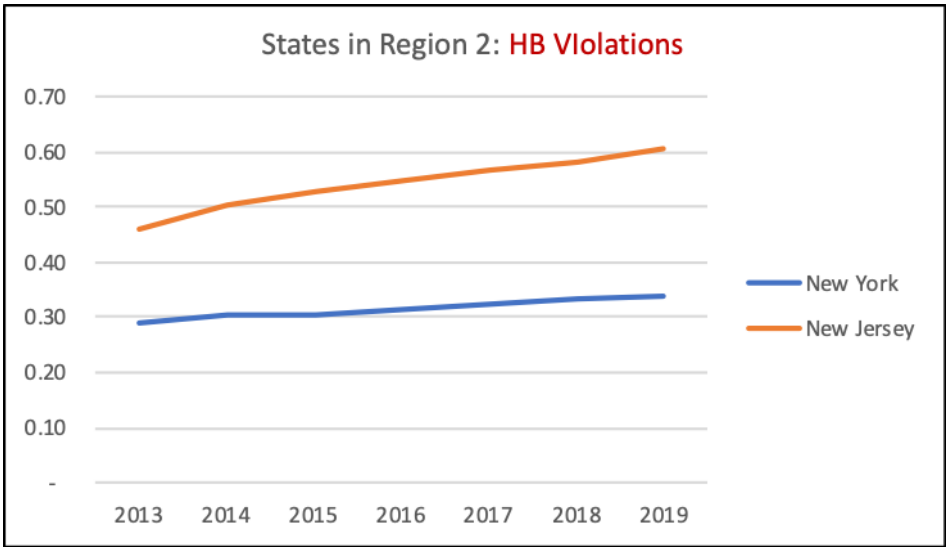
(Figure 24a)



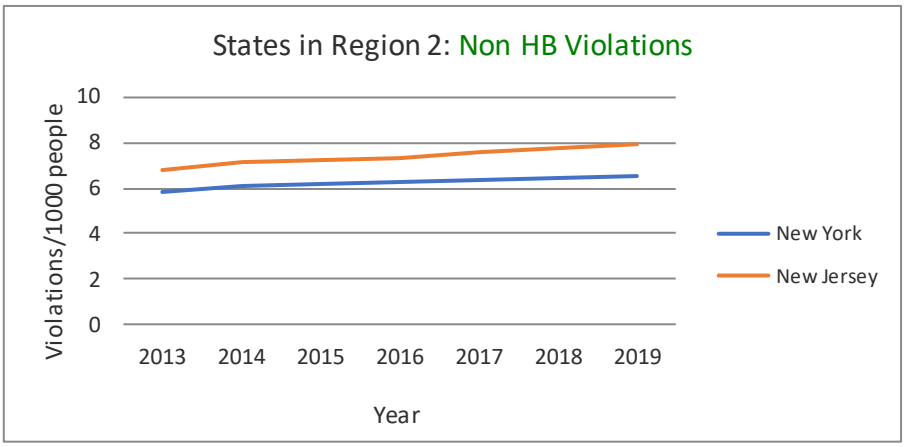
(Figure 24b)

Figures 24 a & b: State regulated systems in EPA region 1: Vermont had both the highest number of HB and Non-HB violations, while Rhode Island had the least number.

State Regulated PWSs in EPA Region 2



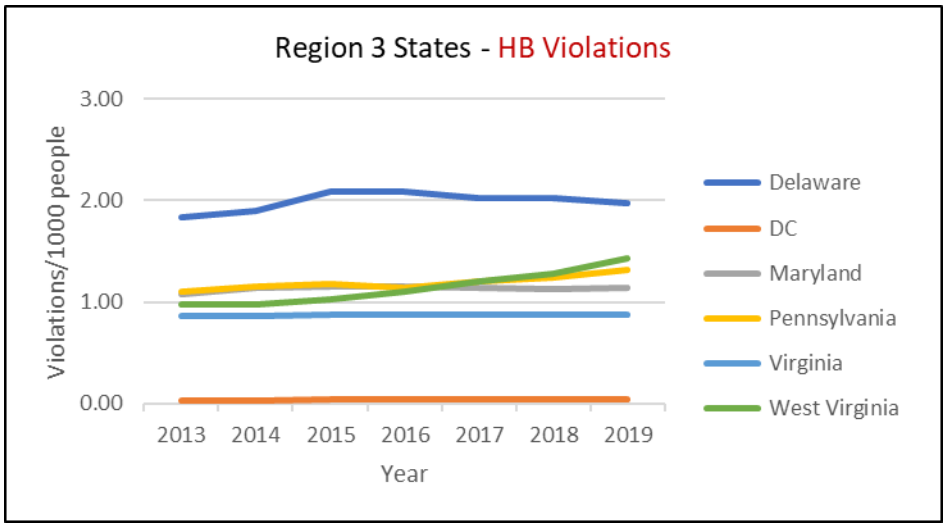
(Figure 25a)



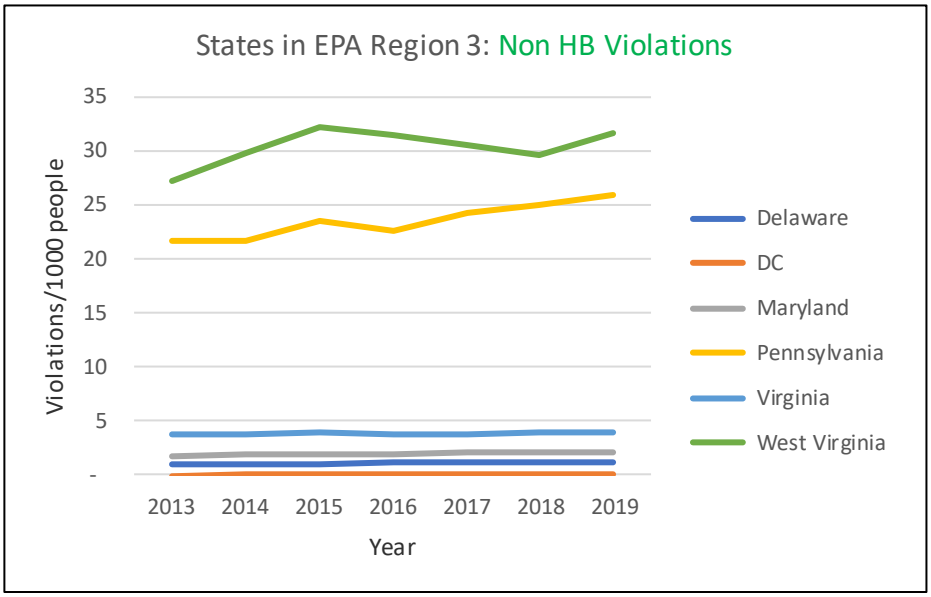
(Figure 25b)

Figures 25 a & b: EPA region 2 states, New Jersey had higher numbers of both HB and Non-HB violations than New York. PR and U.S. Virgin Islands were excluded from this group and grouped with other territories

State Regulated PWSs in EPA Region 3



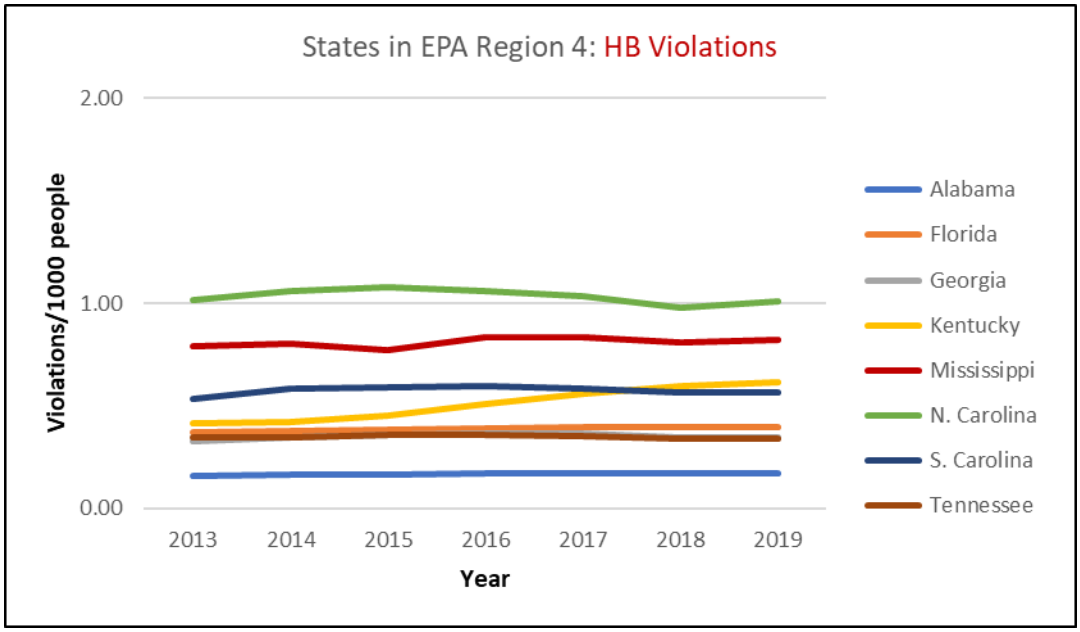
(Figure 26a)



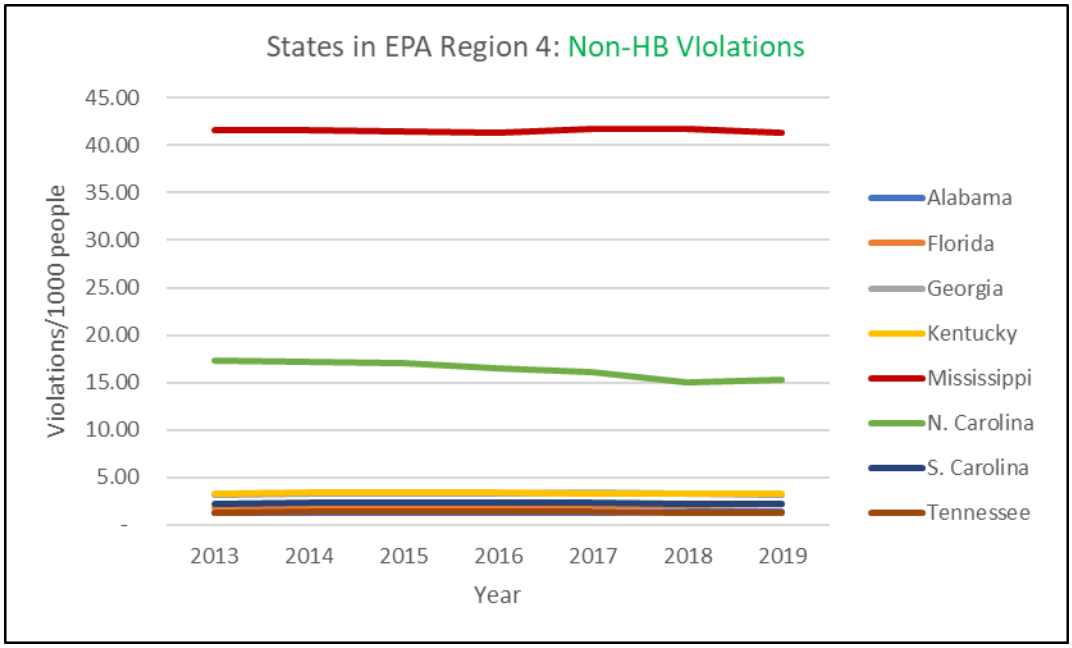
(Figure 26b)

Figures 26 a & b: EPA Region 3 states including D.C show Delaware with the highest number of HB violations and DC with the lowest number. West Virginia had the highest Non- HB violations and DC had the lowest number.

State Regulated PWSs in EPA Region 4

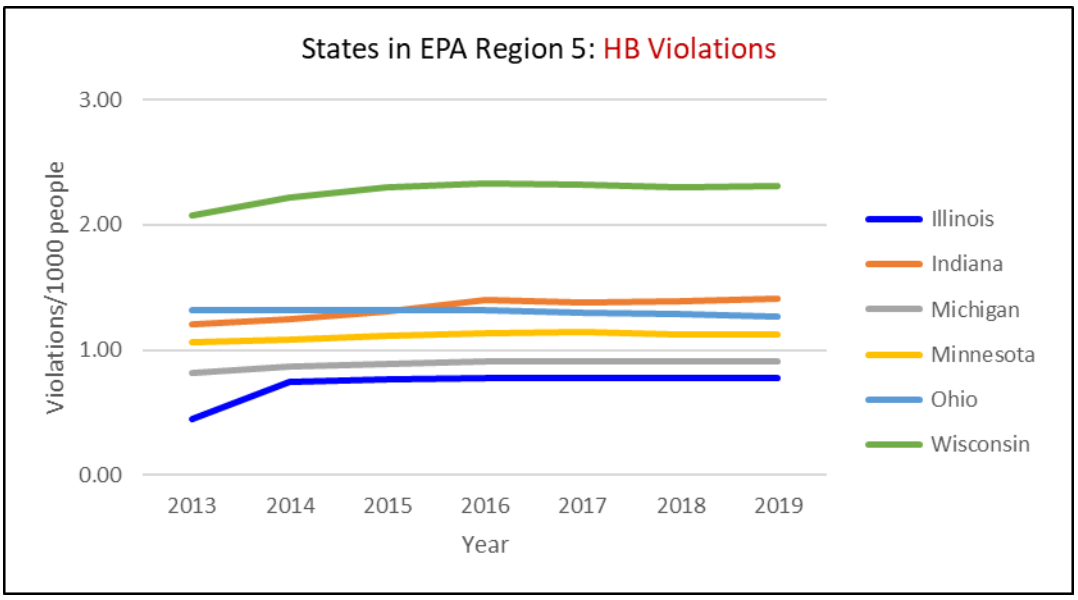


(Figure 27a)

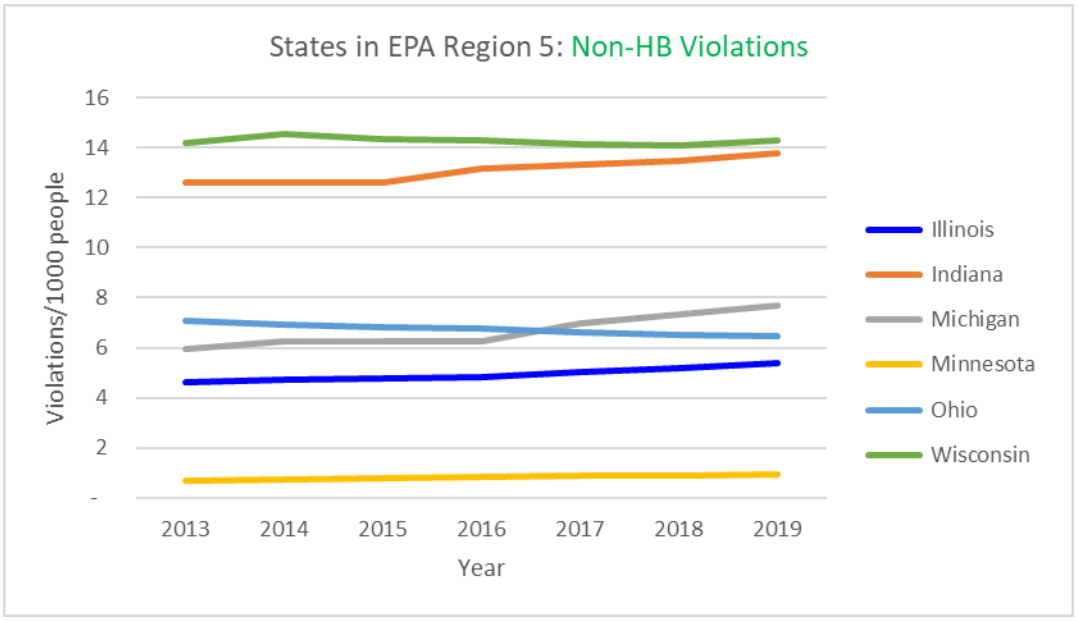


(Figure 27b)

Figures: 27 a & b: Amongst the EPA Region 4 states, North Carolina has the greatest number of HB violations, while Alabama had the least HB violations. Non-HB Violations reported in Mississippi were much higher than all the other 8 states, with 5 of states averaging violations below 5 violations per 1000 people.



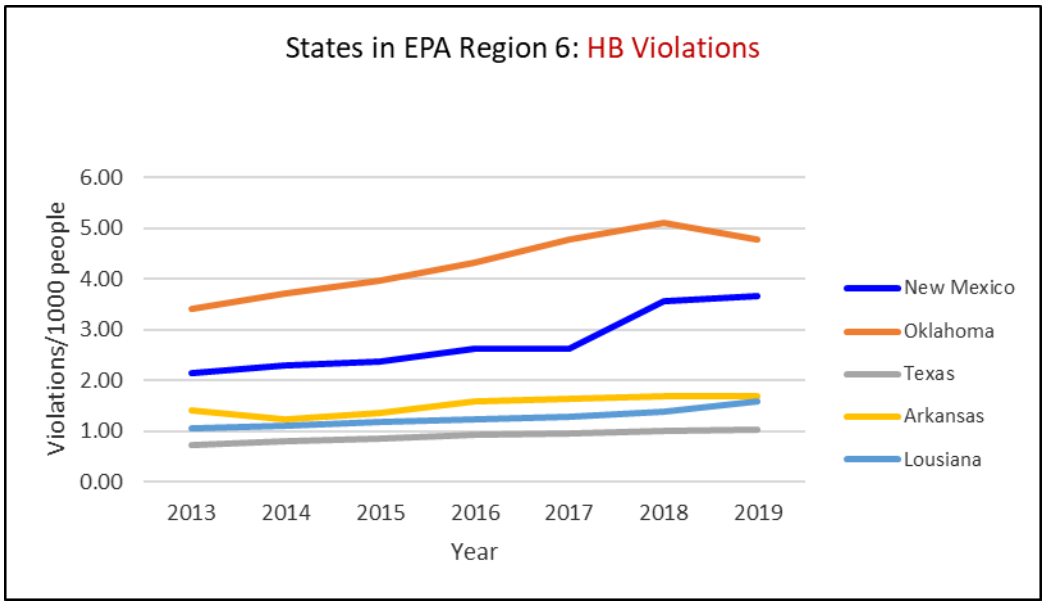
(Figure 28a)



(Figure 28b)

Figures: 28 a & b: Amongst the EPA Region 5 states, Wisconsin had the greatest number of HB and Non-HB; Illinois had the lowest number of HB violations and Minnesota had the lowest in Non-HB violations.

State Regulated PWSs in EPA Region 6



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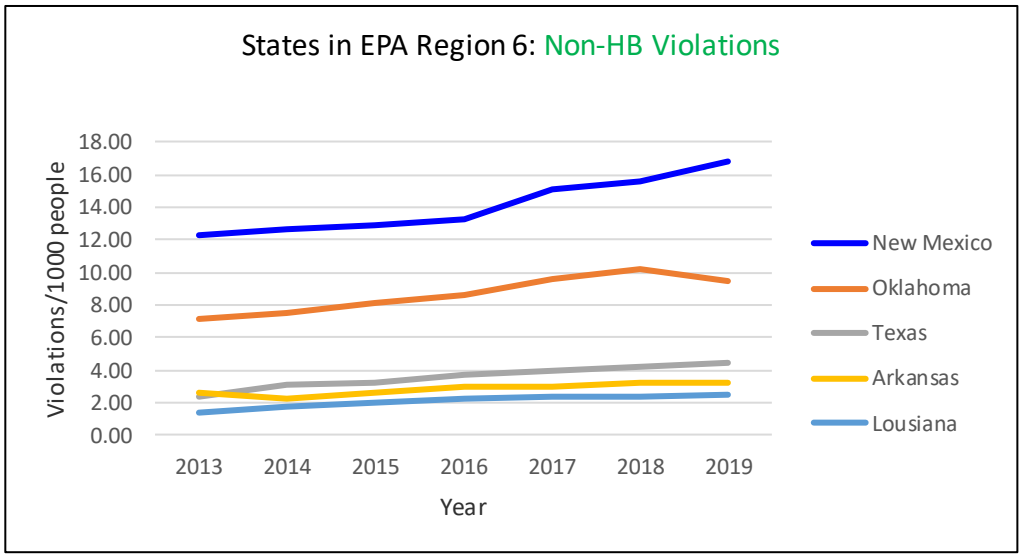
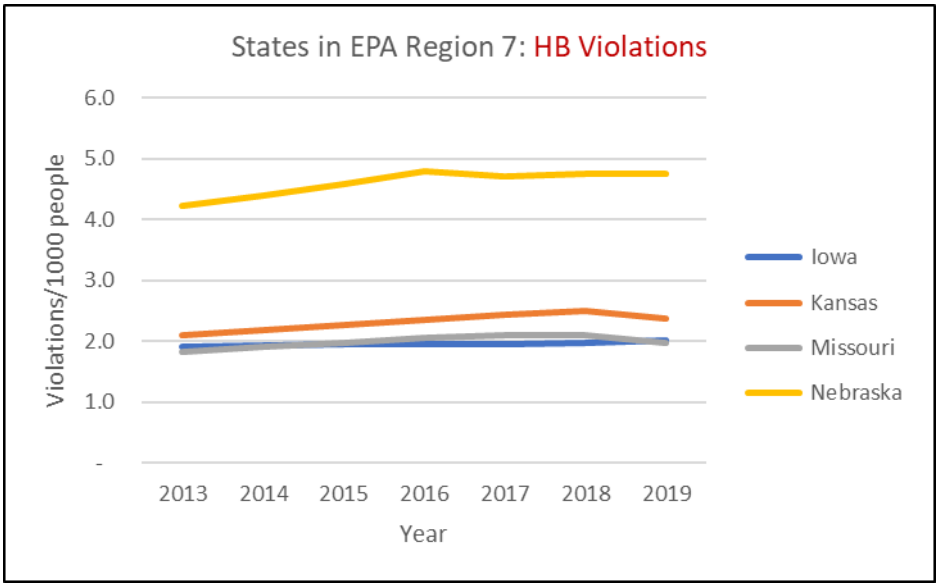


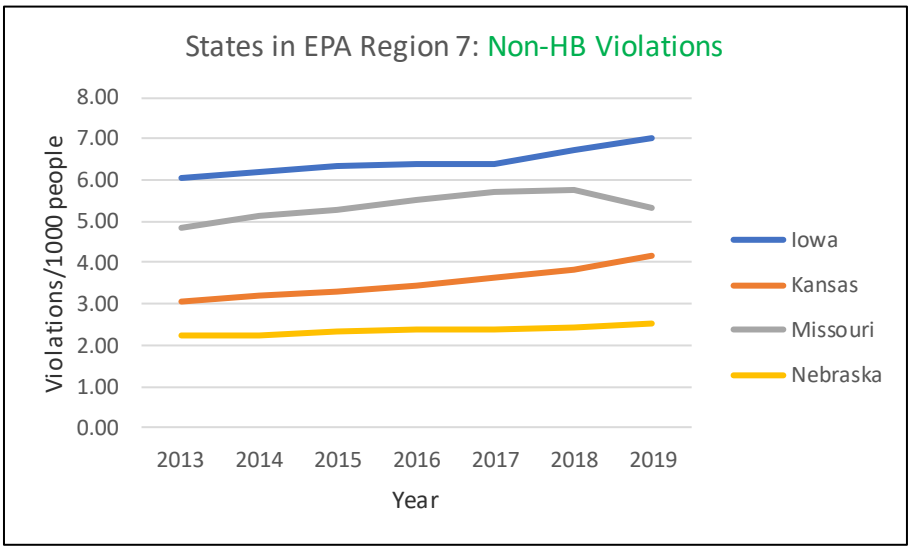
(Figure 29b)

Figures 29 a & b: In EPA Region 6 states, Oklahoma had the greatest number of HB and Texas had the lowest. New Mexico had the highest non-HB violations and Louisiana had the lowest Non-HB violations

State Regulated PWSs in EPA Region 7



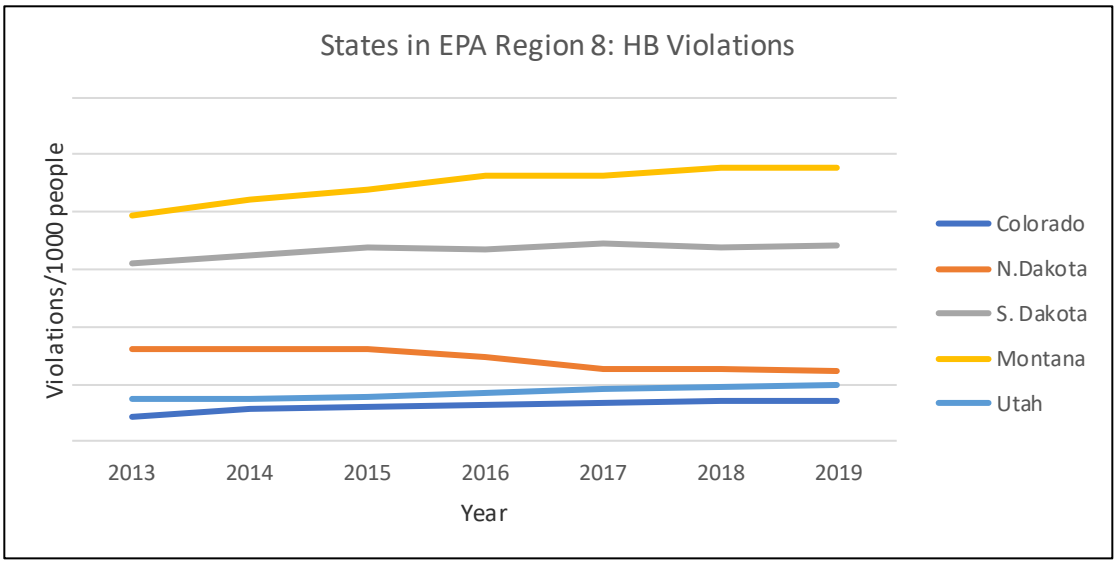
(Figure 30a)



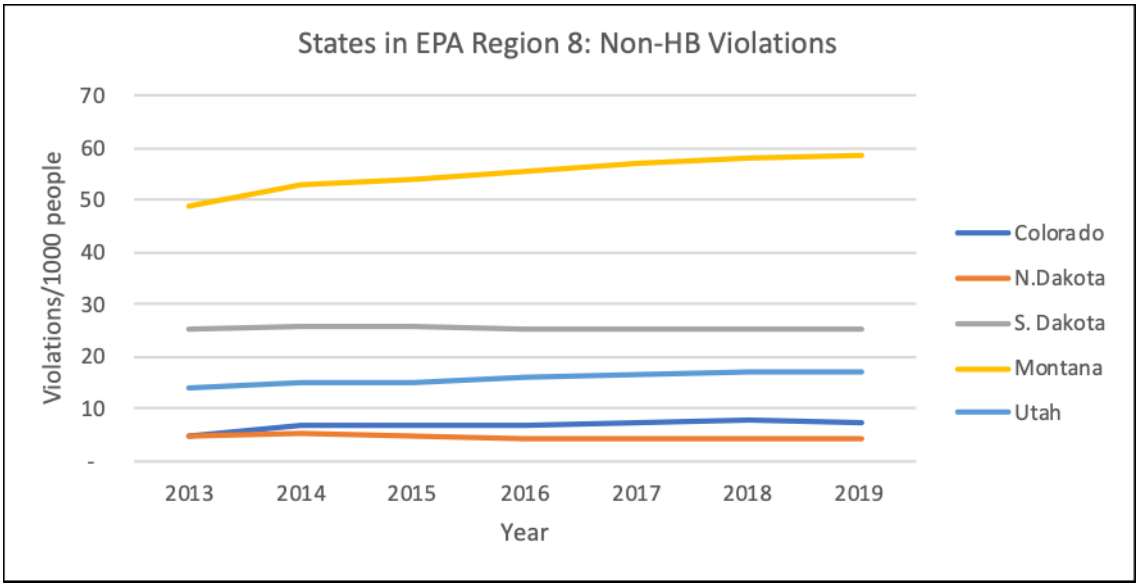
(Figure 30b)

Figures 30 a & b: In EPA Region 7 states, Nebraska had the greatest number of HB and Iowa and Missouri had the lowest. Iowa had the highest non-HB violations and Nebraska had the lowest

State Regulated PWSs in EPA Region 8



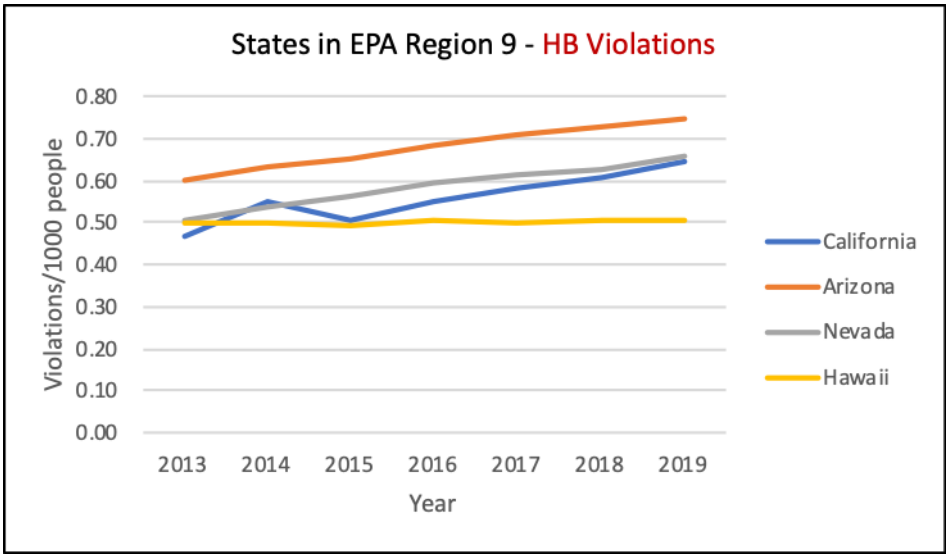
(Figure 31a)



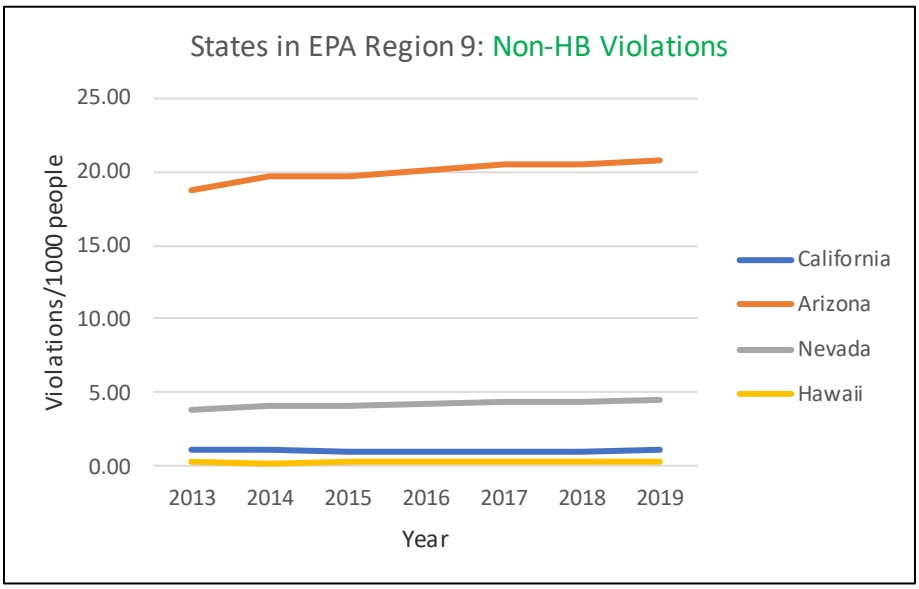
(Figure 31b)

Figures 31 a & b: EPA Region 8 states: Montana had the greatest number of HB and Non-HB Violations. Colorado had the least HB violations and North Dakota had the lowest Non-HB violations.

State Regulated PWSs in EPA Region 9



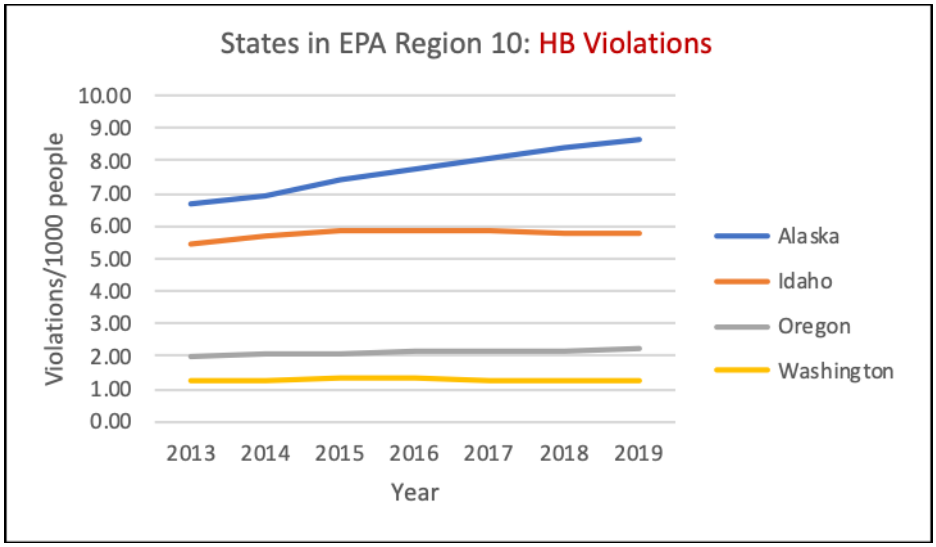
(Figure 32a)



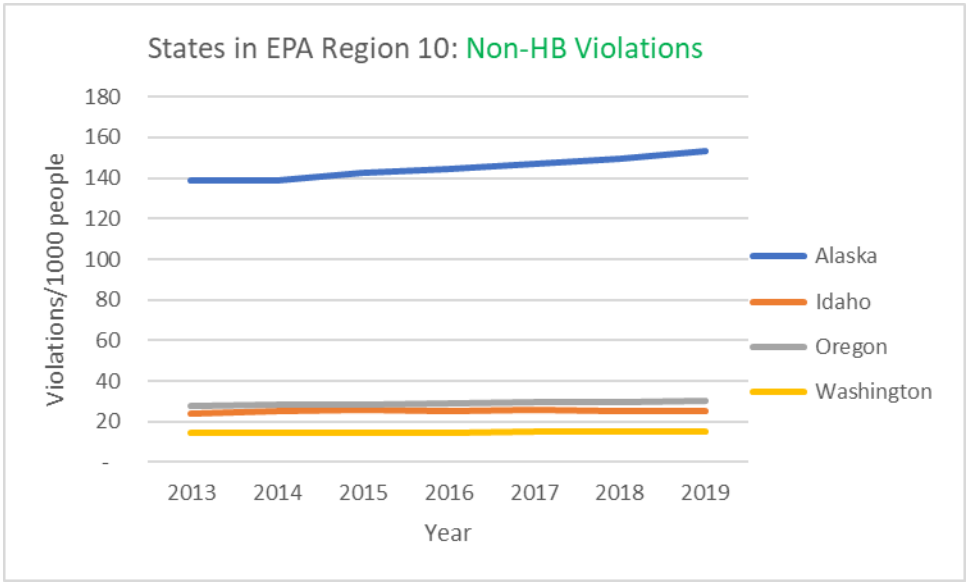
(Figure 32b)

Figures 32 a & b: EPA Region 9 states: Arizona had the greatest number of HB and Non-HB Violations, and Hawaii had the lowest number of HB and Non-HB violations.

State Regulated PWSs in EPA Region 10



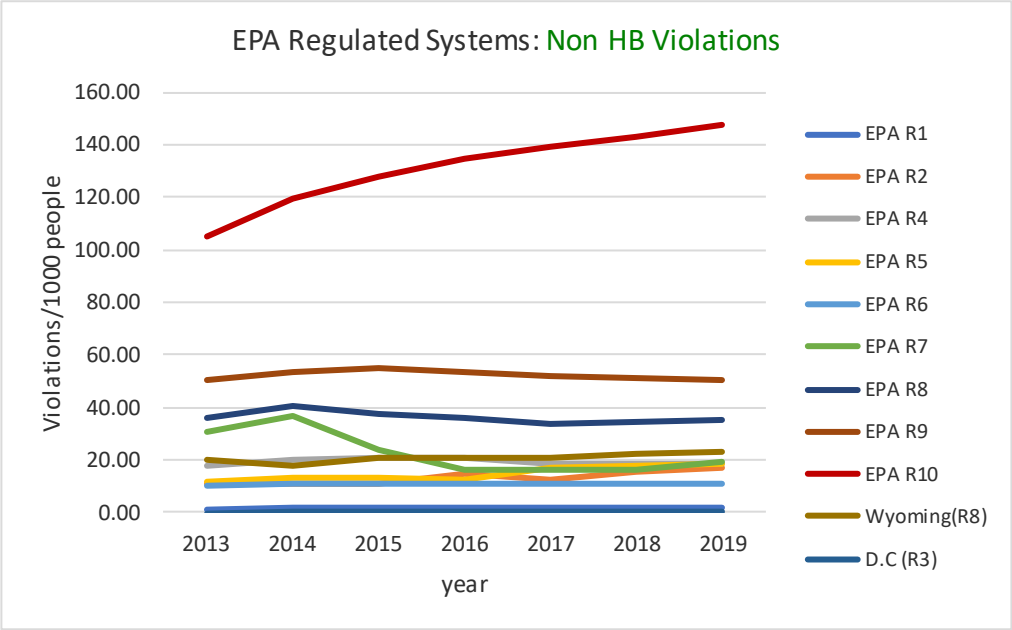
(Figure 33a)



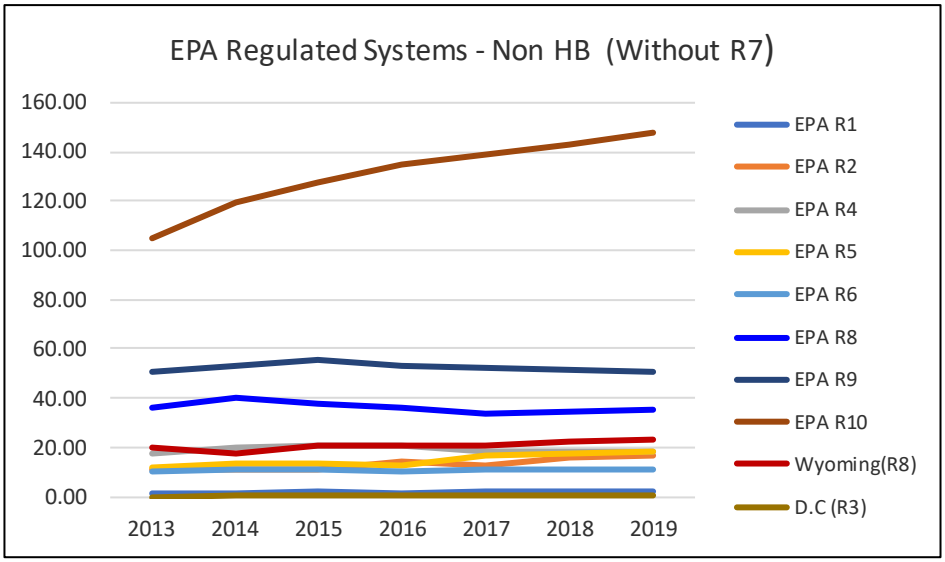
(Figure 33b)

Figures 33 a & b: EPA Region 10 states: Alaska had the greatest number of HB and Non-HB Violations, and Washington State had the lowest number of HB and Non-HB violations.

EPA Regulated PWSs



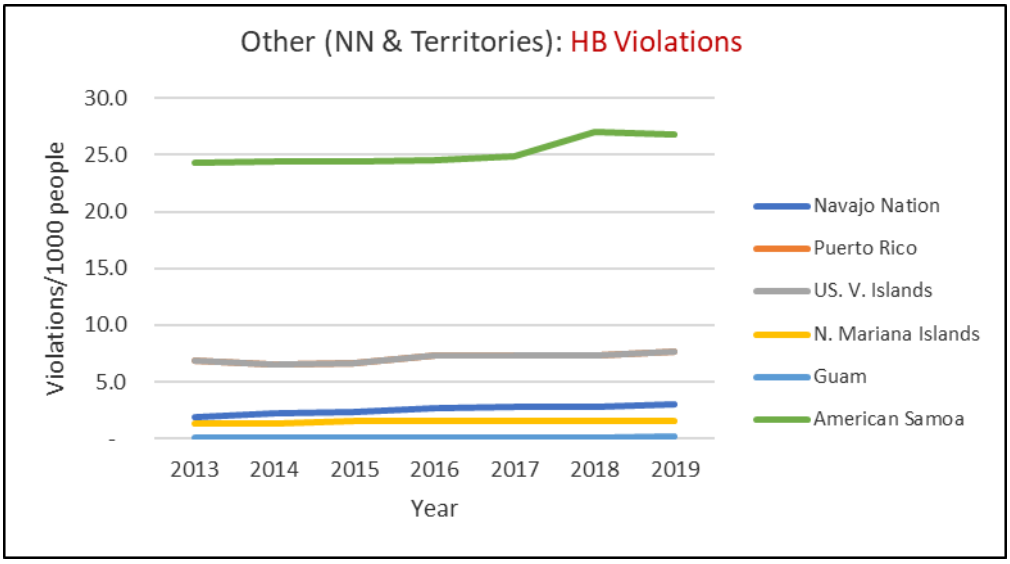
(Figure 34a)



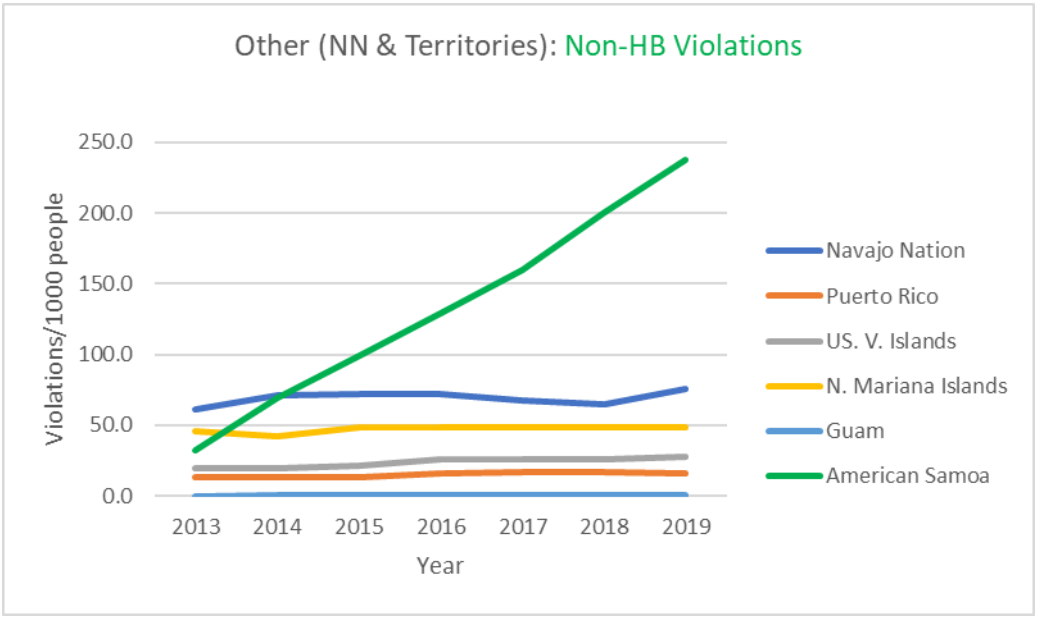
(Figure 34b)

Figure 34 a, & b: EPA Regulated systems (excluding EPA Region 7): EPA Region 8 has the highest HB violations and DC the lowest HB violations. EPA Region 10 had the highest non-HB violations, D.C had the lowest Non-HB violations

Other Regulated PWS (Navajo Nation & Territories)



(Figure 35a)



(Figure 35b)

Figure 35 a & b: Territories & Navajo Nation: American Samoa had the highest number of both HB and Non-HB violations. Guam had the lowest number of violations

Racial Categories in the U.S

Figure 36: Hispanics distribution in the U.S

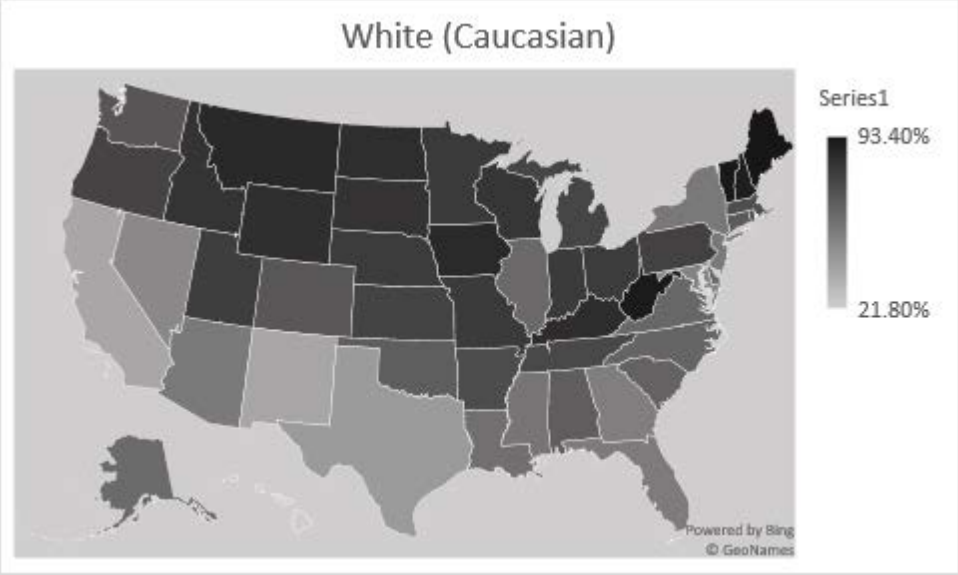


Figure 37: Whites distribution in the U.S

Figure 38: Blacks distribution in the U.S

Figure 39: Asians distribution in the U.S

Figure 40: American Indian distribution in the U.S

Abbreviations and Acronyms

- HB – Health-Based
- SDWA – Safe Drinking Water Act
- PWSS – Public Water System Supervision
- USEPA – United States Environmental Protection Agency
- TT – Treatment Technique
- MCL– Maximum Contaminant Level
- M&R – Monitoring and Reporting
- NNEPA – Navajo Nation Environmental Protection Agency
- PWSs – Public Water Systems
- NPDWR – National Primary Drinking Water Regulations
- DWSRF – Drinking Water State Revolving Fund
- DWINSA – Drinking Water Infrastructure Needs Survey Assessment
- BWA – Boil Water Advisory
- AI– American Indian
- AN – Alaska Native
- IHS – Indian Health Service
- FY– (federal) Fiscal Year [October 1-September 30]
- GPRA – Government Performance and Results Act