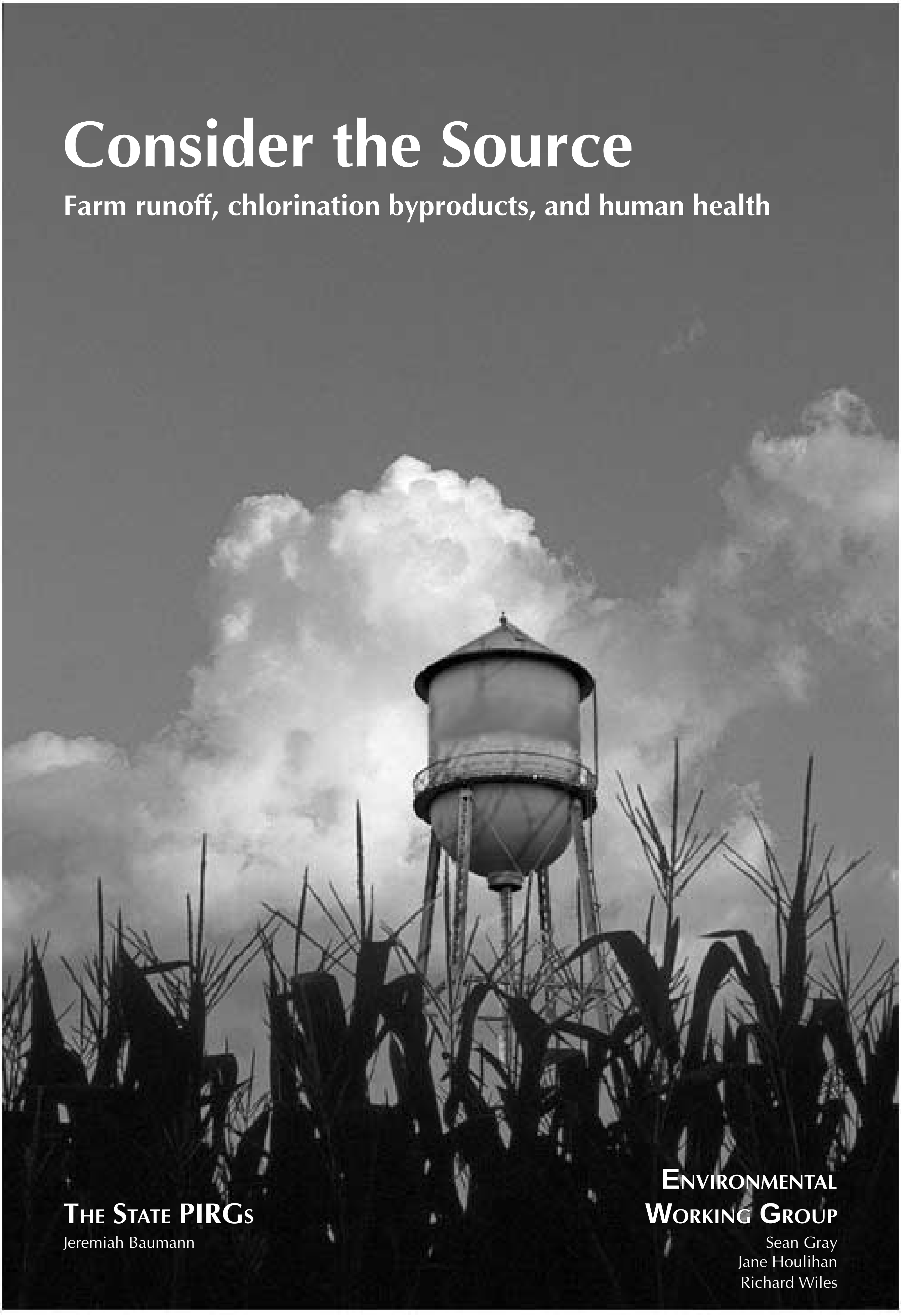
Consider the Source

Farm runoff, chlorination byproducts, and human health



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Contents

Executive Summary

We Recommend:

- A major national effort to clean up drinking water sources, focusing on reducing agricultural and urban pollutants that lead to chlorination byproducts.
- The creation of a nationwide health tracking network to help scientists and policymakers fully understand the link between tap water chlorination byproducts and specific birth defects, cancers, and miscarriage.
- Funding for programs to train operators of small town drinking water systems in improved chlorination techniques.

Chlorinating tap water is a critical public health measure that saves thousands of lives each year by reducing the incidence of water-borne disease. But chlorination is no substitute for cleaning up America's waters.

By failing to clean up rivers and reservoirs that provide drinking water for hundreds of millions of Americans, EPA and the Congress have forced water utilities to chlorinate water that is contaminated with animal waste, sewage, fertilizer, algae, and sediment, in order to provide water free of disease-causing microorganisms. Chlorine combined with the organic matter in this pollution produces harmful byproducts, collectively referred to as chlorination byproducts (CBPs). In spite of the diligent efforts of the water utilities to filter and clean the water before they chlorinate, CBP levels remain high in the water consumed by millions of people each day. Approximately 240 million Americans drink tap water contaminated with some level of CBPs.

A compelling body of scientific evidence - nearly 30 peer-reviewed epidemiologic studies - links chlorination byproducts to increased risks of cancer. At current levels in U.S. tap water, EPA estimates that CBPs cause up to 9,300 cases of bladder cancer each year. A growing body of science links CBPs to miscarriages and birth defects, including neural tube defects, low birth weight, and cleft palate. Other health problems from CBP exposure may include other cancers (rectal and colon), kidney and spleen disorders, immune system problems and neurotoxic effects (63 FR 69390-69476).

Industrial water pollution is not a major contributor to CBPs in tap water. Instead the main causes are sediments, nutrients, and pollution from agricultural and urban runoff, and in some small systems, excess use of chlorine. Until Congress and the EPA act to limit pollution from farms and urban runoff so that water entering drinking water treatment plants is much cleaner than it is today, CBPs will remain at unacceptably high levels.

Until Congress and the EPA act to limit pollution from farms and urban runoff so that water entering drinking water treatment plants is much cleaner than it is today, CBPs will remain at unacceptably high levels.

This first ever national analysis of chlorination byproducts in tap water from both large and small cities, conducted by the Environmental Working Group (EWG), shows that although most water suppliers are in compliance with current and future drinking water standards:

- More than 137,000 pregnancies each year are at increased risk of miscarriage and birth defects each year from exposure to CBPs in tap water.*

- Since 1995, more than 16 million people in 1,258 communities have been served water containing chlorination byproducts for 12 months in a row at levels above the legal limit going into effect in January 2002.*

- A handful of large cities with a history of high CBP levels account for a significant portion of the population at risk, including Washington, DC suburbs, Philadelphia, Pittsburgh suburbs, and San Francisco (Table 1).

- The problem is not confined to large cities. More than 1,100 small towns (fewer than 10,000 people) have reported potentially dangerous levels of CBPs in their tap water over the past six years. Pregnant women living in small towns supplied by rivers and reservoirs are more than twice as likely to drink tap water with elevated levels of CBPs as women in larger communities. Historically, systems serving fewer than 10,000 people have been exempt from all federal health standards for CBPs.

Despite significant population-wide exposures to CBPs, a survey of federal and state-level efforts to monitor and track consumers' exposure to CBPs and related health effects shows that the U.S. fails to collect essential tracking data at a national level that could provide key insight on causes and other critical information on miscarriages and birth defects linked to CBPs.

EWG and U.S. Public Interest Research Group's (U.S. PIRG's) compilation of survey information finds that 10 states and Washington, DC either have no birth defects surveillance system at all, or cursory systems that miss an estimated 90 percent of the cases. Not a single state has an active, well-funded system in place to track first-trimester miscarriages, which account for 90 percent of all miscarriages and which also have been linked to CBP exposures.

The effectiveness of health standards for CBPs and other environmental contaminants is limited by the lack of reliable data on environmentally caused disease.

The need for a nationwide health tracking network

In 1998, EPA completed a revision of the health standard governing two groups of chlorination byproducts in tap water. The new rule makes three major changes in policy. First, it eliminates the long standing exemption

** See "Health Risks" description, page 30, for details on risk thresholds used in this analysis.*

Table 1: At least 400 women in each of 49 U.S. communities face an elevated risk for miscarriage and birth defects from high levels of chlorination byproducts in tap water.

Cities listed below are ordered based on the number of pregnancies each year exposed to at least 80 ppb THMs for at least a trimester. These pregnancies are at increased risk for birth defects and miscarriage.

Rank	Community or Water System	Population Served	Estimated Number of Pregnancies per Year Exposed to 80 ppb THMs* for an Entire Trimester (Percentage of Pregnancies)
1	Maryland Suburbs of DC (WSSC)	1,500,000	12,081 (58%)
2	Philadelphia, PA	1,755,000	5,936 (24%)
3	Pittsburgh Suburbs, PA	569,328	4,053 (51%)
4	San Francisco, CA	789,600	3,957 (36%)
5	Washington, DC	595,000	3,809 (46%)
6	Newark, NJ	275,221	2,847 (74%)
7	Boston, MA	2,000,000	2,579 (9%)
8	Omaha, NE	506,420	2,216 (31%)
9	Charleston, WV	173,005	2,196 (91%)
10	Passaic Valley, NJ	275,000	2,191 (57%)
11	Garland, TX	201,824	2,127 (75%)
12	Columbus, OH	452,765	1,993 (31%)
13	Charleston, SC	304,505	1,940 (46%)
14	Monmouth County, NJ	302,491	1,796 (42%)
15	Akron, OH	308,720	1,693 (39%)
16	Jackson, MS	227,500	1,646 (52%)
17	Trenton City, NJ	225,000	1,527 (48%)
18	Kansas City, KS	164,462	1,520 (66%)
19	New Bedford, MA	139,495	1,450 (74%)
20	Plano, TX	202,000	1,340 (47%)
21	Pittsburgh City, PA	370,000	1,325 (26%)
22	Mesquite, TX	119,600	997 (60%)
23	Evansville, IN	150,000	927 (44%)
24	Aurora, IL	122,271	918 (54%)
25	Knoxville, TN	170,351	899 (38%)
26	New Milford, NJ	713,737	793 (8%)
27	Richardson, TX	89,600	769 (61%)
28	Davenport, IA	130,290	742 (41%)
29	Laredo, TX	193,766	727 (27%)
30	Amarillo, TX	168,000	722 (31%)
31	Durham, NC	153,000	716 (33%)
32	Lancaster, PA	108,000	695 (46%)
33	Fayetteville, NC	170,121	668 (28%)
34	Norristown, PA	83,200	664 (57%)
35	East St Louis, IL	139,200	661 (34%)
36	Boca Raton, FL	109,000	654 (43%)
37	Penn Hills, PA	125,000	650 (37%)
38	Kankakee, IL	55,430	588 (76%)
39	Texarkana, TX	56,367	536 (68%)
40	Kenmore, WA	60,000	521 (62%)
41	Glendale, AZ	180,000	495 (20%)
42	Columbia, MD	175,000	481 (20%)
43	Warren, OH	70,000	476 (49%)
44	New Kensington, PA	47,800	474 (71%)
45	Bucks County, PA	66,100	466 (50%)
46	Lowell, MA	135,000	457 (24%)
47	Mckinney, TX	49,100	437 (64%)
48	Portsmouth, VA	120,000	430 (26%)
49	Gloucester, MA	39,000	412 (76%)
50	Kirkland, WA	36,039	394 (78%)

Source: Environmental Working Group analysis of state and federal tap water testing data.
** Trihalomethanes (THMs) are four individual chemicals that together are the most abundant byproducts of tap water chlorination.*

Not a single state has an active, well-funded system in place to track first-trimester miscarriages, which account for 90 percent of all miscarriages and which also have been linked to CBP exposures.

from health standards for systems serving less than 10,000 people; second, it lowers the amount of trihalomethanes (THMs, the most prevalent chlorination byproducts) allowed in tap water from 100 parts per billion on average over the course of a year, to 80 ppb; and third, it regulates haloacetic acids, another major class of chlorination byproducts, and two other byproducts called chlorite and bromate, for the first time.

The effectiveness of health standards for CBPs and other environmental contaminants is limited by the lack of reliable data on environmentally caused disease. In spite of the growing body of evidence linking CBPs to miscarriages, birth defects, and cancers, EPA lacked solid data on incidence rates for most of these effects, as well as exposure data to CBPs in tap water, throughout the standard setting process. The United States lacks a nationwide health tracking network that could provide reliable data on disease rates, pregnancy outcomes, and levels of exposure to environmental contaminants potentially responsible for harm.

Because of these data limitations, EPA formally considered the risks of just one cancer, bladder cancer, when setting the new health limits for CBPs. The agency made no estimate of the risk or potential reduction in the rates of other cancers, birth defects or miscarriages during the entire process (63 FR 69390-69476). The result is most likely an underestimate of the actual risk, and new health standards that may not significantly reduce the incidence of adverse health effects from CBPs.

EPA's ability to quantify just one of the many health effects linked to CBP exposures (bladder cancer), illustrates how our country's patchwork of health tracking programs ultimately hamstrings public health officials, forcing decisions that more often than not are based on just a fraction of the public health impacts from environmental contaminants. Tracking disease is a cornerstone of public health protection, and has been used effectively to identify and stop infectious disease outbreaks for decades. Nationwide, the tools of tracking and monitoring have not been consistently applied to chronic disease; birth defects and other conditions ranging from Alzheimer's Disease to asthma to miscarriage remain inadequately tracked in the U.S.

Findings

> **In 42 cities ranging in population from 47,000 to 2 million, more than 500 pregnancies are at an increased risk for birth defects or miscarriage each year**

Health Risks from Chlorination Byproducts

From 1979 to the present, the only chlorination byproducts regulated and consistently monitored in tap water have been four compounds together known as trihalomethanes, or THMs. Our analysis of THM levels in public water supplies from 50 states and Washington, DC shows that:

Hundreds of mostly small utilities across the country have high levels of THMs in finished tap water:

- Between 1995 and 2001, more than 1,200 public water supplies serving 16.2 million people reported at least one consecutive 12 month period with THM levels over the 80 ppb health standard that will go into effect beginning in January 2002. More than 1,000 (80 percent) of these systems, and all of the 50 cities with the highest THM levels (Table 9 page 33), served fewer than 10,000 people, the official EPA cutoff for small systems. EPA estimates that long-term exposures at these levels cause up to 7,000 cases of bladder cancer each year nationwide.

- More than 1,500 systems reported quarterly (3 month) averages of 80 ppb or greater during the period analyzed; 1,109 of these were small systems. Substantial evidence indicates that 3 month levels over 80 ppb present elevated risks of miscarriages or birth defects. (See Figure 1, page 12 for a national map depicting relative elevated risk at a county level.; See Chart 1 on page 10 for a description of health effects and cities facing potentially elevated risks).

> **All of the 50 cities with the highest THM levels served fewer than 10,000 people.**

- The maximum THM levels measured in some small water systems were nearly nine times the amount allowed over the course of a year (Table 8 page 32) and long term averages have been as high as 430 ppb, compared to the 80 ppb level going to effect in January 2002 (Table 9 page 33). Because small systems in most states have been exempt from all health standards for chlorination byproducts, small rural drinking water systems have likely delivered water with dangerously high THM levels for years.

Some large cities also have serious problems with chlorination byproducts:

- A number of big cities have THM problems as well, including Washington, DC suburbs, Philadelphia, Pittsburgh suburbs, and San Francisco (Table 1). In metropolitan Philadelphia and the Maryland Suburbs of Washington, DC elevated THM levels put a total of 22,000 pregnancies at increased risk for birth defects or miscarriage each year.

- In 40 cities ranging in population from 55,000 to 2 million, more than 500 pregnancies are at an increased risk for birth defects or miscarriage each year (Table 1).

- On the whole, chlorination byproduct levels in the 100 most contaminated large systems show no decline during the period analyzed, although some individual water suppliers are working to reduce CBP levels in anticipation of new health standards.

Table 2: At least 1,000 women in each of 24 states and the District of Columbia face an elevated risk for birth defects and miscarriage each year from exposure to high levels of chlorination byproducts.

States listed below are ordered on the estimated number of pregnancies statewide at increased risk for birth defects and miscarriage each year.

Rank	State	Number of Water Suppliers Analyzed	Population Served	Estimated Number of Pregnancies at Increased Risk per Year
1	Texas	2,284	18,685,894	26,525
2	Pennsylvania	266	8,820,682	18,419
3	Maryland	34	4,270,287	14,177
4	New Jersey	526	7,256,528	10,456
5	Massachusetts	227	6,577,429	9,077
6	Illinois	671	9,611,027	7,299
7	Ohio	1,170	8,792,614	6,777
8	South Carolina	74	2,313,351	5,474
9	California	892	30,058,603	5,440
10	District of Columbia	1	595,000	3,809
11	Missouri	849	3,998,900	3,459
12	Nebraska	79	1,025,716	2,277
13	Washington	1,576	4,838,998	1,939
14	Florida	130	8,698,023	1,716
15	Iowa	182	1,547,692	1,525
16	North Carolina	306	3,424,966	1,384
17	Tennessee	331	4,377,029	1,366
18	Alabama	376	4,223,222	1,312
19	Indiana	224	3,026,099	1,195
20	Arizona	545	4,246,498	1,175
21	Arkansas	53	1,125,526	1,100
NR*	Virginia	6	2,092,566	2,752
NR	West Virginia	1	173,005	2,196
NR	Kansas	4	927,487	1,832
NR	Mississippi	48	626,771	1,819

Source: Environmental Working Group analysis of state and federal tap water testing data.
**NR = "Not Ranked" because we have only obtained data which accounts for less than 50% of the population drinking from public water supplies.*

A handful of states contain the majority of water systems with the highest levels of CBPs:

- Texas, Pennsylvania, Maryland, New Jersey, and Massachusetts account for well over half (87,000) of the at-risk pregnancies in the 42 states analyzed (Table 2 and Table 7 page 31).

- In six states and Washington, DC more than one out of every 10 pregnancies are at increased risk for birth defects and miscarriage due to high levels of chlorination byproducts in tap water (Table 3).

Tracking environmental exposures and disease

The failure to systematically track the incidence of disease and reproductive outcomes has undermined the ability of health officials to protect the public from environmental threats like chlorination bypoducts and other contaminants in tap water. Our survey of state agencies concludes:

In spite of recent efforts by some state and federal agencies, few comprehensive health tracking programs are up and running:

- Only nine states have active, statewide birth defects surveillance systems in place. Ten states and Washington, DC either have no birth defects surveillance system at all (five states plus DC), or track birth defects only through birth and death certificates, which misses 90 percent of the cases (five states).

- Not a single state has an active, well-funded system in place to track spontaneous abortion (miscarriages that occur prior to week 20 of a

Table 3: In six states and Washington, DC more than 1 in 10 pregnancies face an elevated risk for miscarriage or birth defects from high levels of chlorination byproducts in tap water.

States listed below are ordered on the chance that an individual pregnancy in that state will be exposed to high THM levels. Percent chance calculation excludes population served by non-public water supplies.

Rank	State	Number of Water Suppliers	Population Served	Chance that a Pregnancy Will be at Risk	Estimated Number of Pregnancies at Risk per Year
1	District of Columbia	1	595,000	45.7%	3,809
2	Maryland	34	4,270,287	23.7%	14,177
3	South Carolina	74	2,313,351	16.9%	5,474
4	Nebraska	79	1,025,716	15.9%	2,277
5	Pennsylvania	266	8,820,682	14.9%	18,419
6	New Jersey	526	7,256,528	10.3%	10,456
7	Texas	2,284	18,685,894	10.1%	26,525
8	Massachuesetts	227	6,577,429	9.9%	9,077
9	South Dakota	8	281,782	9.6%	377
10	Arkansas	53	1,125,526	7.0%	1,100

Source: Environmental Working Group analysis of state and federal tap water testing data.
**NR = "Not Ranked" because we have only obtained data which accounts for less than 50% of the population drinking from public water supplies.*

pregnancy). California has a program to track all miscarriages among women whose healthcare provider is Kaiser Permanente, and Rhode Island and Virginia attempt to track a portion of the miscarriages in their states. Through our contact efforts with individual state health departments, we identified no other states that make a systematic effort to track miscarriages.

The lack of data on exposure to environmental contaminants is an equally severe constraint on protection of the public health:

- Most studies of the health effects of CBPs have been limited by the fact that water suppliers are required to test for CBPs only four times a year, and of the more than 100 CBPs in public water supplies, only four chemicals called THMs are tested. For researchers studying first-trimester miscarriages, this means that just a single value for THMs is available to serve as a measure of a woman's exposure to the entire set of CBPs in her tap water through this critical period of pregnancy. In any study, limited exposure data will always tend to mask the full magnitude of health effects.

Recommendations

In an effort to meet new standards requiring lower levels (80 ppb) of chlorination byproducts in tap water, many utilities are switching to a new chlorine compound, chloramine, to control pathogens in tap water. Chloramine is formed from chlorine and ammonia gases.

Chloramine appears to reduce the peak levels of chlorination byproducts, particularly THMs, but at the same time it adds a whole new complex of contaminants to the tap water supply that are very poorly studied. Chloramines are known to be toxic to kidney dialysis patients, who cannot drink chloraminated water, and it is extremely toxic to fish, which die if chloraminated water is used in their tanks. The human health impacts of long term consumption of chloramine byproducts are basically unknown, even as chloramine is being added to the tap water of millions of people nationwide.

The public and policy makers have been led to believe that they must accept either water polluted with pathogens or water contaminated with high levels of chlorination and chloramination byproducts. This is simply not true. Tap water in the United States can meet pathogen standards and be low in CBPs as well.

To achieve this goal and protect the public from potential hazards of chlorination byproducts, we recommend:

The creation of a nationwide health tracking network to track Americans' exposure to chlorination byproducts and also the occurrence of birth defects, miscarriages, and other potential health effects of drinking tap water contaminated with THMs and other chlorination byproducts:

- A growing coalition of public health and environmental groups has requested that Congress appropriate money to the Centers for Disease Control and Prevention (CDC) to create a nationwide health tracking network (Trust for America's Health, 2001). A fully-functioning network is estimated to cost $275 million; at the time of printing, Congress appeared poised to appropriate $20 million as an initial down payment to start planning and creating the network. Lawmakers in the U.S. Senate and House of Representatives expect to introduce legislation in 2002, and to request significantly increased appropriations for the health tracking network. Through these processes, members of Congress will have an opportunity to support a proposal that would begin to close gaps in scientists' and policymakers' knowledge of environmentally-linked diseases, and provide health officials and health care providers with tools to act proactively to prevent CHRONIC disease.

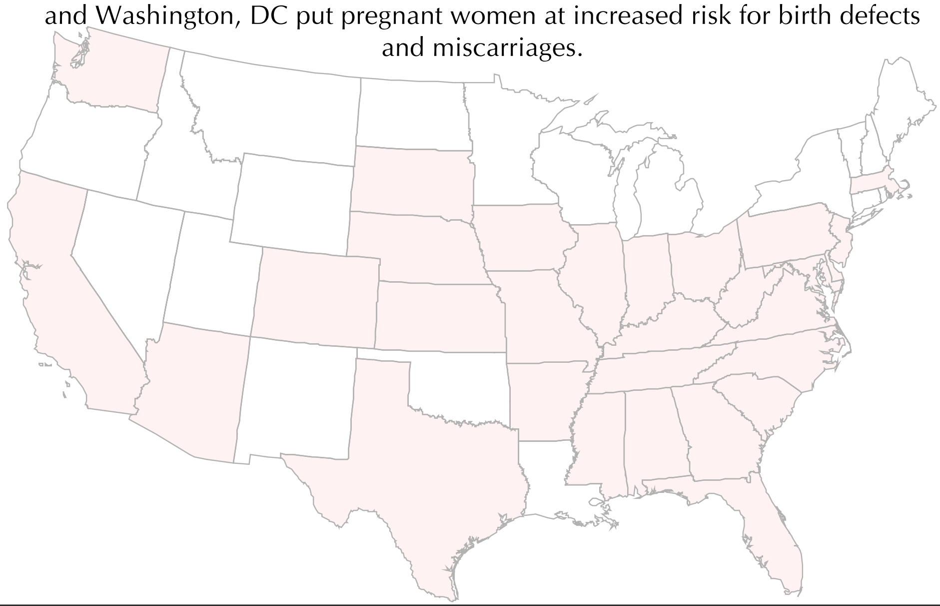
Adequate funding to water utilities for treatment system upgrades and programs to train plant operators in better disinfection (chlorination) techniques, particularly for small drinking water systems:

- Operator education has the potential to reduce the highest CBP levels in smaller drinking water systems and should be aggressively pursued. By itself it will not bring all of these small systems into compliance with the law, and it will not guarantee safe water for the most contaminated systems, but it has the potential to reduce the very highest levels of CBPs.

A major national effort to clean up source water for all surface-supplied drinking water systems in the country:

- Cleaner source water is the critical step to reliably reducing CBP levels while at the same time guaranteeing water as free of pathogens as possible. By failing to clean up drinking water source water, the Congress, EPA, and polluters are forcing water with high levels of CBPs on millions of people. For the majority of the systems with elevated CBP levels (small rural systems), cleaner source water will require definitive action to reduce soil erosion, and nutrient and animal waste runoff from farms and feed lots. For large water suppliers runoff from suburban sprawl and upstream sewage discharges must also be controlled.

Considering all the THM studies available, water from towns in 29 states and Washington, DC put pregnant women at increased risk for birth defects and miscarriages.



Although studies show risks at much lower levels, this study (Consider the Source) focuses on only the very highest exposures (80 ppb THMs and higher)

Chart 1: High levels of chlorination byproducts in tap water may place more than 700,000 pregnancies at increased risk for birth defects and miscarriages.

[1]Bove, F. J., M. C. Fulcomer, J. B. Klotz, J. Esmart, E. M. Dufficy, and J. E. Savrin, 1995: Public drinking water contamination and birth outcomes. *Am J Epidemiol*, **141,** 850-62.

[2]Dodds, L., W. King, C. Woolcott, and J. Pole, 1999: Trihalomethanes in public water supplies and adverse birth outcomes. *Epidemiology*, **10,** 233-7.

[3]Waller, K., S. H. Swan, G. DeLorenze, and B. Hopkins, 1998: Trihalomethanes in drinking water and spontaneous abortion. *Epidemiology*, **9,** 134-40.

[4]Gallagher, M. D., J. R. Nuckols, L. Stallones, and D. A. Savitz, 1998: Exposure to trihalomethanes and adverse pregnancy outcomes. *Epidemiology*, **9,** 484-489.

[5]Klotz, J. B. and L. A. Pyrch, 1999: Neural tube defects and drinking water disinfection by-products. *Epidemiology*, **10,** 383-90.

[6]Kanitz, S., Y. Franco, V. Patrone, M. Caltabellotta, E. Raffo, C. Riggi, D. Timitilli, and G. Ravera, 1996: Association between drinking water disinfection and somatic parameters at birth. *Environ Health Perspect*, **104,** 516-20.

Source: Environmental Working Group analysis of U.S. EPA and state agency tap water contaminant testing results databases.

100 ppb
or greater

45,000 pregnancies yearly are exposed at this level. Studies link these exposures to increased risk for:

- oral cleft defects [1]
- stunted growth of the fetus [1]
- stillbirth [2]
- birth defects identified at birth [1]
- central nervous sytem defects [1]
- neural tube defects [1,5]
- major cardiac birth defects [1]
- first trimester miscarriage [3]
- term low birth weight [4]
- small body length [6]
- small head circumference [6]

The following cities expose more than 500 pregnant women each year to THMs exceeding 100 ppb for an entire trimester:

Charleston, SC
Charleston, WV
Jackson, MS
Newark, NJ
Washington, DC
Maryland Suburbs of Washington, DC (WSSC)
Omaha, NE
Passaic County, NJ
Pittsburgh & suburbs, PA
San Francisco, CA

80 ppb
or greater

137,000 pregnancies yearly are exposed at this level. Studies link these exposures to increased risk for:

- central nervous sytem defects [1]
- neural tube defects [1,5]
- birth defects identified at birth [1]
- major cardiac birth defects [1]
- first trimester miscarriage [3]
- term low birth weight [4]
- small body length [6]
- small head circumference [6]

In addition to those cities listed previously, the following cities expose more than 500 pregnant women each year to THMs exceeding 80 ppb for an entire trimester:

Akron, OH
Amarillo, TX
Aurora, IL
Boston, MA
Davenport, IA
Durham, NC
East St. Louis, IL
Evansville, IN
Fayetteville, NC
Garland, TX
Kankakee, IL
Kansas City, KS
Kenmore, WA
Knoxville, TN
Lancaster, PA
Laredo, TX
Monmouth County, NJ
Mesquite, TX
New Bedford, MA
New Milford, NJ
Norristown, PA
Penn Hills, PA
Philadelphia, PA
Plano, TX
Richardson, TX
Texarkana, TX
Trenton, NJ

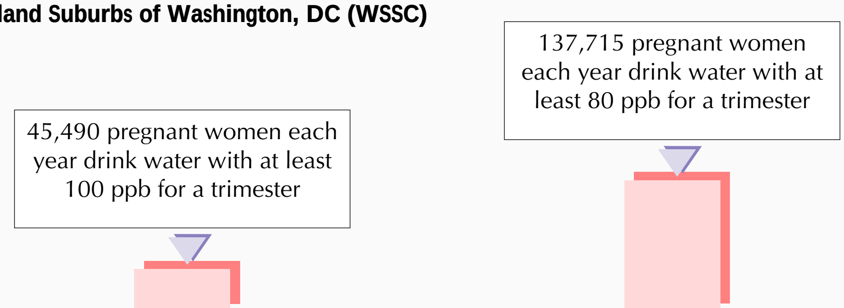


Chart 1 (continued): High levels of chlorination byproducts in tap water may place more than 700,000 pregnancies at increased risk for birth defects and miscarriages.

While this study and EPA have focused on health effects at 80 ppb THMs and greater, epidemiological studies have found increased incidence of birth defects in women drinking water containing only 40 ppb THMs. Hundreds of thousands of pregnant women each year drink tap water with THM levels shown to pose increased risks for birth defects.

75 ppb or greater

187,000 pregnancies yearly are exposed at this level. Studies link these exposures to increased risk for:

- first trimester miscarriage [3]
- term low birth weight [4]
- neural tube defects [5]
- small body length [6]
- small head circumference [6]

In addition to those cities listed previously, the following cities expose more than 500 pregnant women each year to THMs exceeding 75 ppb for an entire trimester:

Brockton, MA
Columbus, OH
Corpus Christi, TX
Glendale, AZ
Howard County, MD
Jersey City, NJ
Lowell, MA
Lower Bucks County, PA
New Kensington, PA
Portsmouth, VA
Seattle, WA
Springfield, IL
Waco, TX
Warren, OH

60 ppb or greater

350,000 pregnancies yearly are exposed at this level. Studies link these exposures to increased risk for:

- term low birth weight [4]
- neural tube defects [5]
- small body length [6]
- small head circumference [6]

In addition to those cities listed previously, the following cities expose more than 1,000 pregnant women each year to THMs exceeding 60 ppb for an entire trimester:

Baltimore, MD
Bellevue, WA
Bryn Mawr, PA
Columbia, SC
Dallas, TX
East Bay Area, CA
La Mesa, CA
Lexington, KY
Little Rock, AR
Norfolk, VA
San Bernadino, CA
Occoquan, VA
Pinellas County, FL
San Diego, CA
Salem - Beverly, MA
Sioux Falls, SD
St. Petersburg, FL
Tampa, FL
Toledo, OH
Topeka, KS

40 ppb or greater

712,000 pregnancies yearly are exposed at this level. Studies link these exposures to increased risk for:

- neural tube defects [5]
- small body length [6]
- small head circumference [6]

In addition to those cities listed previously, the following cities expose more than 2,000 pregnant women each year to THMs exceeding 40 ppb for an entire trimester:

Arlington, TX
Aurora, CO
Birmingham, AL
Cocoa, FL
Columbus, GA
Dekalb County, GA
Denver, CO
Ft Lauderdale, FL
Houston, TX
Indianapolis, IN
Long Beach, CA
Los Angeles, CA
National City-Bonita, CA
Louisville, KY
Mesa, AZ
Newport, DE
Phoenix, AZ
Raleigh, NC
Richmond, VA
Springfield, MA
St. Louis, MO
Tempe, AZ
Wanaque Boro, NJ
Winston - Salem, NC
Worcester, MA

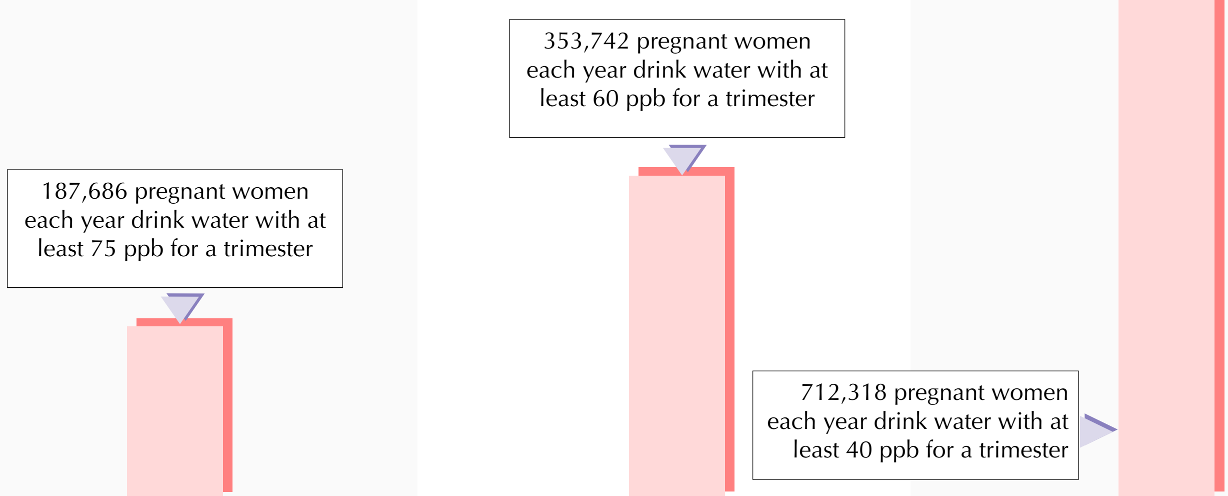
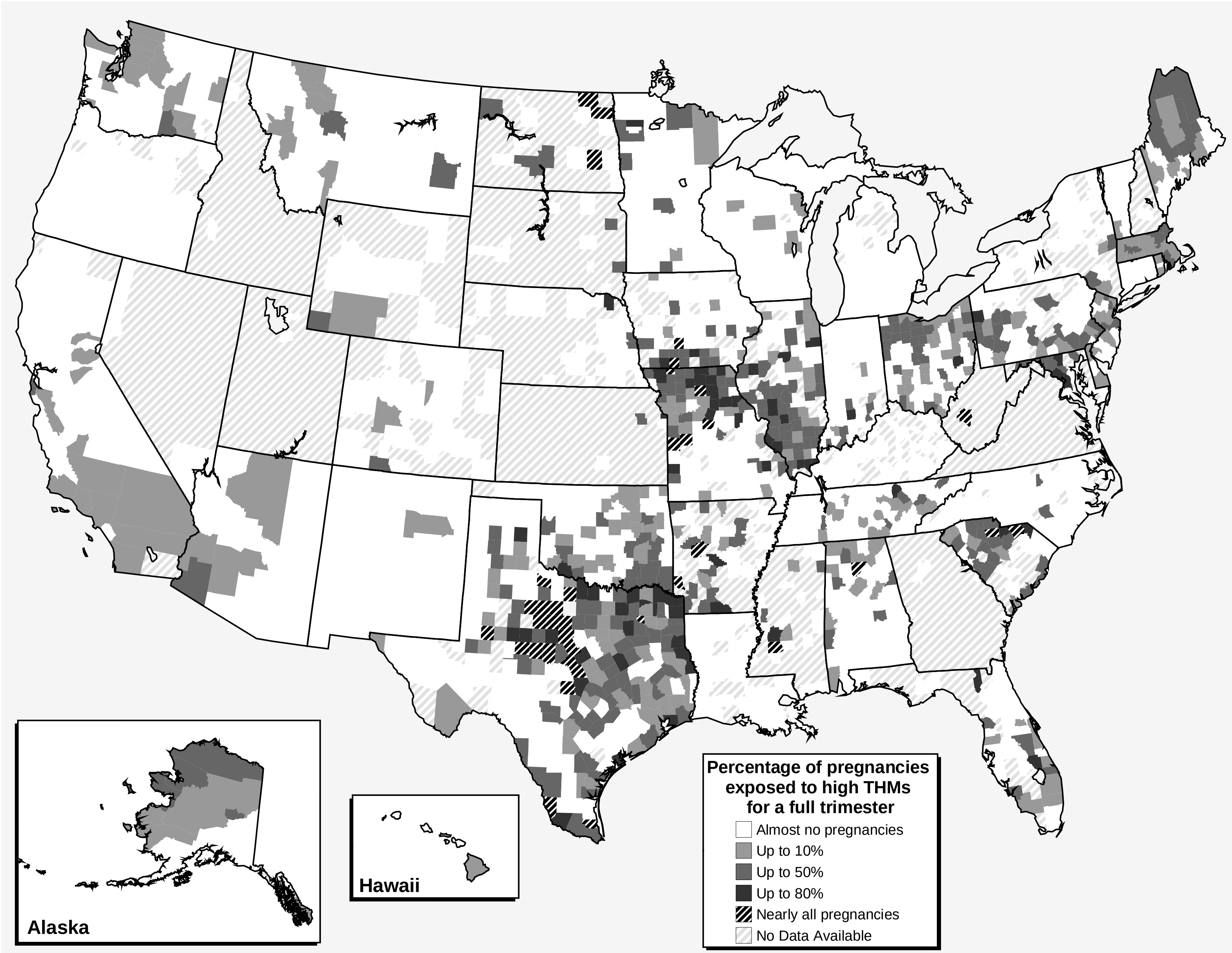


Figure 1. Counties with potentially increased miscarriage and birth defect risks from chlorination byproducts, based on measured THM levels in tap water from community water suppliers



Note: "High THMs" refers to a 3-month average THM level of at least 80 ppb.
Source: Environmental Working Group analysis of US EPA and state drinking water authority tap water test results.

Chapter 1

Agricultural and urban pollution - the source of chlorination byproducts

Chlorination byproducts form when chlorine, added to tap water supplies to kill or inactivate disease-causing microganisms, reacts with "natural organic matter" in the water. Scientists most frequently cite naturally-occurring humic acids and fulvic acids as precursors to chlorination byproducts – these acids are formed as microbes break down plant matter.

In the regulatory arena as well, EPA typically attributes chlorination byproducts (CBPs) to "natural organic matter, including humic acids and fulvic acids" reacting with chlorine, implying that high organics in rivers, lakes, and reservoirs is a natural state of affairs. But the underlying sources of this "natural organic matter" are not natural at all. In much of the country, the bulk of organics in drinking water supplies stems from uncontrolled soil erosion, fertilizer runoff, and sewage treatment plant discharges (Table 4).

- More than a billion tons of topsoil erode from U.S. cropland each year (USDA 1998), much of it deposited in streams and rivers. Soil contains organics that combine with chlorine to form chlorination byproducts. Soil in combination with manure eroding from pasture and range lands contains even higher amounts of CBP-forming organics.

- Nearly one-fifth of all phosphorus from commercial fertilizers eventually contaminates rivers, streams, lakes and reservoirs. Excess phosphorus causes uncontrolled algae blooms that create massive slugs of organic matter which then combine with chlorine to form chlorination byproducts. Most phosphorus is absorbed to soil particles in the field and is carried to streams and rivers through soil erosion. U.S. Geological Survey (USGS) studies show that three-quarters of all streams and rivers in the U.S. are polluted with phosphorus at levels that can support uncontrolled algae growth (USGS 1999, Cooke and Carlson 1989).

- In urban areas, sewage treatment plants flush large quantities of organics and phosphate into rivers that serve as drinking water supplies. Some of these organics can combine with chlorine to form chlorination byproducts. The phosphate stimulates algae growth that ultimately leads to chlorination byproducts. In national water quality surveys, USGS finds the highest phosphate levels in the country in urban areas impacted by sewage discharges (USGS 1999).

Table 4. Agricultural pollution results in harmful chlorination byproducts in tap water.

Cause	What happens	Scope of the Problem
Soil erosion / Siltation	Siltation of lakes and reservoirs forms new, expansive shallow areas that provide habitat for massive growths of weeds. As these plants die and degrade in the water, they leave behind humic materials known to combine with chlorine in the water treatment plant, forming toxic disinfection byproducts.	❖ More than one billion tons of soil erode from U.S. cropland every year. ❖ According to EPA, silt is the most common pollutant in rivers and streams. ❖ Thirteen percent of more than 800,000 river miles surveyed by EPA are degraded by siltation, and silt pollutes 38 percent of all degraded rivers and streams. ❖ Four of every 100 acres of lakes and reservoirs are overrun with noxious aquatic plants. (USDA 1997, EPA 1998)
Soil erosion / Fertilizer runoff / Algae blooms	Phosphorus in fertilizer runoff causes massive algae blooms that plague lakes and reservoirs around the country. Algae cells, decaying cells, and algae waste products can all combine with chlorine in the water treatment plant to form toxic disinfection byproducts. Phosphorus on cropland binds to soil grains, so soil erosion is a principal source of phosphorus contamination to lakes and reservoirs.	❖ Four million tons of phosphorus are applied to cropland each year in commercial fertilizer and manure. ❖ Nearly one-fifth of this eventually contaminates rivers, lakes, and reservoirs. ❖ National water quality surveys by USGS find that three-quarters of all streams and rivers are polluted with phosphorus at levels that would support massive algae growths. ❖ Four of every 100 acres of lakes and reservoirs are overrun with massive algae growth. (USGS 1999, EPA 1998)
Soil erosion / Humic chemicals	All soil is made of minerals in combination with organic matter. The organics include humic chemicals called humus which are formed as bacteria break down plant tissue - and which are widely cited as precursors to disinfection byproducts. Rain falls on cropland, soil erodes, and then the humic chemicals (including humic acid and fulvic acid) dissolve into streams, rivers, lakes, and reservoirs – and from there, to water treatment plants. Muddy rivers and lakes mean high levels of toxic disinfection byproducts	❖ More than one billion tons of soil erodes from U.S. cropland every year. ❖ The top inch of every acre of plowed ground contains between 2000 and 20,000 pounds of organic matter. ❖ Sixty to 80 percent of this is humus known to form toxic disinfection byproducts in chlorinated water supplies. ❖ Humic chemicals are extraordinarily persistent - the half-life of fulvic acid in the environment is estimated to be about 10 to 50 years, while the half-life of humic acid is measured in centuries. (USDA 1997, Brady and Weil 1999)

Source: Environmental Working Group.

Nationwide, more than a billion tons of topsoil are lost from cropland each year through erosion that follows rain.

The science surrounding CBP precursors continues to evolve, but the sights are familiar. Muddy rivers and algae-clogged lakes and reservoirs epitomize the water bodies that are the riskiest drinking water supplies, chock full of organics that, in the presence of chlorine, can form chlorination byproducts linked to cancer and birth defects.

Soil erosion leads to chlorination byproducts

Nationwide, more than a billion tons of topsoil are lost from cropland each year through erosion that follows rain (USDA 1998). Much of this muddy water flows directly into streams and rivers. It is widely accepted that uncontrolled erosion contributes to habitat loss that accompanies siltation of rivers, streams and lakes. Muddy water suffocates fish eggs and bottom-dwelling organisms, clogs fish gills, fills and destroys rocky habitats of insects and spawning salmon, and cuts down on light that passes through the water, impairing aquatic plant life.

Citing environmental concerns, many local governments have plans in place requiring developers and, less frequently, farmers to control sediment-loaded runoff from cleared lands and tilled fields. These plans are not enough. EPA's most recent summary of national water quality shows that environmental officials across 32 states characterize 98,700 miles of rivers and streams as being plagued by siltation problems (EPA 1999).

The full extent of ecological damage from siltation is a subject of debate. The human health impacts, however, have not even made it to the table, as evidenced by EPA's most recent chlorination byproduct rule, which relies solely on water plant treatment techniques to minimize CBP formation, and requires no controls on upstream pollution of source waters.

Much of the elevated levels of chlorination byproducts seen in public water supplies can be traced directly back to the organic matter contained in eroded agricultural soils, and weed growth fostered by siltation of natural waters.

How soil erosion creates chlorination byproducts

All soil is made of minerals in combination with organic matter. The organic matter includes bacteria; intact or decaying leaves, roots, and other plant tissue; and humus, which is a family of complex, highly-variable chemicals formed as bacteria break down plant tissue. Humus includes the humic acids and fulvic acids widely cited as precursors to chlorination byproducts.

The top inch of every acre of plowed ground contains between about 2000 and 20,000 pounds of organic matter (derived from Brady and Weil, 1999), 60 to 80 percent of which is humus. The link to chlorination byproducts is simple: rain falls, soil erodes, and then the soluble fraction of humus, the humic acids and fulvic acids, dissolve from the soil grains into streams, rivers, lakes, and reservoirs – and from there, to water treatment plants. And of course, storm runoff also carries with it fresh or partially-decayed plant matter, which continues its transformation to humic compounds in a water body. Runoff from manure-laden pasture land and rangeland would be expected to be even more highly enriched with organics from both the manure and the native soil.

Humic and fulvic acids are highly resistant to bacterial degradation. The half-life of fulvic acid in the environment is estimated to be about 10 to 50 years, while the half-life of humic acid is measured in centuries (Brady and Weil, 1999). In a water treatment plant, some might be removed by filtration or precipitation processes. The remaining fraction would be available to combine with residual chlorine and other ions to form chlorination byproducts. Among the many CBPs created by humic acids is a chemical known as "MX," or Mutagen X, one of the most powerful mutagens ever tested. MX directly damages cellular DNA material, causes multiple internal cancers in rats, occurs in public drinking water supplies, and has never been studied for its links to cancer in humans.

Much of the research on agricultural runoff as a source of chlorination byproducts has focused on areas with the most highly organic soils, characterized as peat. Scientists from the University of Arizona, for instance, show that the high dissolved organic content in agricultural drains from peat soils

Fertilizer, particularly the phosphorus fraction, is a root cause of massive algae blooms that hit many lakes and reservoirs hard every summer.

in the Sacramento River Delta, flowing into the California Aqueduct, creates a high potential for THM formation.

The levels of organic matter in this water is sufficiently high that the Metropolitan Water District of Southern California, which chlorinates the Aqueduct water and serves it to millions of Southern Californians, was forced to switch disinfectants, from free chlorine to an alternate chemical called chloramine, to meet health standards for THMs (Amy et al 1990). Soil over much of the rest of the country is characterized by lower levels of organic carbon, but the sheer volume of erosion can easily make up for the lower carbon fraction.

How weeds lead to chlorination byproducts

As unlikely as it sounds, weeds are also considered a major contributor to chlorination byproducts in disinfected tap water supplies (Cooke and Carlson 1989). The siltation of rivers, lakes, and reservoirs leads not only to the suffocation of native aquatic plants, but also to the formation of new, expansive shallow areas that tend to foster the growth of weeds. These plants die and degrade in the water, leaving behind the humic materials known to combine with chlorine in the water treatment plant. Once again, chlorination byproducts, this time stemming from weeds, can be traced back to soil erosion.

According to EPA, silt is the most common pollutant in rivers and streams. Thirteen percent of the more than 800,000 miles of rivers and streams assessed by EPA are polluted by silt, and silt contributes to 38% of all water quality problems in rivers and streams. Much of this silt is eventually deposited in lakes and reservoirs, to the point that four of every 100 acres of these water bodies are overrun with noxious aquatic plants. (EPA 1998).

Soil erosion in combination with fertilizer runoff leads to chlorination byproducts

Given that 50% of the land in the continental U.S. is used for agriculture (USGS 1999), much of the elevated levels of chlorination byproducts seen in public water supplies can be traced directly back to the organic matter contained in eroded agricultural soils and weed growth fostered by siltation of natural waters. But another basic source of CBPs involves an alliance that has never been a focus of regulations for chlorination byproducts – soil in combination with fertilizer.

Fertilizer, particularly the phosphorus fraction, is a root cause of massive algae blooms that hit many lakes and reservoirs hard every summer. Algae cells, decaying algae, and excreted waste products from algae have all been shown to combine with chlorine to form byproducts linked to cancer and birth defects (Plummer and Edzwald 2000).

Scientists have known of the link between algae and chlorination byproducts since at least the early 1980s. Various studies have appeared fairly regularly ever since, in publications like the *Journal of the American Water Works Association* and *Environmental Science and Technology*, focusing on the byproducts scientists identify when chlorine combines with specific species of algae and algal waste products (Hoehn et al 1980, Palmstrom et al 1988, Oliver and Shindler 1980, Wachter and Andelman 1984, Oliver 1983, Karimi and Singer 1991, Plummer and Edzwald 2000). Scientists have found that both trihalomethanes and haloacetic acids form when water supplies contaminated with algae or algal wastes are chlorinated.

Algae cells, decaying algae, and excreted waste products from algae have all been shown to combine with chlorine to form byproducts linked to cancer and birth defects.

Algae occurs naturally in water and is present in every healthy stream, river, and lake in the country. But because of excessive algae growth triggered by fertilizer runoff, EPA and water suppliers also consider it one of the most noxious, pervasive pollutants in our country's lakes and reservoirs. In 1999 the U.S. Geological Survey reported the results of a nationwide survey showing that three-quarters of all streams tested in both urban and agricultural areas had dangerously elevated levels of phosphorus, in excess of the 0.1 parts per million standard set by EPA to prevent massive algae blooms (USGS 1999).

EPA tracks phosphorus and algae blooms because of their unarguably devastating effects on aquatic environments and organisms. In healthy water bodies, massive algae growths are rare – phosphorus, typically the limiting nutrient, is nearly always present at low levels that keep excess plant growth rates in check. When phosphorus levels are sustained above about 0.1 ppm, however, conditions become favorable for uncontrolled plant growth. A description of the effects of algal blooms by leading soil scientists gives insight into why EPA and water suppliers concern themselves with controlling algal blooms and the inevitable condition termed "eutrophication" that follows:

> *When phosphorus is added to a phosphorus-limited lake, it stimulates a burst of algal growth (referred to as an algal bloom) and, often, a shift in the dominant algal species. The phosphorus-stimulated algae may cover the surface of the water with mats of algal scum. The lake may also be choked with higher plants that are also stimulated by the added phosphorus. When these aquatic weeds and algal mats die, they sink to the bottom, where their decomposition by microorganisms uses up much of the oxygen dissolved in the water. The decrease in oxygen (anoxic conditions) severely limits the growth of many aquatic organisms, especially fish. Such eutrophic lakes often become turbid... In extreme cases eutrophication can lead to massive fish kills…*
>
> *Eutrophication can transform clear, oxygen-rich, good-tasting water into cloudy, oxygen-poor, foul-smelling, bad-tasting, and possibly toxic water. Eutrophic conditions favor the growth of Cyanobacter, blue-green algae… [that] produces toxins and bad-tasting and –smelling compounds that make the water unsuitable for human or animal consumption. Some filamentous algae can clog water treat-*

To limit the formation of disinfection byproducts, the most important, albeit costly, step is "to significantly reduce external loading of nutrients, silt, and organic matter to the reservoir," a concept that is now called source water protection.

ment intake filters and thereby increase the cost of water remediation… In extreme cases of eutrophication, massive fish kills can occur in sensitive lakes and rivers. The kills result from anoxic conditions, which are brought on by the decay of the masses of algae stimulated by elevated inputs of phosphorus… (Brady and Weil 1999)

And of course the algae growth stimulated by excess phosphorus also serves as a precursor for chlorination byproducts. About two million tons of phosphorus are applied each year as commercial fertilizer, and two million more as manure. The distribution varies across the nation, with the highest application rates occurring over a broad area of the Upper Midwest. Other areas of high phosphorus application are along the East Coast, throughout the Southeast, and in agricultural lands in the West (USGS 1999).

USGS estimates that nearly one-fifth of all phosphorus applied to land eventually contaminates streams, rivers, and lakes. Unlike the other major fertilizer nutrient, nitrate, which moves relatively freely in water, phosphorus tends to be tightly bound to soil grains. Therefore, soil erosion is a major means by which phosphorus makes its way to water bodies (USGS 1999).

EPA published a national survey of lake quality in 1998 that illustrates the extent to which phosphorus and algal blooms impact major water bodies. Of the 7,373 significant, publicly-owned lakes surveyed, fully half of them are considered eutrophic, full of excess organics that lead to the formation of CBPs in water treatment plants (EPA 1999). Phosphorus pollution is so severe that bodies of water as large as Lake Erie have been fundamentally altered over time, and even very deep oxygen-rich lakes, such as Lake Tahoe, have become noticeably more eutrophic over the past four decades.

Just after promulgation of the first standards for THMs in tap water, the American Water Works Association published a guidance manual for controlling THM precursors in public water supply reservoirs. Among the methods proposed to limit the formation of chlorination byproducts, the authors submit that the most important, albeit costly, step is "to significantly reduce external loading of nutrients, silt, and organic matter to the reservoir," a concept that is now called source water protection (Cooke and Carlson 1989).

Sewage as another major source of chlorination byproducts

USGS studies show that in urban areas, sewage treatment plants are a major source of chlorination byproducts, both because of the organic content of treated sewage, as well as its high phosphorus loads that instigate the same uncontrolled algal blooms as does fertilizer runoff.

Early results from an ongoing national water quality survey by USGS show that on a national level, storm runoff contributes about 75 percent of total phosphorus to streams and rivers. Wastewater treatment plants account for the remaining 25 percent. USGS finds the highest average annual concentrations of phosphorus anywhere in the country in rivers near major metropolitan areas in the semiarid western and southwestern parts of the country, where, because of low annual rainfall, discharges from sewage treatment plants can be a significant fraction of the total flow.

When sewage-altered waters are drawn into a water treatment plant intake pipe, this single pollution source – sewage treatment plant effluent – both necessitates chlorination and provides the building blocks for chlorination byproducts.

USGS found, for instance, that rivers flowing from Santa Fe, Las Vegas, and Denver were plagued with high phosphorus levels. In the South Platte River flowing out of Denver, up to 100 percent of the flow stems from sewage treatment plant effluent, contributing 1200 tons of phosphorus annually. The densely populated East also was characterized by high phosphorus levels in urban streams and rivers (USGS 1999).

Of the more than 15,000 sewage treatment plants in the U.S., by 1996 fewer than half had treatment systems in place to effectively reduce phosphorus pollution. Using what is called "secondary treatment," most plants remove only about 10 to 20 percent of the total phosphorus in the raw sewage entering the plant. The treated water that is discharged to streams, rivers, and lakes, has phosphorus concentrations typically in the range of 3 to 5 ppm, or 30 to 50 times the level set by EPA to protect waters from uncontrolled algal growth. A 1997 survey of EPA permit databases showed that only 15.3 percent of sewage treatment plants nationwide test their discharge for phosphorus, and even fewer, a mere 7.3 percent, are subject to enforceable limits on the amount of phosphorus they could dicharge to the environment (Litke 1999).

Nationally, EPA estimates that five of every 100 acres of lakes, reservoirs, and ponds surveyed are polluted by discharges from sewage treatment plants (EPA 1999). Ironically, when sewage-altered waters are drawn into a water treatment plant intake pipe, this single pollution source – sewage treatment plant effluent – both necessitates chlorination and provides the building blocks for chlorination byproducts.

Detergent manufacturers as a source of chlorination byproducts

From the 1940s to the 1970s, phosphorus-containing detergents were a major cause of algae-related chlorination byproducts in this country. Beginning in the 1970s, some states enacted phosphorus detergent bans in an attempt to reverse an alarming trend of massive algae blooms and numerous fish kills caused by excess phosphorus. Laundry detergent manufacturers voluntarily switched to phosphorus-free formulations to avoid national regulation.

At the time, chlorination byproducts had not even been discovered, but environmental damage linked to phosphorus (eutrophication) was apparent. Scientists had discovered that discharge from sewage treatment plants was the primary source of detergent phosphorus to rivers and lakes, and water suppliers knew that conventional sewage treatment processes did not efficiently reduce phosphorus levels in sewage.

Runoff from some of the nation's 450,000 confined animal feeding operations contributes excess nutrients, organic matter, and pathogens to drinking water supplies across the country.

Approximately half of the phosphorus in sewage is from body and food wastes, and the other half continues to stem from detergents. Despite the flurry of state and industry actions in the 1970s, phosphate-based formulations continue to be an industry standard for dishwashing detergents. Sewage treatment plants can reduce phosphate levels by precipitating phosphates out of the water using iron or aluminum salts, but levels of phosphorus in the final effluent can still be ten times the level that protects against algal growths (Peavy et al 1985).

Cascade, manufactured by Proctor & Gamble, is just one of many phosphorus-based detergents currently sold in stores. It contains 7.4% phosphate (a particular form of phosphorus) by weight. Through their continued manufacture and sale of phosphorus dishwashing detergents, these manufacturers are contributing to an unknown number of cancers, miscarriages, and birth defects each year as their products stimulate the formation of harmful chlorination byproducts in public water supplies.

Confined Animal Feeding Operations as sources of chlorination byproducts

Runoff from some of the nation's 450,000 confined animal feeding operations contributes excess nutrients, organic matter, and pathogens to drinking water supplies across the country. Pollution from these hog, cattle, dairy and poultry farms where animals are kept and raised under confined conditions, is almost completely unregulated. Pathogens from this waste increase the use of chlorine in public water supplies, while organics and nutrients in the waste serve as precursors to chlorination byproducts.

EPA's draft strategy for controlling pollution from confined animal farms relies on voluntary actions to control runoff for up to 430,000 farms, and proposes enforceable pollution limits for only up to an estimated 20,000 farms (four percent of the national total). As of March 1999, EPA had placed pollution limits on only 2000 confined animal farms, or 0.4 percent of the national total, through discharge permits issued under the Clean Water Act (EPA 1999).

Other sources of chlorination byproducts

Locally or regionally, other important sources of precursors to chlorination byproducts include mines, and waters naturally rich in organics. Phosphorus mines in Florida contribute phosphorus-laden runoff to some Florida waters that triggers uncontrolled algal blooms known to lead to the formation of chlorination byproducts (USGS 1999). In some U.S. waters a substantial fraction of organic matter in water can be natural, such as in the Everglades and in waters bounded by deciduous forests.

Chapter 2

Health effects of chlorinated tap water: the accumulating evidence on cancer, birth defects, and miscarriage

At least 25 major epidemiological studies collectively provide strong evidence of elevated rates of multiple internal human cancers from chlorinated tap water.

Water chlorination in the U.S. began in 1908, when Jersey City Water Works became the first public supplier to disinfect their water (Faust & Aly 1998). The *New York Times* heralded the new advancement as a cure-all for water pollution: "any municipal water supply can be made as pure as mountain spring water. Chlorination destroys all animal and microbial life, leaving no trace of itself afterwards." (*New York Times*, 7 December 1908, quoted in Morris 1995).

The practice of chlorination rapidly proliferated, and soon nearly every public water supplier drawing water from rivers or reservoirs was adding chlorine to disinfect the water. Rates of waterborne disease plummeted in the ensuing decades; between 1900 and 1950, for instance, the incidence of typhoid fever fell from about 36 of every 100,000 people to very nearly zero (American Water Works Association, 2001). Water chlorination seemed the perfect solution to waterborne disease.

Chlorination byproducts linked to cancer

But then in 1974 scientists identified the presence of chlorination byproducts in public water supplies (Rook 1974), a discovery that would lead to one of the greatest risk-benefit balancing acts in U.S. environmental regulations. Within a few years of the discovery of trihalomethanes (THMs) in drinking water, evidence of their harmful effects began to mount. In 1976 the U.S. National Cancer Institute published the first findings linking chlorination byproducts to cancer, with its seminal study showing cancer in lab animals exposed to chloroform. Later studies would reveal the same finding for other chlorination byproducts, including certain haloacetic acids (dichloroacetic acid) and trihalomethanes (bromodichloromethane, chlorodibromomethane, and bromoform) (Boorman et al. 1999).

The compelling evidence linking chlorination byproducts to cancer has since been extended to include multiple studies showing elevated cancer rates among people drinking chlorinated water supplies. At least 25 major epidemiological studies have been conducted that collectively provide strong evidence of elevated rates of multiple internal human cancers from chlorinated tap water.

In 1992 Dr. Robert Morris, then of the Medical College of Wisconsin, composited and analyzed the results of all available human cancer studies related to chlorination byproducts, using a standard technique called metaanalysis. With this method, Dr. Morris was able to combine the power of between four and eight studies previously published for each cancer. His best statistical estimates show an elevated risk varying from 1% to a maximum of 38% for twelve internal cancers: bladder, brain, breast, colon, colorectal, esophagus, kidney, liver, lung, pancreas, rectum, and stomach. He found the strongest associations for bladder and rectal cancer, both of which were statistically significant (Morris et al. 1992).

Dr. Morris' conclusions show the broad impact on public health that so often characterizes population-wide exposures to common drinking water contaminants: "…given the large number of people who consume chlorinated surface water, the number of cases of cancer potentially attributable to this exposure is substantial. The numbers derived from the metaanalysis suggest that 5,000 … cases of bladder cancer per year and 8,000 … cases of rectal cancer per year [in the U.S.] may be associated with the consumption of chlorinated drinking water." (Morris 1995) A later EPA analysis yielded an even higher estimate for bladder cancers caused by tap water – up to 9,300 cases annually (63 FR 69390-69476).

Early studies of tap water cancers have been criticized for their use of relatively crude exposure estimates (Mills et al 1998). New studies increasingly rely on more sophisticated techniques, such as the use of frequent test results from public water suppliers, and records of tap water consumption, showering and bathing from study participants. But even given any shortcomings in early studies, all studies together as a whole provide a compelling picture, and most studies have found associations with colon, rectal, and bladder cancer, especially the more recent studies that use improved exposure estimates.

Dr. Kenneth P. Cantor, the head of the National Cancer Institute, summarizes available human studies for colon, rectal, and bladder cancer in a 1998 review article (Mills et al 1998). Bladder cancer shows the strongest link to chlorination byproducts – 12 of the 13 studies conducted show increased risk of bladder cancer among people exposed to CBPs. The three studies that have specifically focused on THM levels and bladder cancer have found increased risks for bladder cancer ranging from 50 to 80 percent among people drinking water with THM levels of at least 50 ppb.

Despite the substantial body of evidence linking human cancers to chlorination byproducts, the questions that remain are daunting. In a joint publication by the National Institute of Environmental Health Sciences and other federal agencies, scientists lay out basic research needs for nearly every major class of chlorination byproducts: "many families of chlorinated byproducts lack complete toxicology or carcinogenicity data." (Boorman et al 1999).

One "miscellaneous" chlorination byproduct of recent concern is a chemical dubbed MX, identified by the International Agency for Research on Cancer as the most potent mutagen of all chlorination byproducts (IARC 1991, cited in Boorman et al 1999). MX (more formally known as 3-chloro-

4-(dichloromethyl)-5-hydroxy-2(5H)-furanone) directly damages cellular DNA material, causes multiple internal cancers in rats, occurs in public drinking water supplies, and has never been studied for its links to cancer in humans.

One "miscellaneous" chlorination byproduct of recent concern is a chemical dubbed MX, identified by the International Agency for Research on Cancer as the most potent mutagen of all chlorination byproducts.

Accumulating Evidence that Chlorination Byproducts are Linked to Birth Defects and Miscarriage

Evidence of the carcinogenic effects of chlorination byproducts has been accumulating for decades, but studies focused on the potential for these chemicals to affect rates of miscarriage and birth defects are only now being amassed.

The most striking result from lab animal studies is the diverse, compound-specific range of effects that are seen in studies of reproduction and development. For instance, several byproducts called chloroacetonitriles have been shown to increase malformations of the cardiovascular, digestive, soft tissue, urinary and reproductive systems. Various halogenated acetic acid byproducts, on the other hand, damage testicles in rats, disrupt the formation and mobility of sperm, and cause defects of the neural tube, the head, and the face in laboratory animals (Nieuwenhuijsen et al. 1999). Most chlorination byproducts, however, are unstudied for reproductive and developmental effects.

Epidemiologists face a challenge – how does one pinpoint health effects from a broad class of contaminants, literally more than 100 individual chlorination byproducts, given the difficulties of discerning exposure levels, the need to focus on critical periods in pregnancy, the relative lack of state or national tracking of adverse reproductive outcomes, and the huge range of adverse reproductive outcomes seen in lab animal studies to be associated with individual chlorination byproducts.

Even given these difficulties, a number of well-designed epidemiology studies have emerged, beginning with a study of Iowa women published in 1992. The strongest, statistically significant findings from these studies show increased risks for birth defects, low birth weight, and miscarriages. The epidemiology studies combined with tests of laboratory animals provide a compelling picture of the broad impact to public health from exposures to these complex families of chemicals (Nieuwenhuijsen et al. 1999):

1992. A study of 4,028 pregnancies among Iowa women shows low newborn weight (intrauterine growth retardation) for babies whose mothers drank tap water containing at least 10 ppb of THMs through pregnancy (Kramer et al. 1992) EPA's new drinking water standard is eight times this level.

1993. Among the babies of 2,348 Massachusetts women, researchers found increased rates of stillbirth, neonatal deaths, major congenital malformations, and respiratory and urinary tract defects associated with mothers drinking from disinfected public water supplies (Aschengrau et al. 1993).

MX directly damages cellular DNA material, causes multiple internal cancers in rats, occurs in public drinking water supplies, and has never been studied for its links to cancer in humans.

1995. Over 81,602 babies born in 75 New Jersey towns between 1985 and 1998 showed increased risk of low weight, central nervous system defects, neural tube defects, major cardiac defects, and oral cleft defects when their mothers drank tap water with high levels of THMs (greater than 100 ppb based on quarterly measurements) (Bove et al. 1995).

1995. In a study of 1003 pregnant women in North Carolina, elevated rates of miscarriage and low birth weight were seen among women drinking high levels of THMs, based on quarterly monitoring from their water suppliers (Savitz et al. 1995).

1996. Researchers following the outcomes of 676 pregnancies in Liguria, Italy found increased rates of neonatal jaundice, low birth weight, small body length, and small heads associated with a mother's ingestion of disinfected tap water (Kanitz et al. 1996).

1998. In a population of 5,144 pregnant women from California, researchers found increased risk of spontaneous abortion associated with high THM exposures, with the highest risks associated with bromodichloromethane in particular (Waller et al. 1998).

1998. Among 1,244 live births in Colorado between 1989 and 1991, researchers found increased risk of low birth weight associated with a mother's ingestion of high THMs in tap water during the last trimester of pregnancy (Gallagher et al. 1998).

1999. A study of 49,842 Nova Scotia births found a drop in gestational size, and an increased risk of stillbirth, chromosomal abnormalities, and neural tube defects associated with a mother's drinking tap water with high levels of THMs (Dodds et al. 1999).

1999. Researchers in New Jersey found that among 360 pregnant women studied, babies were twice as likely to have neural tube defects for tap water with greater than 40 ppb THMs than for mothers drinking water with less than 5 ppb THMs (Klotz and Pyrch, 1999).

1999. Among 141,077 births in Norway, a mother's reliance on a chlorinated tap water supply was linked to increased rates of all birth defects, urinary tract defects, neural tube defects, major cardiac defects, and respiratory tract defects (Magnus et al. 1999).

The bulk of the evidence linking specific chlorination byproducts to these adverse reproductive effects is considered preliminary, but compelling. In particular, the 1998 Waller et al. study, which found a nearly doubling in risk of miscarriage among women drinking water with levels of THMs below the proposed standard, has set off a new series of follow-up studies funded by EPA and others that may continue to add to the accumulating body of evidence linking chlorination byproducts to birth defects and pregnancy loss.

Chapter 3

An analysis of chlorination byproduct levels in tap water across the country

This study represents the first ever analysis of chlorination byproducts (CBPs) in tap water from both big and small cities across the country. It also presents the first compilation of communities in the U.S. where people face an elevated risk for cancer, or where pregnant women are at an increased risk for miscarriages and certain birth defects, from high levels of CBPs in tap water.

The Study Data: 41 states and Washington, DC; 80 percent of the U.S. population

In May 2001, EWG requested data from each of the 50 state agencies that collects and monitors data on tap water for their state. Analysts followed up with phone calls and e-mails to all 50 states and over the next four months received usable data from 31 states and the District of Columbia. Data from water systems serving more than half the population of 10 additional states were obtained from the U.S. EPA. For the remaining nine states we obtained limited data from U.S. EPA representing less than half the population in each state.

The data analyzed in this study represent trihalomethane (THM) levels in 26,773 public water systems from 50 states and the District of Columbia for the years 1995 through 2001. These 26,773 systems represent 51 percent of all community water suppliers nationwide, and serve 80 percent of the U.S. population. Of these, 17,310 water suppliers provided data from more than a single sampling date; these water suppliers are the focus of the analysis in this study. Data from states with unusually high THM levels, like Texas, Missouri, and Pennsylvania were verified through phone conversations with state officials.

Key Findings - elevated risks in big cities and small towns alike

This first ever analysis of CBP data from across the country has produced several important new findings.

Nearly one-tenth of all water suppliers studied – 1,533 water suppliers in total – reported quarterly (three-month) average THM levels of 80 ppb or greater during the period analyzed. Substantial evidence indicates that pregnant women exposed to THM levels over 80 ppb face an increased risk of miscarriage or certain birth defects. These 1,533 water suppliers with

Table 5. Nationwide, pregnant women in small towns are 2.3 times as likely to be exposed to high levels of THMs as women in large cities.

	Small Community Water Suppliers	Large Community Water Suppliers
Total population served	7,492,359	117,781,468
Total pregnancies at increased risk each year	15,404	105,860
Percent of all pregnancies at increased risk	14.7%	6.4%

Note: This table reflects data for community water suppliers using surface water as the primary source for their tap water.

Source: Environmental Working Group. Data compiled from U.S. EPA and state environmental and health agencies.

Tap water in small communities supplied by rivers and reservoirs is 2.3 times as likely to have high levels of chlorination byproducts as tap water in large cities.

elevated quarterly THM levels serve an estimated 450,000 pregnant women each year, and of these an estimated 137,000 are served water high in THMs for at least a trimester of pregnancy.

People living in small communities are much more likely to drink water with high levels of THMs than people in larger communities. Tap water in small communities supplied by rivers and reservoirs is 2.3 times as likely to have high levels of chlorination byproducts as tap water in large cities (Table 5). Nationwide, water suppliers for 1,109 small communities have measured high THM levels in treated water, higher than levels shown to increase risks for birth defects and miscarriage.

The bulk of the population at risk from high THM levels is dominated by big city residents. In terms of the number of pregnancies facing elevated risks each year, the top 100 water suppliers (seven percent of 1,533 systems) account for more than two-thirds of the total at-risk pregnancies (Table 6). Among the big cities plagued by high THM levels are Philadelphia; Washington, DC; Newark, NJ; San Francisco; and Pittsburgh.

Just nine states account for 75 percent of the pregnancies nationwide that face an elevated risk of miscarriage and birth defects each year from high levels of CBPs in tap water: Texas, Pennsylvania, Maryland, New Jersey, Massachusetts, Illinois, Ohio, South Carolina, and Missouri (Table 7).

Nearly one in every two pregnancies in Washington, DC, and almost a quarter of all pregnant women in Maryland, will be exposed to high THM levels (greater than 80 ppb) for at least a trimester of pregnancy (Table 7).

Most studies of miscarriage and birth defects have been limited to characterizing exposures on a trimester basis simply because large water suppliers typically measure THMs every three months at most. But some researchers suspect that even shorter-term exposures to high spikes of chlorination byproducts may account for reproductive and developmental risk. Small towns are particularly prone to very high spikes in THM concentrations. Eighty-six percent of the top 50 single highest measurements of

THMs in community water systems have been associated with small water suppliers serving fewer than 10,000 people (Table 8).

On July 24, 2000, Ridgeway, Missouri measured 861 ppb of total trihalomethanes in chlorinated tap water leaving the treatment plant – the single highest value for THMs in our database. Fifty water suppliers serving 248,634 people have found THM levels from about five times up to nearly eleven times the new legal annual average (Table 8).

The problem of elevated cancer risks in small towns

Between 1995 and 2001, more than 1,200 public water supplies (1,258) serving 16.2 million people reported at least one consecutive 12 month period with THM levels over the 80 ppb health standard that will go into effect beginning in January 2002. More then 1,000 (80%) of these systems, and all 50 of the top 50 most contaminated (Table 9), served fewer than 10,000 people, the official EPA cutoff for small systems. Long term exposures at these levels are estimated by the EPA to cause up to 7,000 cases of bladder cancer each year nationwide.

The problem is bigger than what the data show

Beginning in 1979 and until January 1, 2002, small water suppliers in nearly every state have been completely exempt from controlling levels of chlorination byproducts and from testing for CBPs. Therefore, the available data on CBP levels in public water supplies are dominated by large water systems serving 10,000 people or more. Certain states have required some testing for small water suppliers. The available data show that tap water in small communities supplied by rivers and reservoirs is more than twice as likely to have dangerous levels of CPBs as tap water in large cities (based on the probability that THM levels will be at least 80 ppb for three consecutive months).

We made no attempt to characterize exposures for systems for which only one test result is available for THMs, but from these data we see that 80 water suppliers serving 433,000 people reported THMs greater than 80 ppb on the lone available test date, a level shown to be linked to elevated risks for miscarriage and birth defects. The highest recorded THM concentration for any of the systems with only one test available is 485 ppb, measured at the Plantation Bay Water Treatment Plant in Ormond Beach, Florida on August 24, 2000 (Table 10). It is likely that tap water in many small towns that have never been required to test also is contaminated with high, potentially dangerous levels of chlorination byproducts.

Table 6: Nearly half of all pregnant women at risk from high chlorination byproduct levels are served by just 20 large water suppliers.

Cities listed below are ordered based on the number of pregnancies each year exposed to at least 80 ppb THMs for at least a trimester. These pregnancies are at increased risk for birth defects and miscarriage.

Rank	Community or Water System	Population Served	Testing Information	Highest 3-Month Average THM Level Recorded	Maximum Spike	Estimated Number of Pregnancies per Year Exposed to 80 ppb THMs for an Entire Trimester (Percentage of Pregnancies)
1	Maryland Suburbs of Washington, DC (WSSC)	1,500,000	157 tests between 10/4/95 and 4/17/01	140 ppb on 8/20/95	253 ppb on 8/17/99	12,081 (58%)
2	Philadelphia, PA	1,755,000	27 tests between 1/18/96 and 4/26/01	100 ppb on 6/28/96	133 ppb on 7/17/96	5,936 (24%)
3	Pittsburgh Suburbs, PA	569,328	29 tests between 1/16/96 and 4/9/01	137 ppb on 6/22/96	146 ppb on 8/6/96	4,053 (51%)
4	San Francisco, CA	789,600	15 tests between 8/18/97 and 5/29/01	100 ppb on 6/14/00	145 ppb on 8/15/00	3,957 (36%)
5	Washington, DC	595,000	72 tests between 1/15/95 and 12/15/00	109 ppb on 6/16/99	148 ppb on 8/15/99	3,809 (46%)
6	Newark, NJ	275,221	36 tests between 2/1/95 and 5/8/01	161 ppb on 6/19/96	211 ppb on 9/18/96	2,847 (74%)
7	Boston, MA	2,000,000	109 tests between 1/17/95 and 12/1/00	90 ppb on 5/18/00	99 ppb on 8/14/00	2,579 (9%)
8	Omaha, NE	506,420	16 tests between 8/20/97 and 5/21/01	135 ppb on 4/6/01	149 ppb on 5/21/01	2,216 (31%)
9	Charleston, WV	173,005	5 tests between 9/11/97 and 9/3/98	104 ppb on 10/19/98	137 ppb on 9/11/97	2,196 (91%)
10	Passaic Valley, NJ	275,000	74 tests between 1/12/95 and 6/19/01	130 ppb on 6/13/95	223 ppb on 7/18/97	2,191 (57%)
11	Garland, TX	201,824	24 tests between 3/20/95 and 5/21/01	97 ppb on 1/31/97	97 ppb on 12/16/96	2,127 (75%)
12	Columbus, OH	452,765	21 tests between 1/4/95 and 4/7/99	108 ppb on 9/3/95	135 ppb on 10/18/95	1,993 (31%)
13	Charleston, SC	304,505	32 tests between 2/9/95 and 7/18/01	123 ppb on 6/28/96	150 ppb on 5/15/97	1,940 (46%)
14	Monmouth County, NJ	302,491	43 tests between 2/7/95 and 4/18/01	103 ppb on 7/8/96	161 ppb on 8/21/96	1,796 (42%)
15	Akron, OH	308,720	30 tests between 8/8/95 and 2/7/01	109 ppb on 6/5/00	164 ppb on 8/9/00	1,693 (39%)
16	Jackson, MS	227,500	16 tests between 2/16/95 and 7/8/98	169 ppb on 12/18/97	322 ppb on 1/7/98	1,646 (52%)
17	Trenton City, NJ	225,000	31 tests between 3/28/95 and 5/21/01	92 ppb on 10/20/99	127 ppb on 9/16/96	1,527 (48%)
18	Kansas City, KS	164,462	6 tests between 8/28/97 and 11/23/98	92 ppb on 7/14/97	111 ppb on 8/27/98	1,520 (66%)
19	New Bedford, MA	139,495	29 tests between 2/1/95 and 4/14/00	122 ppb on 8/1/97	136 ppb on 9/24/98	1,450 (74%)
20	Plano, TX	202,000	24 tests between 4/12/95 and 4/23/01	99 ppb on 6/8/00	109 ppb on 6/27/00	1,340 (47%)
21	Pittsburgh City, PA	370,000	25 tests between 1/22/96 and 3/7/01	115 ppb on 7/31/00	132 ppb on 7/18/96	1,325 (26%)
22	Mesquite, TX	119,600	26 tests between 1/31/95 and 5/21/01	98 ppb on 8/26/00	98 ppb on 7/11/00	997 (60%)
23	Evansville, IN	150,000	20 tests between 5/30/96 and 2/15/01	108 ppb on 7/28/98	163 ppb on 10/7/98	927 (44%)
24	Aurora, IL	122,271	29 tests between 2/6/95 and 10/24/00	136 ppb on 7/14/95	136 ppb on 8/28/95	918 (54%)
25	Knoxville, TN	170,351	16 tests between 2/28/95 and 6/19/00	101 ppb on 10/8/95	146 ppb on 12/17/98	899 (38%)
26	New Milford, NJ	713,737	43 tests between 1/25/95 and 6/14/01	92 ppb on 8/15/99	174 ppb on 9/5/95	793 (8%)
27	Richardson, TX	89,600	25 tests between 7/17/95 and 5/21/01	98 ppb on 2/21/97	98 ppb on 4/7/97	769 (61%)
28	Davenport, IA	130,290	39 tests between 1/31/95 and 1/11/01	100 ppb on 7/17/96	122 ppb on 9/13/96	742 (41%)
29	Laredo, TX	193,766	38 tests between 1/24/95 and 3/14/01	111 ppb on 7/20/96	111 ppb on 9/3/96	727 (27%)
30	Amarillo, TX	168,000	42 tests between 1/6/95 and 3/21/01	83 ppb on 10/24/98	119 ppb on 11/11/98	722 (31%)
31	Durham, NC	153,000	7 tests between 7/24/97 and 10/22/98	83 ppb on 6/7/98	131 ppb on 7/22/98	716 (33%)
32	Lancaster, PA	108,000	57 tests between 2/13/96 and 5/15/01	102 ppb on 8/7/99	140 ppb on 8/28/96	695 (46%)
33	Fayetteville, NC	170,121	8 tests between 1/24/96 and 10/14/98	98 ppb on 5/25/97	135 ppb on 7/9/97	668 (28%)
34	Norristown, PA	83,200	21 tests between 1/23/96 and 2/6/01	118 ppb on 4/25/99	132 ppb on 6/9/99	664 (57%)
35	East St Louis, IL	139,200	28 tests between 2/22/95 and 11/7/00	118 ppb on 1/10/97	128 ppb on 2/24/97	661 (34%)
36	Boca Raton, FL	109,000	23 tests between 9/30/97 and 12/14/00	130 ppb on 7/15/98	166 ppb on 9/30/98	654 (43%)
37	Penn Hills, PA	125,000	31 tests between 2/20/96 and 4/18/01	99 ppb on 7/26/98	119 ppb on 8/20/98	650 (37%)
38	Kankakee, IL	55,430	24 tests between 3/21/95 and 11/14/00	98 ppb on 5/15/98	169 ppb on 6/23/86	588 (76%)
39	Texarkana, TX	56,367	34 tests between 3/17/95 and 6/18/01	143 ppb on 9/19/98	151 ppb on 9/26/00	536 (68%)
40	Kenmore, WA	60,000	21 tests between 3/15/96 and 2/27/01	94 ppb on 1/30/96	96 ppb on 9/12/97	521 (62%)
41	Glendale, AZ	180,000	66 tests between 1/4/95 and 4/12/01	94 ppb on 8/7/00	247 ppb on 7/9/98	495 (20%)
42	Columbia, MD	175,000	28 tests between 2/6/96 and 3/22/01	87 ppb on 8/15/00	90 ppb on 9/29/00	481 (20%)
43	Warren, OH	70,000	28 tests between 1/19/95 and 4/17/01	139 ppb on 6/26/98	178 ppb on 7/8/98	476 (49%)
44	New Kensington, PA	47,800	23 tests between 3/4/96 and 5/8/01	104 ppb on 9/10/99	120 ppb on 7/26/99	474 (71%)
45	Bucks County, PA	66,100	32 tests between 1/30/96 and 4/11/01	134 ppb on 8/16/98	150 ppb on 7/1/98	466 (50%)
46	Lowell, MA	135,000	35 tests between 2/7/95 and 12/15/00	99 ppb on 9/23/00	137 ppb on 6/18/98	457 (24%)
47	Mckinney, TX	49,100	24 tests between 5/16/95 and 4/23/01	98 ppb on 6/24/00	101 ppb on 2/23/98	437 (64%)
48	Portsmouth, VA	120,000	6 tests between 7/10/97 and 10/8/98	80 ppb on 5/26/97	91 ppb on 7/10/97	430 (26%)
49	Gloucester, MA	39,000	30 tests between 2/21/95 and 12/12/00	150 ppb on 5/11/97	189 ppb on 6/25/97	412 (76%)
50	Kirkland, WA	36,039	22 tests between 3/28/96 and 2/27/01	95 ppb on 4/3/99	95 ppb on 2/16/99	394 (78%)

Source: Environmental Working Group analysis of state and federal tap water testing data.

Table 6 - Continued: Nearly half of all pregnant women at risk from high chlorination byproduct levels are served by just 20 large water suppliers.

Cities listed below are ordered based on the number of pregnancies each year exposed to at least 80 ppb THMs for at least a trimester. These pregnancies are at increased risk for birth defects and miscarriage.

Rank	Community or Water System	Population Served	Testing Information	Highest 3-Month Average THM Level Recorded	Maximum Spike	Estimated Number of Pregnancies per Year Exposed to 80 ppb THMs for an Entire Trimester (Percentage of Pregnancies)
51	New Braunfels, TX	40,698	31 tests between 5/22/95 and 4/26/01	152 ppb on 6/13/96	161 ppb on 8/14/96	390 (69%)
52	Lawrence, MA	70,000	30 tests between 3/8/95 and 12/6/00	107 ppb on 7/3/98	115 ppb on 4/5/00	378 (39%)
53	Silver Spring, PA	74,816	22 tests between 1/29/96 and 4/20/01	98 ppb on 4/28/00	148 ppb on 6/8/99	374 (36%)
54	Waco, TX	110,000	38 tests between 2/14/95 and 3/12/01	105 ppb on 6/5/95	111 ppb on 8/16/95	369 (24%)
55	Cullman, AL	26,100	2 tests between 8/16/95 and 6/17/97	132 ppb on 7/2/95	132 ppb on 8/16/95	365 (100%)
56	St Joseph, MO	77,000	19 tests between 1/12/95 and 4/19/01	140 ppb on 6/7/98	205 ppb on 8/26/98	360 (33%)
57	Jersey City, NJ	238,000	39 tests between 2/10/95 and 6/22/01	88 ppb on 6/29/00	95 ppb on 7/13/00	358 (11%)
58	Springfield, IL	146,000	29 tests between 1/20/95 and 11/28/00	80 ppb on 8/31/97	158 ppb on 9/25/86	346 (17%)
59	Mcallen, TX	117,096	36 tests between 3/17/95 and 5/14/01	97 ppb on 10/5/98	118 ppb on 10/22/98	343 (21%)
60	Perris, CA	253,705	23 tests between 1/13/95 and 8/1/00	88 ppb on 5/22/99	88 ppb on 4/6/99	341 (10%)
61	Spartanburg, SC	107,344	31 tests between 3/6/95 and 4/30/01	97 ppb on 11/17/95	116 ppb on 10/2/95	340 (23%)
62	Decatur, IL	83,885	29 tests between 2/28/95 and 12/5/00	85 ppb on 6/29/99	181 ppb on 8/23/88	339 (29%)
63	Potomac, MD	44,000	22 tests between 1/29/96 and 3/15/01	153 ppb on 6/27/99	194 ppb on 9/13/99	338 (55%)
64	Kennewick, WA	55,900	34 tests between 3/29/95 and 12/14/00	349 ppb on 11/9/97	516 ppb on 12/18/97	320 (41%)
65	Rowlett, TX	41,250	26 tests between 3/20/95 and 5/21/01	108 ppb on 10/2/97	123 ppb on 12/9/97	319 (55%)
66	California Water Service - Bear Gulch, CA	65,540	18 tests between 5/24/95 and 7/19/00	117 ppb on 4/9/95	117 ppb on 5/24/95	315 (34%)
67	Sharon, PA	37,260	21 tests between 1/25/96 and 1/17/01	116 ppb on 6/13/99	155 ppb on 7/28/99	313 (60%)
68	Topeka, KS	123,993	16 tests between 8/6/97 and 6/4/01	88 ppb on 10/4/97	100 ppb on 11/4/98	312 (18%)
69	Desoto, TX	44,859	26 tests between 2/24/95 and 5/14/01	111 ppb on 5/29/98	111 ppb on 4/13/98	309 (49%)
70	Allen, TX	33,386	26 tests between 1/17/95 and 4/23/01	103 ppb on 6/18/00	107 ppb on 6/27/00	308 (66%)
71	Clermont County, OH	63,191	18 tests between 9/28/95 and 2/23/99	102 ppb on 7/20/98	102 ppb on 9/3/98	295 (33%)
72	Prichard, AL	42,000	2 tests between 1/19/95 and 9/25/97	81 ppb on 8/11/97	81 ppb on 9/25/97	294 (50%)
73	Tempe, AZ	160,000	71 tests between 3/14/95 and 12/4/00	112 ppb on 7/21/95	132 ppb on 9/14/95	292 (13%)
74	Ft Lauderdale, FL	20,500	2 tests between 5/22/98 and 2/4/99	206 ppb on 12/21/98	206 ppb on 2/4/99	287 (100%)
75	Lancaster County, SC	31,050	3 tests between 2/7/95 and 7/17/95	109 ppb on 9/1/95	117 ppb on 7/17/95	286 (66%)
76	Taunton, MA	54,000	29 tests between 3/7/95 and 1/30/01	115 ppb on 8/9/97	136 ppb on 9/23/97	285 (38%)
77	North Billerica, MA	37,029	22 tests between 2/22/95 and 12/6/00	146 ppb on 4/19/98	163 ppb on 5/11/98	284 (55%)
78	Corpus Christi, TX	270,000	35 tests between 3/16/95 and 4/10/01	81 ppb on 5/26/01	97 ppb on 9/17/97	284 (8%)
79	Hagerstown, MD	75,000	33 tests between 2/21/96 and 4/3/01	101 ppb on 8/21/97	123 ppb on 9/10/99	278 (27%)
80	Brockton, MA	97,547	34 tests between 2/18/95 and 5/16/00	92 ppb on 7/27/96	110 ppb on 9/8/98	277 (20%)
81	Columbia, SC	259,293	29 tests between 2/10/95 and 6/14/01	82 ppb on 6/25/95	114 ppb on 8/9/95	276 (8%)
82	Greenwood, SC	39,660	31 tests between 3/6/95 and 5/17/01	139 ppb on 7/18/95	175 ppb on 6/6/96	270 (49%)
83	Oakmont, PA	39,829	24 tests between 1/9/96 and 4/24/01	147 ppb on 5/28/99	170 ppb on 8/23/99	269 (48%)
84	Marshall, TX	25,586	34 tests between 3/7/95 and 4/16/01	150 ppb on 8/26/00	173 ppb on 9/22/00	266 (74%)
85	San Angelo, TX	93,204	31 tests between 2/21/95 and 3/21/01	124 ppb on 6/26/98	124 ppb on 8/10/98	266 (20%)
86	Sioux Falls, SD	123,975	10 tests between 7/16/97 and 2/1/01	80 ppb on 6/1/97	102 ppb on 7/16/97	252 (15%)
87	Angleton, TX	21,000	24 tests between 3/24/95 and 1/17/01	171 ppb on 9/29/96	235 ppb on 10/7/99	245 (83%)
88	Bowling Green, OH	30,000	29 tests between 1/11/95 and 4/11/01	115 ppb on 7/24/95	136 ppb on 12/4/97	244 (58%)
89	Danvers, MA	27,600	34 tests between 1/23/95 and 11/29/00	112 ppb on 12/21/99	158 ppb on 9/27/00	243 (63%)
90	Weymouth, MA	52,140	83 tests between 2/2/95 and 1/29/01	143 ppb on 6/11/00	200 ppb on 6/14/00	242 (33%)
91	College Station, TX	51,000	7 tests between 5/24/95 and 11/6/00	93 ppb on 3/30/97	93 ppb on 5/14/97	233 (33%)
92	Delaware, OH	27,500	21 tests between 1/24/95 and 2/16/99	106 ppb on 9/5/95	138 ppb on 10/20/95	231 (60%)
93	Barberton, OH	29,000	28 tests between 7/19/95 and 5/1/01	148 ppb on 6/4/95	158 ppb on 5/20/98	231 (57%)
94	Troy, NY	54,269	9 tests between 7/9/95 and 5/21/01	90 ppb on 8/11/96	159 ppb on 8/27/96	224 (29%)
95	Beverly, MA	72,265	25 tests between 2/23/95 and 10/24/00	86 ppb on 7/10/96	107 ppb on 8/22/96	222 (22%)
96	Santa Barbara, CA	95,064	15 tests between 12/16/97 and 8/15/00	108 ppb on 4/21/98	108 ppb on 3/6/98	218 (16%)
97	El Dorado, AR	23,146	28 tests between 2/16/95 and 7/3/01	88 ppb on 8/18/01	93 ppb on 10/30/96	218 (67%)
98	Duncanville, TX	36,100	26 tests between 4/5/95 and 4/23/01	98 ppb on 9/26/97	110 ppb on 11/2/98	217 (43%)
99	Falls Township, PA	24,000	31 tests between 2/13/96 and 4/30/01	138 ppb on 8/16/98	153 ppb on 7/1/98	216 (64%)
100	Yuma, AZ	58,000	37 tests between 2/7/95 and 2/22/01	102 ppb on 5/15/96	120 ppb on 9/20/95	215 (26%)

Source: Environmental Working Group analysis of state and federal tap water testing data.

HEALTH RISKS FROM CHLORINATION BYPRODUCTS

Chlorination byproducts are a complex mixture of more than 100 potentially toxic compounds. EPA estimates that 240 million people are exposed to these compounds in tap water in the United States. Only trihalomethanes (THMs), five haloacetic acids, bromate, and chlorite are currently monitored and regulated, or proposed for regulation. Several chlorination byproducts are classified by the agency as "likely" human carcinogens (bromodichloromethane, bromoform, and dichloroacetic acid), and CBPs as a whole have the clear potential to cause birth defects or reproductive damage.

A compelling body of scientific evidence - nearly 30 peer-reviewed epidemiologic studies - links chlorination byproducts to increased risks of cancer. A growing body of science links CBPs to miscarriages and birth defects, including neural tube defects, low birth weight, and cleft palate. Epidemiology studies often find adverse effects at levels considered legal under federal drinking water law. The specifics of which byproduct causes which effect remains unknown, and indeed may never be known.

Cancer: EPA estimates the maximum health benefit of the new THM standard (80 ppb, reduced from the current standard of 100 ppb) as a potential reduction of 2,332 cases of bladder cancer per year out of their upperbound estimate of 9,300 annual cases currently caused by THMs. The agency then notes that the bladder cancer risk "captures only a portion of the potential risk associated with CBPs in drinking water" (63 FR 69390-69476). In the exposure assessment presented in this report, estimates of the number of water systems and people at increased risk for cancer are based on systems for which the average THM level over any consecutive 12-month period was at least 80 parts per billion (ppb).

Miscarriages and Birth Defects: At least ten major epidemiological studies of more than 287,000 pregnant women show elevated risks for neural tube defects, reduced growth rates in the womb, miscarriages, and other adverse effects for women drinking chlorinated tap water. Scientists have found elevated risks associated with THM levels as low as 10 ppb (Kramer et al 1992), and for exposures to high but legal levels of THMs (75 ppb) over a single trimester of pregnancy (Waller et al 1998). In the exposure assessment presented in this report, estimates of the number of pregnant women facing an elevated risk for birth defects and miscarriage are based on systems for which the average THM level over at least one consecutive three month period was at least 80 ppb (see Methodology appendix for more detail).

Table 7: In each of 20 states and Washington, DC, more than 1,000 pregnant women yearly are exposed to risky levels of chlorination byproducts for at least one trimester.

States listed below are ordered on the estimated number of pregnancies statewide at increased risk for birth defects and miscarriage each year.

Rank	State	Number of Water Suppliers Analyzed	Population Served	Percentage of Population Accounted For	Chance that a Pregnancy Will be at Risk	Estimated Number of Pregnancies at Risk per Year	Average THM Level for the State (ppb)**
1	Texas	2,284	18,685,894	89.3%	10.1%	26,525	32.3
2	Pennsylvania	266	8,820,682	84.0%	14.9%	18,419	39.1
3	Maryland	34	4,270,287	92.5%	23.7%	14,177	44.2
4	New Jersey	526	7,256,528	93.5%	10.3%	10,456	25.2
5	Massachusetts	227	6,577,429	76.1%	9.9%	9,077	30.2
6	Illinois	671	9,611,027	88.1%	5.4%	7,299	25.3
7	Ohio	1170	8,792,614	88.8%	7.1%	6,777	27.9
8	South Carolina	74	2,313,351	70.5%	16.9%	5,474	41.0
9	California	892	30,058,603	86.7%	1.3%	5,440	10.8
10	District of Columbia	1	595,000	100.0%	45.7%	3,809	54.8
11	Missouri	849	3,998,900	84.8%	6.2%	3,459	26.7
12	Nebraska	79	1,025,716	73.0%	15.9%	2,277	40.7
13	Washington	1576	4,838,998	95.9%	2.9%	1,939	19.1
14	Florida	130	8,698,023	55.5%	1.4%	1,716	22.3
15	Iowa	182	1,547,692	62.4%	7.0%	1,525	24.0
16	North Carolina	306	3,424,966	59.3%	2.9%	1,384	16.8
17	Tennessee	331	4,377,029	85.8%	2.2%	1,366	17.1
18	Alabama	376	4,223,222	85.5%	2.2%	1,312	15.1
19	Indiana	224	3,026,099	73.5%	2.8%	1,195	19.0
20	Arizona	545	4,246,498	96.6%	2.0%	1,175	17.4
21	Arkansas	53	1,125,526	49.8%	11.5%	1,100	38.8
22	Rhode Island	71	779,157	82.0%	7.7%	839	26.0
23	Oklahoma	476	2,879,179	84.5%	1.8%	714	6.6
24	Minnisota	650	3,584,428	93.5%	1.0%	476	12.6
25	South Dakota	8	281,782	43.8%	9.6%	377	45.8
26	North Dakota	19	357,775	64.4%	7.1%	357	26.9
27	Alaska	360	427,379	96.8%	4.5%	267	15.3
28	Maine	358	591,986	96.8%	3.1%	260	9.2
29	Montana	544	643,381	93.0%	2.5%	225	15.3
30	Wisconsin	1952	3,533,846	96.9%	0.3%	129	8.7
31	Wyoming	13	235,042	58.4%	1.2%	40	15.0
32	Vermont	337	414,839	83.7%	0.5%	28	12.4
33	Hawaii	18	1,100,819	85.6%	0.1%	11	2.5
34	Delaware	100	532,507	88.0%	7.0%	8	23.2
35	New Mexico	456	1,333,812	88.0%	0.0%	4	2.8
36	Colorado	147	2,451,931	63.8%	0.0%	2	27.2
37	Connecticut	80	2,364,714	89.3%	0.0%	0	19.9
37	Kentucky	151	1,866,421	43.2%	0.0%	0	22.7
37	Louisiana	148	3,157,688	63.3%	0.0%	0	3.5
37	Michigan	299	3,299,342	46.8%	0.0%	0	7.3
37	Nevada	2	632,000	40.0%	0.0%	0	25.2
37	Oregon	157	1,574,083	57.5%	0.0%	0	6.9
	Subtotal	14,858	150,870,301			129,638	
NR*	Virginia	6	2,092,566	31.7%	9.4%	2,752	53.7
NR	West Virginia	1	173,005	9.7%	90.7%	2,196	78.2
NR	Mississippi	48	626,771	21.8%	20.7%	1,819	31.8
NR	Kansas	4	927,487	37.8%	14.1%	500	38.7
NR	New York	96	446,487	2.5%	4.3%	270	33.3
NR	Georgia	7	2,195,712	33.5%	0.0%	0	34.1
NR	Idaho	1	186,000	20.5%	0.0%	0	6.8
NR	New Hampshire	1	128,000	16.8%	0.0%	0	47.2
NR	Utah	4	1,329,835	39.6%	0.0%	0	23.6
	Total	15,026	158,976,164			137,175	

Source: Environmental Working Group analysis of state and federal tap water testing data.
**NR = "Not Ranked" because we have only obtained data which accounts for less than 50% of the population drinking from public water supplies.*
*** Average is population weighted to account for varying sizes of water suppliers; see Appendix B for details.*

Table 8: Small communities are particularly at risk for exposure to trihalomethanes at many times the legal annual limit. Spikes more than three to nearly nine times the allowable annual level have been measured in 50 communities.

Cities listed below are ordered on the highest recorded single THM level measured for that cities' water supplier.

Rank	Community or Water System	Population Served	Maximum Spike
1	Ridgeway, MO	379	861 ppb on 7/24/00
2	Buena Vista Subdivision, Burnet, TX	330	853 ppb on 8/21/00
3	Creighton, MO	303	741 ppb on 7/12/00
4	Lakeshore Sites Water Co., Haskell, TX	320	600 ppb on 7/28/99
5	Nolan County FWSD No. 1, Blackwell, TX	425	585 ppb on 12/27/00
6	Bristol County Water Authority, Warren, RI	47,000	585 ppb on 6/20/00
7	Timberland Estates, Porter, TX	180	580 ppb on 3/23/01
8	Selawik Safewater Facility, Selawik, AK	800	576 ppb on 3/5/96
9	Carlinville, IL	6,688	568 ppb on 10/9/90
10	Norwell Water Department, Plymouth, MA	10,200	561 ppb on 4/21/99
11	Butler, MO	4,000	546 ppb on 7/17/00
12	Bucklin, MO	613	541 ppb on 6/11/96
13	Kennewick, WA	55,900	516 ppb on 12/18/97
14	Linneus, MO	364	515 ppb on 6/18/96
15	Lancaster, MO	855	508 ppb on 7/1/96
16	Garden City, MO	1,364	507 ppb on 7/10/96
17	Rock Creek, OH	550	492 ppb on 6/28/00
18	Marco Shores Utilities in Marco Island, FL	886	492 ppb on 2/9/99
19	Rockaway Beach Water, Bainbridge Island, WA	190	475 ppb on 3/4/96
20	Pole Road Water Association, Lynden, WA	1,560	475 ppb on 3/4/96
21	Cascade Village MHP, Moses Lake, WA	190	475 ppb on 3/4/96
22	North Augusta, SC	27,060	471 ppb on 4/18/01
23	Bistone Municipal Water Supply, Mexia, TX	534	470 ppb on 9/27/00
24	Armstrong, MO	310	461 ppb on 5/30/96
25	Iowa Park, TX	6,990	461 ppb on 7/10/00
26	Adrian, MO	1,625	460 ppb on 7/6/99
27	Chalkyitsik, AK	92	459 ppb on 12/30/95
28	Talladega, AL	20,400	457 ppb on 2/10/97
29	Bronte, TX	1,000	452 ppb on 8/11/00
30	Coulterville, IL	1,100	450 ppb on 8/15/94
31	Paint Rock, TX	336	440 ppb on 8/31/98
32	LYSD Kotlik Community System, Kotlik, AK	205	439 ppb on 12/29/98
33	Clinton, MO	9,000	432 ppb on 7/9/96
34	Lake Williamson Christian Center in Brushy Mound, IL	880	432 ppb on 8/21/91
35	Thorne Bay, AK	612	432 ppb on 6/8/98
36	Deering, AK	150	429 ppb on 1/27/98
37	Clyde, TX	3,002	423 ppb on 9/26/00
38	Hugo, OK	6,500	423 ppb on 1/28/98
39	Coatesville, PA	15,000	420 ppb on 9/28/99
40	Ashley, IL	650	419 ppb on 8/23/95
41	Bunker Hill, IL	2,550	419 ppb on 11/5/90
42	Downing, MO	359	416 ppb on 7/18/96
43	Matagorda Dunes Subdivision, Austin, TX	375	409 ppb on 12/2/99
44	Northeast Texas Municipal Water, Hughes Springs, TX	26	408 ppb on 10/19/99
45	Arroyo Water Supply Corporation, Rio Hondo, TX	847	391 ppb on 3/22/01
46	Lewistown, MO	502	390 ppb on 7/1/96
47	King City, MO	1,187	389 ppb on 7/16/96
48	Woodson, TX	210	385 ppb on 7/20/00
49	Fairchild Air Force Base, Spokane, WA	11,227	383 ppb on 10/14/97
50	Anahuac, TX	2,808	382 ppb on 5/16/00

Source: Environmental Working Group analysis of state and federal tap water testing data.

Table 9: Residents of many small towns face an elevated cancer risk from high levels of chlorination byproducts in water, in some towns 3 to 4 times the cancer risk allowed in big cities. For some towns, EPA's new allowable limits will not be enforced for another four years.

Cities listed below are ordered on the long-term average THM level, an indicator for lifetime cancer risk.

Rank	Community or Water System	Population Served	Testing Information	Long Term THM Average
1	Lakeshore Sites Water Co., Haskell, TX	320	11 tests between 7/23/98 and 6/14/01	430 ppb
2	Iowa Park, TX	6,990	8 tests between 10/21/98 and 3/14/01	346 ppb
3	Woodson, TX	210	4 tests between 11/17/98 and 7/20/00	337 ppb
4	Nolan County FWSD No. 1, Blackwell, TX	425	7 tests between 7/13/98 and 6/13/01	315 ppb
5	Selawik Safewater Facility, Selawik, AK	800	3 tests between 12/19/95 and 1/7/98	309 ppb
6	Timberland Estates, Porter, TX	180	2 tests between 3/20/01 and 3/23/01	300 ppb
7	Bistone Municipal Water Supply, Mexia, TX	534	5 tests between 9/2/98 and 9/27/00	288 ppb
8	Buena Vista Subdivision, Burnet, TX	330	5 tests between 12/9/98 and 3/1/01	288 ppb
9	Ballinger, TX	3,975	7 tests between 4/22/99 and 2/28/01	278 ppb
10	A.G. Holley State Hospital, Lantana, FL	498	2 tests between 4/11/00 and 9/22/00	272 ppb
11	Chalkyitsik, AK	92	4 tests between 12/30/95 and 6/10/98	272 ppb
12	Bryson, TX	534	5 tests between 11/17/98 and 3/12/01	271 ppb
13	Pickwick Home Owners Assoc., Grafford, TX	75	2 tests between 11/2/98 and 2/23/99	268 ppb
14	Windthorst Water Supply Corp., Windthorst, TX	1,242	4 tests between 10/6/98 and 3/23/01	267 ppb
15	Live Oak Bend WSC, Sargent, TX	333	4 tests between 8/25/98 and 3/22/01	265 ppb
16	Graham, TX	8,100	6 tests between 6/23/99 and 3/14/01	265 ppb
17	Throckmorton, TX	1,036	4 tests between 10/28/98 and 3/14/01	261 ppb
18	FWSC/Marco Shores, Marco Island, FL	886	2 tests between 2/9/99 and 4/27/00	246 ppb
19	Stamford, TX	3,817	9 tests between 7/13/98 and 3/5/01	242 ppb
20	Rule, TX	763	5 tests between 10/28/98 and 3/14/01	241 ppb
21	Paint Rock, TX	336	6 tests between 8/31/98 and 3/21/01	237 ppb
22	Golovin, AK	170	3 tests between 12/11/95 and 11/9/98	234 ppb
23	N. Central TX Mun. Water Authority, Munday, TX	115	5 tests between 7/23/98 and 3/23/01	231 ppb
24	SLC Water Supply Corp., Groesbeck, TX	1,128	2 tests between 9/25/00 and 3/12/01	231 ppb
25	Deering, AK	150	5 tests between 3/1/95 and 1/27/98	231 ppb
26	Clyde, TX	3,002	5 tests between 6/29/98 and 3/1/01	223 ppb
27	Coleman, TX	5,185	6 tests between 4/22/99 and 3/1/01	221 ppb
28	Cooksville, IL	250	2 tests between 6/27/00 and 9/19/00	221 ppb
29	Pleasure Point WSC, Zavalla, TX	216	2 tests between 4/7/99 and 5/16/00	220 ppb
30	LYSD Kotlik Community System, Kotlik, AK	205	2 tests between 12/22/96 and 12/29/98	219 ppb
31	Arroyo Water Supply Corporation, Rio Hondo, TX	847	4 tests between 6/7/99 and 3/22/01	218 ppb
32	Panther Woods Country Club, Fort Pierce, FL	505	3 tests between 4/27/00 and 12/28/00	217 ppb
33	NSBU-Kaktovik, Barter Island, Barrow, AK	280	9 tests between 10/10/95 and 9/21/98	216 ppb
34	Ridgeway, MO	379	26 tests between 1/12/95 and 4/27/01	216 ppb
35	Henrietta, TX	3091	5 tests between 10/21/98 and 3/14/01	215 ppb
36	Goldthwaite, TX	1,800	9 tests between 12/2/98 and 3/14/01	213 ppb
37	Hamlin, TX	2,785	7 tests between 7/22/98 and 2/28/01	211 ppb
38	South Road WSC, Marble Falls, TX	100	5 tests between 12/9/98 and 3/1/01	209 ppb
39	Breckenridge, TX	5,665	6 tests between 7/20/99 and 3/2/01	205 ppb
40	Arrowhead Lake Lots –RRA, Wichita Falls, TX	1613	4 tests between 6/23/99 and 3/14/01	204 ppb
41	Bronte, TX	1,000	4 tests between 7/13/99 and 2/27/01	201 ppb
42	Lakeway Harbor, Mabank, TX	1,033	4 tests between 11/16/98 and 5/18/01	200 ppb
43	Groesbeck, TX	3,360	8 tests between 3/25/99 and 3/12/01	197 ppb
44	Albany, TX	2,010	4 tests between 7/26/99 and 3/2/01	195 ppb
45	Creighton, MO	303	27 tests between 1/12/95 and 4/12/01	194 ppb
46	Brookesmith Treatment Plant, Brownwood, TX	2,985	5 tests between 2/25/99 and 3/1/01	193 ppb
47	Granite Shoals, TX	4884	6 tests between 12/9/98 and 3/1/01	193 ppb
48	Nocona, TX	2,870	3 tests between 7/20/99 and 3/12/01	192 ppb
49	La Joya, TX	2,646	5 tests between 2/16/99 and 3/22/01	192 ppb
50	Sargent, TX	1,762	2 tests between 1/11/99 and 9/25/00	192 ppb

Source: Environmental Working Group analysis of state and federal tap water testing data.

Table 10: Many water suppliers with only one available test for chlorination byproducts registered a high level in excess of safe limits.

Water systems listed below are ordered on the single recorded THM level available for each water system.

Community or Water System	Population Served	THM Level	Sampling Date
Plantation Bay Water Treatment Plant in Ormond Beach, FL	1,600	484.6 ppb	8/24/00
S. Water District - #2 in of Columbiana County, OH	4,020	399.3 ppb	8/15/00
Earlham Municipal Waterworks in Earlham, IA	1,298	325.0 ppb	7/2/95
Horseshoe Beach Water Treatment Plant in Horseshow Beach, FL	1,330	318.0 ppb	2/11/98
Harrah, OK	4,206	295.1 ppb	9/3/97
Central Macoupin County Rural Water District, IL	425	249.0 ppb	11/14/00
Grandfield, OK	1,445	239.7 ppb	1/6/98
Oasis Villagein Okeechobee, FL	318	229.7 ppb	11/9/00
Ankeny, IA	27,117	229.0 ppb	11/1/95
Marshall Co Water Corp, OK	6,325	196.6 ppb	5/6/01
Sugar Mill Country Club Estate in New Smyrna Beach, FL	2,254	195.0 ppb	1/14/98
River Park Mobile Home Park in Fort Pierce, FL	125	185.2 ppb	9/27/00
Ka-ron Acres Mobile Home Park in Chocktaw, OK	50	178.8 ppb	7/22/97
Inglis, FL	1,825	177.4 ppb	3/31/98
Deer Butte Subdivision in Houston, TX	204	174.4 ppb	12/2/99
Davidson, OK	501	173.1 ppb	12/21/97
Gulf Env. Services San Carlos in Estero of Lee County, FL	21,988	173.1 ppb	11/3/99
Menands Village, Albany County, NY	4,300	171.0 ppb	8/27/96

Source: Environmental Working Group analysis of state and federal tap water testing data.

Chapter 4

Health tracking

The urgent need to track environmental pollution, exposures, and disease

In spite of the overwhelming public health impact of chronic disease, the U.S. fails to collect essential tracking data at a national level that could provide key insight on causes and critical information on disease rates.

More than one-third of the U.S. population suffers from some form of chronic disease such as cancer, asthma, immune system disorders, or neurodegenerative diseases like Alzheimer's. Chronic disease is the number one killer in the U.S., accounting for seven of every 10 deaths. Three to four percent of all infants born in the U.S. are diagnosed with major birth defects. At least twenty to thirty percent of all pregnancies end in miscarriage. Environmental pollutants have been linked to many chronic diseases, chronic conditions like birth defects, as well as miscarriages.

In spite of the overwhelming public health impact of chronic disease, the U.S. fails to collect essential tracking data at a national level that could provide key insight on causes and critical information on disease rates. An effective nationwide health tracking network would incorporate tracking pollution releases (a concept called "Hazard Tracking"), surveying amounts of individual pollutants to which people are exposed ("Exposure Tracking"), and tracking disease incidence and pregnancy outcomes ("Health Tracking").

As it stands, individual states bear the responsibility for collecting much of the country's basic health tracking information. Many states lack the funding to maintain the full, effective tracking systems that they aim for, while other states have more complete, better-funded programs. Some of the basic building blocks for a nationwide tracking network are already in place, but need coordination to become an effective public health tool at a national level.

What is known about CBP toxicity to humans comes from close to 40 studies that have measured cancer, miscarriage, and birth defects rates among people drinking chlorinated tap water. The ability of researchers to identify effects from these studies has been compromised by the poor quality of the underlying data.

As a measure of people's exposure to CBPs, researchers are typically forced to rely on quarterly tests conducted by water suppliers for four CBPs called trihalomethanes (THMs), the testing required under federal drinking water regulations. For studies focused on pregnancy outcomes, researchers

Table 11. Ten states and Washington, DC keep records on fewer than ten percent of all birth defects

Either No Birth Defects Tracking or a Vital Records Based System that Misses 90% of the Cases		Only Passive** Birth Defects Surveillance		In the Process of Developing Birth Defects Surveillance
Idaho*	Oregon	Alaska	Missouri	Louisiana
Indiana	South Dakota*	Connecticut	Montana	Maine
Minnesota*	Vermont	Florida	Nebraska	Pennsylvania
New Hampshire*	Washington, DC*	Illinois	New Jersey	Rhode Island
North Dakota	Wyoming*	Kansas*	Virginia	
Ohio		Maryland	Washington	
		Massachusetts	West Virginia	
		Michigan	Wisconsin*	
		Mississippi		

Source: Environmental Working Group and U.S. PIRG.
** Based on data published in Teratology 2000 collected by CDC in May 1999.*
*** Passive surveillance involves limited data sources with little or no verification of the data.*

Ten states and Washington DC either have no birth defects surveillance system at all (five states plus DC), or track birth defects only through birth and death certificates, which misses 90 percent of the cases (five states).

might have just one THM test that would be used to represent a woman's CBP exposure over an entire trimester of pregnancy - and this THM concentration would be what was measured at the plant or in the distribution pipes, not at a person's kitchen faucet where she draws water to drink. For pollutants that change significantly in concentration seasonally and throughout the water distribution system, such as CBPs, quarterly monitoring by water suppliers will always be a poor measure of people's actual exposures.

Researchers are also hampered by the lack of data on health and pregnancy outcomes. One reason key miscarriage studies have been conducted in California is that the state has an agreement with Kaiser Permanente to collect basic information on pregnancy outcomes, including miscarriages. This is probably the best miscarriage database in the country, even though it is limited to California women under Kaiser Permanente health care plans, and is further limited to only those women who lose their babies after their first visit with an obstetrician at Kaiser - earlier miscarriages are not tracked.

The ultimate effect of inadequate health tracking data is that it takes far more time to tease out real health effects from exposures to toxic chemicals instead of, for example, three to five studies based on comprehensive data with replicate findings of adverse health effects, health authorities must wait for scores of studies with similar findings before regulatory decisions will withstand opposition from affected industries. The result is perhaps decades of exposure and health damage that could have been avoided with better information.

Despite the data limitations, studies show that CBP exposures are linked to increased rates of bladder cancer, neural tube defects, spontaneous abortion (early miscarriages), and low birth weight. Currently, none of these effects are sufficiently surveyed on a national and regional level. Data uncertainties have the effect of masking significant health effects in scientific studies, which makes the body of literature linking CBPs to a broad range of problems - cancers, birth defects, and miscarriages - even more compelling, and which also gives urgency to the need for a nationwide health tracking network that would allow scientists to more fully define the public health impacts of water chlorination.

Data Collection Methods

To assess the status of health tracking systems at the state level, in August 2001 EWG and U.S. PIRG researchers compiled information through telephone interviews with birth defects surveillance and vital records experts from all 50 states and Washington, DC. Forty states provided information during this data collection process. For the ten states that failed to respond, our conclusions on state health tracking systems rely on a Centers for Disease Control and Prevention (CDC) study updated in May 1999 (State Services Branch 2000). An update to this CDC study is scheduled for publication in Fall 2001.

Findings

Inadequate birth defects tracking: Only nine states have statewide, active, well-funded birth defects surveillance systems in place. Ten states and Washington DC either have no birth defects surveillance system at all (five states plus DC), or track birth defects only through birth and death certificates, which misses 90 percent of the cases (five states) (Tables 11 and 12). Universally throughout our study, we heard from state health departments that they want to do more, but are constrained by skimpy funding or even a complete lack of funds.

Nearly complete lack of early miscarriage tracking: Not a single state has an active, well-funded system in place to track spontaneous abortion (miscarriages that occur prior to week 20 of a pregnancy). California has a program to track all miscarriages among women whose healthcare provide is Kaiser Permanente, and Rhode Island and Virginia attempt to track a portion of the miscarriages in their states. Through our contact efforts with individual state health departments, we identified no other states that make a systematic effort to track miscarriages.

Lack of exposure data: Most studies of the health effects of CBPs have been limited by the fact that water suppliers are required to test for CBPs only four times a year, and of the more than 100 CBPs in public water supplies, only four chemicals called THMs are tested. For researchers studying first-trimester miscarriages, this means that just a single value for THMs is available to serve as a measure of a woman's exposure to the entire set of CBPs in her tap water through this critical period of pregnancy. In any study, limited exposure data will always tend to mask the full magnitude of health effects.

Birth defect surveillance

Birth defects are the leading cause of infant mortality in the U.S. Major birth defects are diagnosed for between three and four percent of all infants in their first year of life, and 8,000 of these infants die each year before their first birthday (Lynberg and Edmonds 1994), If both major and minor birth defects are considered, an estimated eight to 12 percent of all infants are affected (Pryor et al 2000). Chlorination byproducts are among the many environmental pollutants implicated as an underlying cause for some of these birth defects.

Studies show that some of the estimated 100,000 to 150,000 infants born each year with major birth defects may have been harmed in the womb from their mother's exposure to chlorinated tap water. Scientists have found elevated rates of a number of birth defects among babies born to women drinking chlorinated water, including lung and urinary track defects, neural tube defects, oral cleft defects, and major heart defects (Aschengrau et al. 1993, Bove et al. 1995, Dodds et al. 1999, Klotz and Pyrch 1999, and Magnus et al. 1999).

But scientists are uncertain of the number of infants potentially harmed by CBPs, or even the full extent of maternal CBP exposures, because the nation lacks basic exposure and pregnancy outcome data that would be vital in identifying potential causes of, and eventually preventive measures for, birth defects. A 1999 study by the Pew Environmental Health Commission found that state birth defect registries cover less than half of the U.S. population (Pew, 1999).

In their efforts to collect data on birth defects, state efforts progress from the use of birth or death certificates only (vital records), to newborn hospital discharge data, mandatory hospital reporting data, and records from clinics and healthcare facilities providing services to children with handicapping conditions. Some states attempt to record birth defects identified in the first year of life; other states track defects identified in children up to five or even 12 years of age.

Some states combine many data sources with follow-up phone calls and other verification methods in what is called an active system. Other states collect records and store them in a database with no active verification – these are called passive surveillance systems. States with active surveillance systems are estimated to capture up to 10 times the number of birth defects as a passive system based only on vital records (Lynberg and Edmonds 1994). Obviously, active surveillance systems require a much higher level of funding than passive systems; some states either have not prioritized or cannot afford a full, active program. Most state programs fall somewhere between passive and active.

Five states and Washington, DC have no birth defects tracking system in place whatsoever. Five states maintain birth defects registries based on birth and death certificates only, a method that a Centers for Disease Control and Prevention study shows misses an estimated 90 percent of all cases (Lynberg and Edmonds 1994). Only nine states maintain statewide, active, well-funded birth defects registries (Table 12).

Table 12. Only nine states have active, statewide birth defects tracking systems.

State	THM Data Electronic	Cancer Surveillance	Birth Defects Surveillance	Spontaneous Abortion Surveillance
Arizona	■	■	■	
Arkansas	■	■	■	
Hawaii	■	■	■	
Iowa	■	■	■	
Oklahoma	■	■	■	
South Carolina	■	■	■	
Texas	■	■	■	
Utah*	■	■	■	
Colorado	■	■	■	
California	■	■	F1	S
Alabama*	■	■	F2	
Delaware*	■	■	F3	
North Carolina	■	■	F3	
Kentucky	■	■	F3	
Georgia	■	■	F4	
New Mexico	■	■	F5	
New York	■	■	F6	
Tennessee	■	D	F7	
Nevada		■	F8	
Mississippi	■	■	P/FD	
Washington	■	■	P/FD	
West Virginia		■	P/FD	
Louisiana	■	■	FD	
Virginia		■	P	S
Massachusetts	■	■	P	
Alaska	■	■	P	
Connecticut	■	■	P	
Florida	■	■	P	
Illinois	■	■	P	
Kansas*	■	■	P	
Maryland	■	■	P	
Michigan	■	■	P	
Missouri	■	■	P	
Montana	■	■	P	
Nebraska	■	■	P	
New Jersey	■	■	P	
Wisconsin*	■	■	P	
Maine	■	■	PD	
Rhode Island	■	■	PD	S
Pennsylvania	■	■	D	
Indiana	■	■	VR	
North Dakota	■	■	VR	
Ohio	■	■	VR	
Oregon	■	■	VR	
Vermont	■	■	VR	
Idaho*	■	■		
New Hampshire*		■		
South Dakota*	■	D		
Washington, DC*	■	■		
Minnesota*	■	■		
Wyoming*	■	■		

Key and Notes

F#	= Surveillance program for a portion of the state or a subset of birth defects (see below)
P/FD	= Passive system in place and developing a full system
FD	= Full surveillance under development
P	= Passive surveillance
PD	= Currently developing a passive program
VR	= Vital record surveillance only (inadequate)
D	= In the process of developing a system, no other information available
S	= Some attempt at data collection

Full surveillance system**

F1	= limited to 11 counties, no surveillance over the rest of the state
F2	= limited to Mobile and Alabama counties, no surveillance over the rest of the state
F3	= limited to selected birth defects, passive for all other birth defects
F4	= Metro Atlanta only, no surveillance over the rest of the state
F5	= limited to NTDs, oral-facial clefts, and prenatal diagnoses, passive for all birth defects
F6	= limited to the Lower Hudson area, passive for the rest of the state
F7	= limited to selected state areas, no surveillance over the rest of the state
F8	= limited to Southern Nevada, passive for the rest of the state

*State health officials failed to provide requested information to EWG and U.S. PIRG. The data presented reflects information collected by the States Services Branch, Division of Birth Defects and Pediatric Genetics, Centers for Disease Control and Prevention and published in Teratology 61:33-85 (2000).

** "Full surveillance system" is defined here as a system based on active, population-based data collection methods. This requires phone calls, interviews, surveys, or other auditing techniques to be completed by state health officials.

■ State data is relatively complete. For birth defects, state has an active, population-based system in place.

State data includes only partial coverage. See legend for details.

Spontaneous abortions (early miscarriage) surveillance

Scientists estimate that between 43 and 78 percent of all fertilized eggs in women do not develop into surviving newborn babies. Some of these pregnancy losses occur very early, before the egg implants into the lining of the uterus. Among women whose pregnancies are sustained through egg implantation, 20 to 30 percent miscarry their babies. Yet physical and hospital records ultimately reflect only a 10 to 12 percent rate of pregnancy loss. These figures show that between 40 and 70 percent of all miscarriages happen outside a doctor's office or a hospital and never make it into the records (Pryor et al. 2000). And of the pregnancy losses recorded in official medical records, only a fraction are ultimately placed in state health department surveillance records.

With few exceptions, we found that states maintain records only on deaths among babies that are at least 20 weeks into gestation. For these babies, doctors and hospitals must file official "Fetal Death" certificates with the State – these records are maintained electronically by the States, typically at Vital Records offices. Yet about 90 percent of all miscarriages occur in the first trimester of pregnancy, well before doctors and hospitals are required to report the event to the state.

Chlorination byproducts have been linked to increased risks of first-trimester miscarriages (see, for example, Waller et al 1998). We found only three states that attempt to track first-trimester miscarriages (Table 12). The California health department maintains records on miscarriages that occur among women whose healthcare provider is Kaiser Permanente. This limited surveillance effort results in the most complete miscarriage database in the country, and was used in the Waller et al. study (1998).

Rhode Island enters miscarriage data from hospital discharge records, a method which captures fewer than ten percent of recognized miscarriages. Virginia is the only state we found with state legislation mandating a surveillance systems for all miscarriages, yet the health department lacks the funds to educate doctors and hospitals about the program, and the funds to administer the program, so the data are not being collected.

Cancer surveillance

Of all environmentally-linked health effects, cancer may be the effect with the best surveillance systems in place. Forty-eight states and Washington, DC have active cancer registries, many of which are currently being upgraded as a result of the 1992 national Program of Cancer Registries Act. The remaining two states (South Dakota and Tennessee) are in the process of developing registries (Table 12).

Cancer studies continue to be difficult to conduct, however, primarily because researchers lack critical data on exposure levels and complete data on residence history. For cancer, the chlorinated tap water a person drank 30 years ago may be responsible for the bladder cancer she is diagnosed with today. Researchers attempting to conduct epidemiology studies linking exposures to disease may have state-by-state cancer rate data, but the lack of exposure and residence data severly limits the power of the studies. All these data limitations tend to obscure finding results, and result in underestimates of the link between environmental contaminants and cancer.

Scientists need better data on CBP levels in public water supplies

Most studies of the health effects of CBPs have been limited by the fact that water suppliers are required to test for CBPs only four times a year, and of the more than 100 CBPs in public water supplies, only four chemicals called trihalomethanes (THMs) are tested. For researchers studying first-trimester miscarriages, this means that just a single value for THMs is available to serve as a measure of a woman's exposure to the entire set of CBPs in her tap water through this critical period of pregnancy. In any study, limited exposure data will always tend to mask the full magnitude of health effects.

Even after EPA's stronger regulations go into effect over the next several years, test results will be available for only up to 11 of the more than 100 known chlorination byproducts. The incomplete data will continue to limit scientists' understanding of the full extent of public health impacts from chlorination byproducts in tap water.

In our efforts to collect CBP data for tap water in all 50 states, we found that four states (Nevada, New Hampshire, Virginia, and West Virginia) maintain no electronic data whatsoever on testing of contaminant levels in public water supplies (Table 12). Many of the standard types of epidemiological studies would be impossible to conduct in these states.

Recommendations

To achieve this goal and protect the public from potential hazards of chlorination byproducts, we recommend the creation of a nationwide health tracking network to track Americans' exposure to chlorination byproducts and also the occurrence of birth defects, miscarriages, and other potential health effects of drinking tap water containing THMs and other chlorination byproducts.

A growing coalition of public health and environmental groups has requested that Congress appropriate money to the Centers for Disease Control and Prevention (CDC) to create a nationwide health tracking network (Trust for America's Health, 2001). A fully-functioning network is estimated to cost $275 million; at the time of printing, Congress appeared poised to appropriate $20 million as an initial down payment to start planning and creating the network. Lawmakers in the U.S. Senate and House of Representatives expect to introduce legislation in 2002, and to request significantly increased appropriations for the health tracking network. Through these processes, members of Congress will have an opportunity to support a proposal that would begin to close gaps in scientists' and policymakers' knowledge of environmentally-linked diseases, and provide health officials and health care providers with tools to act proactively to prevent CHRONIC disease.

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Appendix A: Data sources - state drinking water authorities and U.S. EPA

In May 2001, EWG requested data from each of the 50 state agencies that collects and monitors data on tap water for their state. Analysts followed up with phone calls and e-mails to all 50 states and over the next four months received usable data from 31 states and the District of Columbia. Data from water systems serving more than half the population of 10 additional states were obtained from the U.S. EPA. For the remaining nine states we obtained limited data from U.S. EPA representing less than half the population in each state.

The data analyzed in this study represent trihalomethane (THM) levels in 26,773 public water systems from 50 states and the District of Columbia for the years 1995 through 2001. These 26,773 systems represent 51 percent of all community water suppliers nationwide, and serve 80 percent of the U.S. population. Of these, 17,310 water suppliers provided data from more than a single sampling date; these water suppliers are the focus of the analysis in this study. Data from states with unusually high THM levels, like Texas, Missouri, and Pennsylvania were verified through phone conversations with state officials. Data coverage is illustrated on Table A-1 and Figure A-1.

When available, Environmental Working Group incorporated drinking water test result data provided by the appropriate state drinking water management authorities. Our request for data caught many states unprepared because state resources for database management are limited in both time and money. We greatly appreciate the effort exerted by the following state authorities that provided useful data:

Alabama Department of Environmental Management, Drinking Water Branch

Arizona Department of Environmental Quality, Water Quality Division

Arkansas Department of Health, Environmental Health Services

California Department of Health Services, Drinking Water Program

Delaware Health and Social Services, Division of Public Health

District of Columbia, US Army Corps of Engineers, Washington Aqueduct Water Quality Division

Florida Department of Environmental Protection, Water Office

Hawaii Department of Health, Safe Drinking Water Branch

Illinois Environmental Protection Agency, Bureau of Water

Indiana Department of Environmental Management, Office of Water Quality

Iowa Department of Natural Resources, Water Supply Section

Maryland Department of the Environment, Water Management Administration

Massachusetts Department of Environmental Protection, Drinking Water Program

Minnesota Department of Health, Drinking Water Protection Section

Missouri Department of Natural Resources, Public Drinking water Program

Montana Department of Environmental Quality, Public Water Supply Section

Nebraska Department of Health and Human Services, Regulation and Licensure, Environmental Health Services

New Jersey Deptartment of Environmental Protection, Bureau of Safe Drinking Water

New York Department of Health, Water Quality Division

North Dakota Department of Environmental Quality, Water Quality Division

Ohio Environmental Protection Agency, Division of Groundwater and Drinking Water

Oklahoma Department of Environmental Quality, Water Quality Division

Oregon Department of Human Resources, Drinking Water Program

Pennsylvania Department of Environmental Protection, Bureau of Water Supply

Rhode Island Department of Health, Division of Drinking Water Quality

South Carolina Department of Health and Environmental Control, Bureau of Water.

South Dakota Department of Environment & Natural Resources, Drinking Water Program

Tennessee Department of Environment & Conservation, Division of Water Supply

Texas Natural Resource Conservation Commission, Water Utilities Division

Washington Department of Health, Division of Drinking Water

Wisconsin Department of Natural Resources, Bureau of Water Supply

Wyoming, EPA Region VIII, Wyoming Drinking Water Program

We also appreciate the efforts of water suppliers for the following communities or counties, each of whom provided electronic data when we found state databases incomplete: San Francisco; Topeka, Kansas; Newport News, Virginia; and San Bernardino County, California (Water Facilities Authority).

These data sources were significantly more robust than the Safe Drinking Water Information System database maintained by U.S. EPA. For those states that provided data to our project, EWG exclusively used the state provided data in place of SDWIS data. The data was subject to the QA/QC analysis routine below.

Information Collection Rule

Additional data for water suppliers serving more than 100,000 people were obtained from U.S. EPA's Information Collection Rule (ICR) database. The Information Collection Rule (ICR) was promulgated in 1996 to support regulation of microbial contaminants, disinfectants, and disinfection byproducts. The data were collected from 296 public water systems each serving at least 100,000 people, from July 1997 to December 1998. Along with increased monitoring, a total of 99 treatment studies were conducted under the ICR to evaluate disinfection byproduct precursor removal with evaluating either granular activated carbon or nanofiltration. The collected data and research will be used to develop the Stage 2 Disinfectants/Disinfection Byproducts Rule by May 2002 to help further control disinfection byproducts. Several states did not participate in the ICR: Montana, North Dakota, Vermont, and Wyoming.

Environmental Working Group has included ICR data in the analysis of THMs. The use of the data was limited to distribution system averages as computed in the ICR database and the simulated distribution system (SDS) results. Since the data has been verified prior to release to EWG, no additional QA/QC was preformed on this data.

Safe Drinking Water Information System / Federal Version

Finally, wherever state data were not available, our study database was populated from EPA's Safe Drinking Water Information System / Federal Version (SDWIS), a database maintained by EPA to oversee and manage the Safe Drinking Water Act (SDWA). With respect to chlorination byproducts testing results, SDWIS contains limited information according to what data has been provided by the states and EPA regions. The data submitted to SDWIS varies in quality and quantity by state and also has a substantial time lag in data entry. Thus, Environmental Working Group has included SDWIS only in the absence of state provided data sources. This data was subjected to the QA/QC analysis routine described below.

Quality Assurance / Quality Control

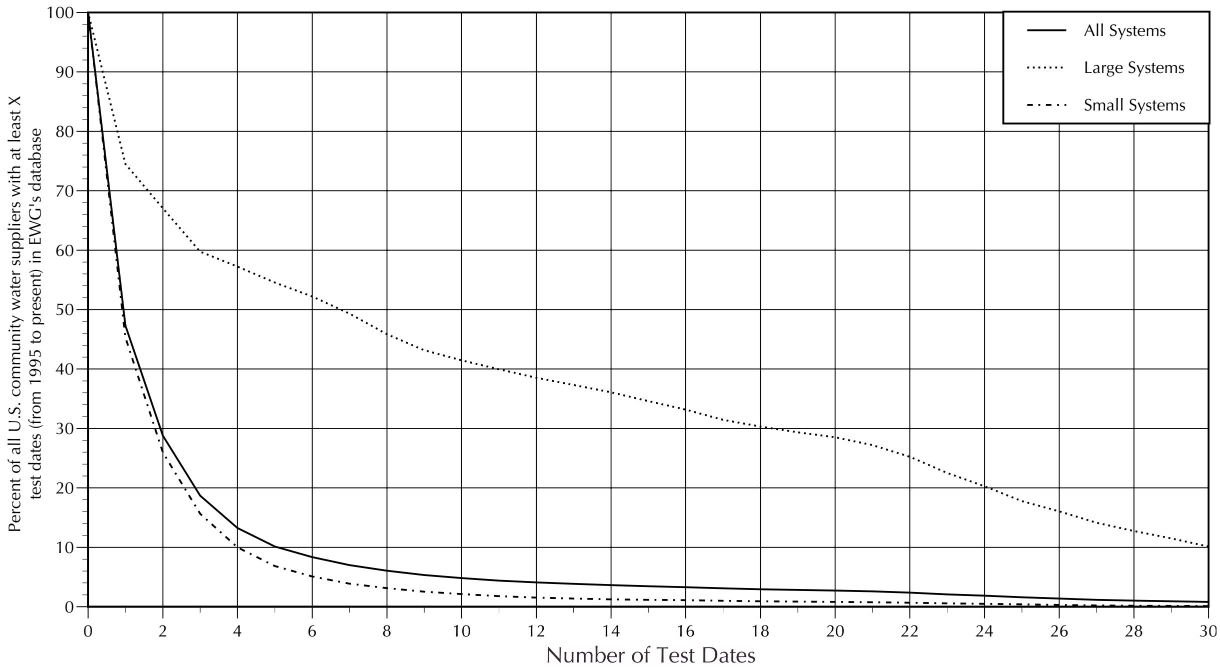
Data from states with unusually high THM levels, like Texas, Missouri, and Pennsylvania, were verified through phone conversations with state officials. Some data were struck from the database or corrected as a result of these conversations. Additionally, EWG has applied other quality control procedures to minimize errors inherent in the databases. Sample results were removed from the THM database if the TTHM value was significantly different from the system mean. These points may have been data entry errors and differed from all other sample results for that water supplier by two or three orders of magnitude. If these removed values are actually valid results, our quality assurance procedure would lead to an underestimate of the threat posed by THMs for a particular water system. Although all care was taken to ensure the quality of the data, ultimately we are limited by the care that water suppliers and states take to ensure the quality of data in their electronic databases.

Table A-1. EWG obtained on chlorination byproduct levels in tap water from 29 state agencies, Washington DC, and the U.S. EPA covering 70 percent of the U.S. population.

	Small Community Water Suppliers (serving <10,000 people)		All Community Water Suppliers (serving at least 25 people)	
	Number of Systems (Percent of all Small Systems) Represented in EWG Database	Population Served (Percent of Population Drinking from Small Suppliers)	Number of Systems (Percent of all Systems) Represented in EWG Database	Population Served (Percent of all People Drinking from Public Suppliers)
All water suppliers that reported THM test results on at least 2 days	12,855 (26%)	18,266,347 (36%)	15,328 (29%)	174,680,079 (68%)
All Systems that reported only one THM test result	8,890 (17%)	7,862,584 (16%)	9,136 (17%)	15,985,365 (6%)
State data coverage of systems reporting THM test results on at least two (2) distinct dates				
Alabama	293 (60.9%)	936,244 (66.1%)	376 (65.4%)	4,223,222 (85.5%)
Alaska	353 (81.1%)	206,305 (93.5%)	360 (81.4%)	427,379 (96.8%)
Arizona	499 (62.9%)	491,143 (81.1%)	545 (64.7%)	4,246,498 (96.6%)
Arkansas	18 (2.6%)	107,406 (10.0%)	53 (7.3%)	1,125,526 (49.8%)
California	554 (15.6%)	1,455,203 (53.4%)	892 (22.5%)	30,058,603 (86.7%)
Colorado	125 (15.9%)	88,500 (14.6%)	147 (17.5%)	2,451,931 (63.8%)
Connecticut	48 (8.4%)	174,211 (55.8%)	80 (13.2%)	2,364,714 (89.3%)
Delaware	96 (41.9%)	75,707 (62.7%)	100 (42.7%)	532,507 (88.0%)
District of Columbia	0 (0.0%)	NA (NA)	1 (50.0%)	595,000 (100.0%)
Florida	60 (3.3%)	127,621 (7.2%)	130 (6.3%)	8,698,023 (55.5%)
Georgia	0 (0.0%)	0 (0.0%)	7 (0.4%)	2,195,712 (33.5%)
Hawaii	4 (3.6%)	21,961 (11.4%)	18 (14.4%)	1,100,819 (85.6%)
Idaho	0 (0.0%)	0 (0.0%)	1 (0.1%)	186,000 (20.5%)
Illinois	474 (29.6%)	1,022,831 (44.2%)	671 (37.3%)	9,611,027 (88.1%)
Indiana	179 (20.9%)	404,567 (33.7%)	224 (24.4%)	3,026,099 (73.5%)
Iowa	151 (13.5%)	272,707 (25.7%)	182 (15.8%)	1,547,692 (62.4%)
Kansas	0 (0.0%)	0 (0.0%)	4 (0.4%)	927,487 (37.8%)
Kentucky	130 (34.5%)	430,296 (38.1%)	151 (31.6%)	1,866,421 (43.2%)
Louisiana	105 (8.8%)	312,713 (19.9%)	148 (11.8%)	3,157,688 (63.3%)
Maine	345 (88.0%)	252,034 (92.8%)	358 (88.4%)	591,986 (96.8%)
Maryland	4 (0.8%)	18,644 (5.1%)	34 (6.6%)	4,270,287 (92.5%)
Massachusetts	106 (29.9%)	404,962 (57.4%)	227 (44.2%)	6,577,429 (76.1%)
Michigan	252 (18.7%)	412,972 (28.0%)	299 (20.3%)	3,299,342 (46.8%)
Minnisota	575 (65.5%)	678,231 (74.8%)	650 (68.1%)	3,584,428 (93.5%)
Mississippi	34 (2.9%)	54,806 (3.2%)	48 (3.9%)	626,771 (21.8%)
Missouri	798 (57.5%)	734,147 (52.9%)	849 (58.9%)	3,998,900 (84.8%)
Montana	536 (73.5%)	311,848 (86.6%)	544 (73.8%)	643,381 (93.0%)
Nebraska	69 (11.0%)	123,713 (26.6%)	79 (12.4%)	1,025,716 (73.0%)
Nevada	0 (0.0%)	0 (0.0%)	2 (0.7%)	632,000 (40.0%)
New Hampshire	0 (0.0%)	0 (0.0%)	1 (0.1%)	128,000 (16.8%)
New Jersey	403 (86.5%)	678,375 (83.8%)	526 (86.8%)	7,256,528 (93.5%)
New Mexico	434 (69.8%)	319,957 (72.4%)	456 (70.6%)	1,333,812 (88.0%)
New York	89 (3.2%)	109,128 (5.2%)	96 (3.2%)	446,487 (2.5%)
North Carolina	249 (11.0%)	361,101 (23.7%)	306 (13.0%)	3,424,966 (59.3%)
North Dakota	9 (2.9%)	47,125 (20.2%)	19 (5.9%)	357,775 (64.4%)
Ohio	1,031 (81.3%)	1,313,138 (78.6%)	1,170 (81.9%)	8,792,614 (88.8%)
Oklahoma	432 (36.8%)	666,249 (56.5%)	476 (39.0%)	2,879,179 (84.5%)
Oregon	130 (15.7%)	128,347 (22.2%)	157 (17.8%)	1,574,083 (57.5%)
Pennsylvania	119 (5.8%)	287,323 (14.6%)	266 (12.1%)	8,820,682 (84.0%)
Rhode Island	56 (84.8%)	36,910 (45.0%)	71 (85.5%)	779,157 (82.0%)
South Carolina	25 (3.9%)	128,062 (16.1%)	74 (10.6%)	2,313,351 (70.5%)
South Dakota	0 (0.0%)	0 (0.0%)	8 (1.7%)	281,782 (43.8%)
Tennessee	243 (45.8%)	744,736 (60.1%)	331 (52.4%)	4,377,029 (85.8%)
Texas	2,026 (46.9%)	3,071,303 (57.9%)	2,284 (49.9%)	18,685,894 (89.3%)
Utah	0 (0.0%)	0 (0.0%)	4 (0.8%)	1,329,835 (39.6%)
Vermont	329 (72.9%)	225,019 (73.6%)	337 (73.4%)	414,839 (83.7%)
Virginia	0 (0.0%)	0 (0.0%)	6 (0.4%)	2,092,566 (31.7%)
Washington	1,485 (67.4%)	1,007,304 (84.3%)	1,576 (68.7%)	4,838,998 (95.9%)
West Virginia	0 (0.0%)	0 (0.0%)	1 (0.2%)	173,005 (9.7%)
Wisconsin	1,896 (174.9%)	1,150,914 (109.3%)	1,952 (169.9%)	3,533,846 (96.9%)
Wyoming	5 (2.0%)	18,250 (9.8%)	13 (5.0%)	235,042 (58.4%)

Source: Environmental Working Group analysis of state and federal tap water testing data.

Figure A-1. Number of test dates available for each water system.



Source: Environmental Working Group analysis of state and federal tap water testing data.

Appendix B: Methodology for exposure assessments

Water System Averages

Computation of water system averages was completed based on a systemwide, time-weighted mean.

$$\overline{\text{THM}} = \frac{\sum_i (t_i \times \text{THM}_i)}{\sum_i t_i} \qquad \text{(Equation 1)}$$

where t is time, i represents an individual test date, and THM is the systemwide average total trihalomethane level in parts per billion (ppb) with the following boundary conditions:

$$t_i = 0.5 \times (date_{i+1} - date_{i-1}) \qquad \text{(Equation 2)}$$
$$t_0 = date_0 - date_1 \qquad \text{(Equation 3)}$$
$$t_n = date_n - date_{n-1} \qquad \text{(Equation 4)}$$

This method for computing a long-term average removes the problem of overweighing data clusters. It also conforms to the method that will be employed in the Stage 1 D/DBP rule for computing annual average THM levels.

Pregnancies at increased risk for birth defects and miscarriages

Pregnancies at increased risk were computed as the likelihood that a woman drinking water from a particular water supplier would be served tap water with THMs exceeding 80 ppb for at least one trimester (or three months). According to the U.S. Census, approximately 4.0 million children were born in the U.S. last year to a population of approximately 276 million people. This translates to an estimated 14 pregnancies per 1,000 people per year in the U.S. Thus, we were able to estimate the number of pregnancies exposed to high THMs for an entire trimester.

$$\text{Pregnancies at risk per year} = \left(\text{percent of pregnancies at risk}\right)\left(0.014 \frac{\text{pregnancies}}{\text{person year}}\right)\left(\text{population served by the water supplier}\right) \qquad \text{(Equation 5)}$$

$$\text{Percent of pregnancies at risk} = \frac{\left(\text{number of days since 1995 with a 3-month TTHM average exceeding 80 ppb during the subsequent 9 months}\right)}{\left(\text{number of days since 1995 with any TTHM test results during the subsequent 9 months}\right)} \qquad \text{(Equation 6)}$$

County Averages

County averages account for all water systems for which EWG has obtained data within the county. To account for the various population sizes served within the county, EWG computed the population-weighted average.

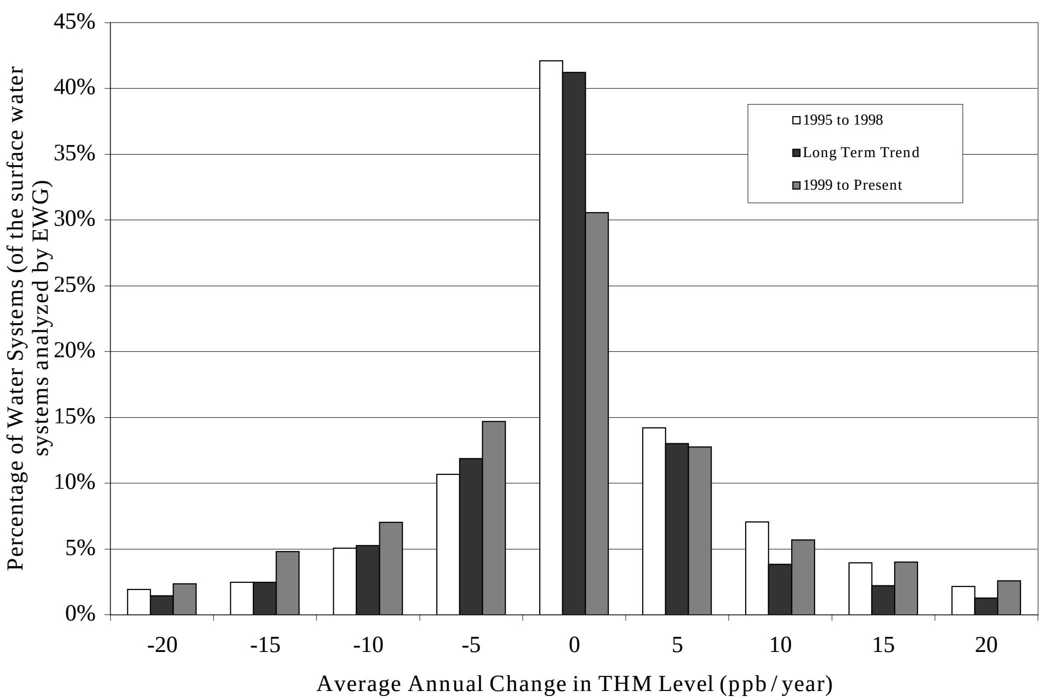
$$\text{County Average} = \frac{\sum_i (P_i \times K_i)}{\sum_i P_i} \qquad \text{(Equation 7)}$$

where P is the population served by each water system and K represents the quantity being averaged for the county. For the production of maps in the state reports, K represents the long term THM average as an estimate of cancer risks or percentage of pregnancies at increased risk for miscarriages and birth defects.

Trend Analysis

To assess the validity of considering data spanning 1995 to present, we conducted an analysis to determine if THM levels have changed significantly during this period. A simple least-squares analysis was performed for each of the more than 15,000 water systems analyzed for the entire time period of record as well as the early and late periods. We found no evidence of systematic changes in THM levels. On average, levels remained unchanged over the period of analysis (Figure B-1).

Figure B-1. On average, trihalomethane (THM) levels in public water systems remained unchanged from 1995 to present.



Source: Environmental Working Group analysis of state and federal tap water testing data. Based on a least squares trend analysis of available THM levle for each surface water system analyzed.

Appendix C: The regulation of chlorination byproducts

Early 1900's: Water suppliers begin the practice of chlorinating public water supplies.

1974: Chlorination byproducts are discovered in chlorinated tap water.

1979: People served by large water systems are for the first time protected against high levels of chlorination byproducts when EPA promulgates a drinking water standard for four DBPs called trihalomethanes (THMs). The allowable level is set at 100 parts per billion (ppb), calculated as the running annual average of the total THM concentration. The regulations apply only to water systems serving more than 10,000 people and using surface water as a water source. Short-term spikes up to hundreds of parts per billion remain legal. Small systems, which provide tap water to about 20 million people, remain completely unregulated.

Today: EPA's 1979 regulations are still in place, but the Agency has finalized stricter standards set to go into effect between 2002 and 2004. EPA calculates that these new standards will cost taxpayers $2.3 billion up front, and $684 million each year thereafter (EPA 2001) to control the toxic byproducts of chlorination, and the agricultural and urban pollutants that are their precursors. Upstream polluters pay none of the costs.

2002: Large water systems will be subject to a clampdown on allowable THM levels, and new standards for up to seven other chlorination byproducts. The allowable level for total trihalomethanes will decline from 100 ppb to 80 ppb, as an annual running average. Large water systems will also be required to meet new standards for seven chlorination (or ozonation) byproducts being regulated for the first time – five haloacetic acids, bromate (for plants that disinfect with ozone), and chlorite (for plants that disinfect with chlorine dioxide). Also for the first time, large water systems will be required to filter out some of the organic precursors to chlorination byproducts, with between 15 and 50% removal required. Short-term spikes of trihalomethanes up to hundreds of parts per billion remain legal. Small water suppliers remain completely unregulated.

2004: The 20 million people served by small water systems will for the first time receive federal protections from high levels of chlorination byproducts. Small water systems will be required to comply with regulations to control chlorination byproducts that have until now applied only to systems serving more than 10,000 people. Total trihalomethanes, five haloacectic acids, bromate, chlorite, and organic precursors to chlorination byproducts will all be regulated at the same levels that apply to large water systems. Short-term, high spikes of all these compounds will remain legal.

2005-2007 (estimated): Three to five years after EPA promulgates what are called the "Stage 2" disinfection byproduct rules, people drinking from public water supplies will, for the first time, get some protection from high levels of chlorination byproducts that can form as treated water travels down the pipes of the distribution system. Up until now, allowable levels for chlorination byproducts have been based on the yearly average level over the entire water distribution system (80 ppb for THMs and 60 ppb for haloacetic acids). But levels of chlorination byproducts change as water travels through the distribution system, so people receive different levels of protection depending on how close they live to the water treatment plant. THMs increase as water travels down the pipes, while haloacetic acid (HAA) levels tend to be highest nearest the treatment plant. Now, no matter where people are served from the distribution system, the average levels of THMs and HAAs in their water cannot be more than 50 or 67 percent higher, respectively, than the system-wide averages of 80 and 60 ppb.

2008-2012 (estimated): EPA rules will provide further protection from high levels of DBPs between 6 and 10.5 years after Stage 2 rules are promulgated. In theory, by 2012 all customers of public water suppliers will be served water with THM and HAA levels less than 80 and 60 ppb, respectively, based on an annual average.

After 2012 – What is left undone?

Still legal – Agricultural and urban pollution of drinking water supplies that leads to the formation of chlorination byproducts in tap water.

Still legal – The presence of over 100 chlorination byproducts in tap water, most of them largely unstudied for their potential to harm human health.

Still legal – Seasonal spikes - hundreds of parts per billion – of total trihalomethanes and other chlorination byproducts. Major studies of pregnant women drinking chlorinated tap water show that short-term exposures to high levels during a single trimester of pregnancy increase the risk for miscarriage and birth defects.

Still unregulated – Most chlorination byproducts. The regulated byproducts, trihalomethanes and haloacetic acids, form the bulk of byproducts in tap water, but scientists are uncertain exactly which of the more than 100 individual identified chlorination byproduct chemicals might be responsible for the cancers, miscarriages, and birth defects observed in numerous studies of people drinking chlorinated tap water. Classes of chlorination byproducts that remain unregulated: haloacetonitriles, haloaldehydes, haloketones, halohydroxyfuranones, aldehydes, ketones, and carboxylic acids.

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