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MTBE in California's Drinking Water: A Comparison of Groundwater Versus Surface Water Sources

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During the last decade, the fuel oxygenate methyl tertiary butyl ether (MTBE) has received widespread attention as a potential threat to water quality, primarily due to leaking underground gasoline storage tanks and watercraft with two-stroke engines. In this article, we examine the annual detection frequency, number of new source detections, and concentration of MTBE detected in California's public drinking water groundwater and surface water sources from 1995 to 2002. This work builds on our previous evaluations of California's water quality monitoring database. However, it is unique in that it includes separate evaluations for groundwater and surface water sources that are of greatest concern to regulators, and which are likely being used for current public consumption. Our evaluations also include full-year data for 2002 (which have not been published previously) and an analysis of how the sampling and reported detections of MTBE vary by geographic location. We find that MTBE was generally detected (at any level) in approximately 0.5–0.9% and 0.2–0.4% of all groundwater sources assuming a one-detection and two-detection criterion, respectively. The overall detection frequency for MTBE in surface water sources is significantly higher than for groundwater sources, although these surface water detections appear to have substantially declined since 1996 (e.g., 7–9% for all surface water sources during 1996 to 1999 and 4% for all surface water sources during 2000 to 2002, assuming a one-detection criterion). The detection frequency of MTBE concentrations at or above the state drinking water standards in all drinking water sources (both groundwater and surface water sources) and the subset of drinking water sources that are likely to currently be delivered to consumers is markedly lower (and often zero). Despite the significant increase in water sampling over time, the number of new drinking water sources found to contain MTBE in California has not increased at the same rate and appears to have remained relatively stable or to have decreased since 1998. The data also show that nearly all of the 58 counties in California have routinely sampled at least some of their groundwater and surface water sources for MTBE over the last 8 years. Geographical evaluations show that MTBE has been detected (at least once) in groundwater sources in 34 counties and in surface water sources in 18 counties but has only been detected routinely (i.e., for 3 or more years) in 16 and 7 counties, respectively. Detected concentrations of MTBE are also generally below state drinking water standards, particularly for surface water sources. In short: (1) MTBE is rarely found in California groundwater or surface water sources that are of greatest concern to regulators or the public, and (2) drinking water detections of MTBE are expected to decline in the future due to the pending phase-out of MTBE and recent regulatory programs aimed at controlling gasoline releases from underground storage tanks and two-stroke-engine watercraft.

Keywords: MTBE, groundwater, surface water, gasoline, underground storage tanks, two-stroke engines

Introduction

Over the last decade, the fuel oxygenate methyl tertiary butyl ether (MTBE) has received widespread attention as a potential threat to water quality in the United States. The use of MTBE as a fuel additive was originally intended to improve air quality under the 1990 Clean Air Act Amendments, but detections of MTBE in some drinking water sources have raised concerns about the continued use of this oxygenate in gasoline (NSTC, 1997; UC, 1998; NESCAUM, 1999; U.S. EPA, 1999). On a national basis, MTBE has been cited as one of the most frequently detected volatile organic compounds (VOCs) in untreated ambient groundwater or drinking water, and there are claims that this chemical may pose a significant long-term threat to drinking water supplies (Happel et al., 1998; Squillace et al., 1999; Johnson et al., 2000; Grady and Casey, 2001). In California, some drinking water sources have been closed due to the presence or possible threat of MTBE (U.S. EPA, 2000; Jones, 2002; Perkins, 2002), and these findings, in conjunction with recommendations from a University of California report (UC, 1998), have resulted in the Governor of California issuing a statewide ban on the use of MTBE in gasoline to be effective by the end of 2002 (later extended to the end of 2003) (CARB, 1999, 2002; Davis, 1999).

Studies suggest that the primary source of MTBE drinking water contamination in groundwater is leaking underground gasoline storage tanks (e.g., liquid and possible vapor releases)

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(Happel et al., 1998; Davidson and Creek, 1999; Malcolm Pirnie, Inc., 1999; White, 1999; Johnson et al., 2000; Stephenson, 2002) and in surface water is watercraft with two-stroke engines, which release unburned gasoline directly into the environment (TRPA, 1999; Dale et al., 2000; CARB, 2001; USGS, 2001). Several reports also suggest that recently instituted regulatory programs should help to control these sources of gasoline releases, which will ultimately lead to decreased contamination of groundwater and surface water by MTBE (Malcolm Pirnie, Inc., 2001; White, 2001; Exponent and AES, 2002). For example, the U.S. Environmental Protection Agency initiated a 10-year program in 1988 to upgrade, replace, or close selected underground storage tanks, which is expected to greatly minimize the frequency of gasoline leaks over time (U.S. EPA, 1988). Indeed, as part of the federal underground tank program, about 1.5 million unsafe tanks have been closed and 270,000 leaks have been cleaned up (Horinko, 2002). Approximately 89% of all regulated tanks in the U.S. are also estimated to have received federally required equipment upgrades by the end of 2000 (GAO, 2001) and about 8 in 10 tanks are now believed to be in compliance with federal regulations (Horinko, 2002). A similar compliance program was initiated in California in 1998, and as of June 2002 over 95% of underground storage tanks in the state were found to be in compliance with the 1998 system standards (Exponent and AES, 2002). In regard to surface waters, the State of California has adopted new marine engine standards for outboard engines, personal watercrafts, and jet boats (CARB, 2001), and some regional water quality boards have initiated resolutions to ban two-stroke engines from selected water bodies (TRPA, 1999). These initiatives are expected to result in fewer surface water detections of MTBE.

Despite the anticipated progress of these programs, there remains some concern that MTBE has had or will have a significant impact on public drinking water sources served by groundwater or surface water in California and elsewhere. Groundwater aquifers or wells in particular are often touted as the primary water type that will be most affected by MTBE, although approximately 60–70% of California's drinking water is derived from surface water sources. To date, however, there has been little attempt to characterize the overall extent of MTBE drinking water contamination (specifically for groundwater versus surface water sources) or to evaluate how MTBE groundwater and surface water detections have changed over time or by geographic region. Such analyses would likely be useful for determining the relative contribution of the primary sources of MTBE drinking water detections (e.g., underground storage tanks versus watercraft with two-stroke engines) and for tracking the success of regulatory programs aimed at reducing MTBE groundwater and surface water detections.

To examine these issues further, we evaluated the annual detection frequency, number of new source detections, and detected concentration of MTBE in California's groundwater and surface water sources of public drinking water from 1995 to 2002. Although this work builds on some of our previous evaluations of California's water quality monitoring database in which we characterized drinking water detections and potential exposures and health risks from MTBE and other VOCs in public drinking water sources (Williams, 2001; Williams et al., 2000, 2002), it presents new data as well as results from a number of unique (and not previously published) analyses:

1. This article includes California water sampling data for full-year 2002.
2. The article's focus is on MTBE detections specifically in groundwater versus surface water sources of drinking water (most reported MTBE results are based on combined groundwater and surface water data).
3. Separate evaluations compare MTBE detections at any concentration to MTBE detections that are of greatest concern to regulators and the public (i.e., detections that exceed state drinking water standards).
4. Separate evaluations compare MTBE detections at all points of the distribution system (e.g., raw and treated) and in all drinking water sources (e.g., active and inactive) to MTBE detections in drinking water that is likely to be used for current public consumption.
5. Time-series data on the number of new groundwater or surface water sources found to contain MTBE are presented (most reported MTBE results do not distinguish between total versus new source detections).
6. This article characterizes how the sampling and reported detections of MTBE in groundwater and surface water sources vary geographically in California over time.

All of these analyses provide greater insight into the nature and extent of MTBE drinking water contamination in California.

Methods

For the current analysis, we obtained the most recent version of the California Department of Health Services (CDHS) drinking water monitoring database on MTBE and other contaminants (CDHS, 2003). The data set for MTBE contains approximately 65,000 groundwater samples and 5,500 surface water samples collected from April 10, 1995, to December 31, 2002. These data represent samples collected from approximately 10,400 and 750 distinct groundwater and surface water sources, respectively. Note that the current analysis focuses on drinking water sources (each of which can contain multiple samples and can be a part of a larger drinking water system), because these data are believed to be the most representative of MTBE drinking water detections on a statewide or regional basis. Although MTBE sampling data are not available for all water sources in California, the data that had been collected as of November 2002 represent drinking water systems that collectively serve more than 92% of the state's population (CDHS, 2002).

Database Management

Although the CDHS (2003) database contains sampling records for both "detect" and "nondetect" MTBE samples, there are a number of errors and inconsistencies in the coding of these samples that requires additional quality control (QC) measures prior to their use. Consequently, the CDHS (2003) MTBE sampling data were recoded in the same manner as in our previous evaluations (Williams, 2001; Williams et al., 2002) when confronted with uncertainty about "detect" or "nondetect" MTBE samples. Specifically, MTBE samples were coded as nondetects if: (1) the XMOD field contained a "$<$" sign, (2) the XMOD field was blank or 0 and the FINDING field was blank or 0, or (3) the XMOD field contained a "–" sign and the FINDING field contained a value of 0.5 ppb or 5 ppb (which is assumed to be the analytical limit of detection).[1] MTBE samples were coded as detects if the XMOD field was either blank or 0 and the FINDING field contained a positive value. All of these methods for coding data were based on prior analyses and discussions with the CDHS database manager (Williams, 2001).

For the purposes of the current analysis, we relied only on sampling data for drinking water sources classified as groundwater (G) or surface water (S) in the WATER_TYPE field. Mixed (M) drinking water sources, which are composed of both groundwater and surface water sources, were not included because the focus of this analysis was specifically on groundwater versus surface water. False positive (FP) samples and groundwater sources never used for public consumption (i.e., monitoring and agricultural/irrigation wells) were also excluded from the analysis. Based on these criteria, 72 drinking water sources that were sampled for MTBE from 1995 through 2002 were excluded from further evaluation (see Table 1).

Of the remaining 10,359 groundwater and 749 surface water sources, more than half represent "active raw drinking water." According to the State of California, "raw drinking water" is unfinished water that must first be treated before it is delivered to consumers (this differs from untreated drinking water, which already meets state drinking water requirements and does not require any treatment before human consumption). Most of the other drinking water sources included in the evaluation are currently classified as "active treated" or "active untreated." Drinking water that is rarely or only periodically in use includes sources currently classified as "inactive" (i.e., not in service for periods of one year or greater) or "on standby" (i.e., used less than 15 calendar days per year), while drinking water that has been classified as "abandoned" or "destroyed" is no longer used for public consumption. Approximately 10% or less of the drinking water sources included in the current evaluation are classified according to one of these latter categories. It is important to recognize that the status of a drinking water source can vary over time (e.g., an active source becomes inactive or on standby) and the CDHS (2003) database only provides the current status classification for each drinking water source (Table 1).

[1] In the CDHS (2003) database, the XMOD field corresponds to a finding of "detect" or "nondetect," which is represented graphically by a "$<$" symbol (the symbol is supposed to represent a nondetect sample). The FINDING field depicts the actual concentration of MTBE that is measured in a detect sample or depicts the analytical limit of detection (LOD) of the nondetect sample. Of the approximate 70,000 samples, only 12% have a reported LOD, with the most frequently reported LODs being 0.5 μg/L, 3 μg/L, and 5 μg/L.

Table 1. *Number of drinking water sources sampled for MTBE in California by water type from 1995 to 2002*

	Number of sources sampled		
	Groundwater	Surface water	Total
Included in current analysis			
Active—treated or untreated[a]	3,663	235	3,898
Active—raw[a]	5,327	476	5,803
Inactive[b]	696	26	722
Standby[b]	388	9	397
Abandoned	143	2	145
Destroyed	142	1	143
Total included	10,359	749	11,108
Excluded from current analysis			
Mixed water	NA	NA	22
Monitoring wells	15	NA	15
Agricultural/irrigation wells	30	5	35
Total excluded	45	5	72

[a] Includes sources classified as active, combined or distribution.
[b] Includes sources classified as raw, treated and untreated.

Data Evaluation

Several different approaches were used to evaluate the groundwater and surface water source data based on a set of predetermined criteria. These are described briefly below.

One-Detection versus Two-Detection

All evaluations were conducted using either a "one-detection" or a "two-detection" criterion. The one-detection criterion assumes that a drinking water source contains MTBE if it is detected only once in given year or time period. The two-detection criterion assumes that a drinking water source contains MTBE if it is detected at least twice in the same year or time period. Our previous estimates of the detection frequency for MTBE were based only on a one-detection criterion, although the State of California and some other researchers have historically relied on a two-detection criterion (Malcolm Pirnie, Inc., 2001; CDHS, 2002). It should be noted that a single detection of MTBE at a very low concentration may represent a false positive result or transient impact on a drinking water source, whereas the double detection of MTBE in a drinking water source would provide more confirmatory evidence of water contamination.

Any Concentration versus Concentration Greater than State Standards

Some evaluations were based on all drinking water sources that were found to contain MTBE regardless of the detected concentration in water, while other evaluations were based only on those drinking water sources with detectable levels of MTBE at or above California's primary or secondary maximum contaminant level (MCL) of 13 μg/L and 5 μg/L, respectively. Prior evaluations of the MTBE water quality monitoring database in California have tended to focus on MTBE drinking water detections at any concentration. Evaluations based on the 13 μg/L and 5 μg/L cutoff criteria, however, represent drinking water conditions of greatest concern to regulators (and ultimately consumers) in California because they are based on health-risk and aesthetic (i.e., taste and odor) considerations, respectively.

All Drinking Water versus Drinking Water Likely to Reach Consumers

Some evaluations were based on all drinking water sources regardless of their current status, while other evaluations were based only on those drinking water sources that are likely to be used for current public consumption. Specifically, the first data set includes both currently active and inactive drinking water sources that are raw, treated, or untreated, as well as those sources that have been abandoned and destroyed (all possible drinking water sources). The second data set excludes all drinking water sources for which the water is not actually delivered to consumers (i.e., raw water) or is no longer or only rarely in use (i.e., sources that are inactive, on standby, abandoned, and destroyed). None of the prior estimates of the detection frequency for MTBE appear to have excluded data for drinking water that is currently unlikely to reach consumers. The primary rationale for excluding these data is to develop a data set that is more representative of current exposures to MTBE in contaminated drinking water.

Results

Detection Frequency in Drinking Water

To calculate the detection frequency of MTBE in any given year, it was assumed that a drinking water source was found to contain MTBE if it met one or more of the above-referenced criteria. For groundwater sources in California, the overall detection frequency for MTBE is very low and has not changed much over time (see Table 2). For example, MTBE was detected at least once and at any level in approximately 0.5–0.9% of all groundwater sources during 1996 to 2002. Higher detections of MTBE were observed in 1995 (about 3%), but this is primarily an artifact of the sampling methodology in which initial sampling efforts targeted groundwater sources where a known gasoline release had occurred. The groundwater detection frequency for MTBE is about 2–3 times lower if a two-detection criterion is used (generally ranging from about 0.2% to 0.4%) and is markedly lower if evaluations are based on drinking water detections at or above 5 μg/L (generally ranging from about 0.1% to 0.2%, assuming a two-detection criterion). Even fewer detections of MTBE were found in drinking water at concentrations at or above 13 μg/L or in the subset of groundwater that is likely to be currently delivered to consumers. For example, MTBE was detected in only five drinking water sources served by groundwater at concentrations at or above 13 μg/L during 2000 to 2002 (assuming a two-detection criterion) and only one of these sources had detectable levels of MTBE at or above 13 μg/L for all three years. In short, MTBE is rarely found in groundwater sources of drinking water that are of greatest concern to regulators or the public.

Table 2. *MTBE detection frequency in California drinking water from 1995 to 2002: Groundwater sources*

	1995	1996	1997	1998	1999	2000	2001	2002
All sources								
Number of sources sampled	129	2,229	2,767	3,727	3,928	3,529	6,625	6,441
Percent detects (%): one-detection criterion	3.1	0.5	0.6	0.7	0.6	0.9	0.6	0.6
Percent detects (%): two-detection criterion	2.3	0.4	0.3	0.4	0.3	0.3	0.3	0.2
All sources with concentrations $\geq$ 5 μg/L								
Number of sources sampled	129	2,229	2,767	3,727	3,928	3,529	6,625	6,441
Percent detects (%): one-detection criterion	2.3	0.3	0.2	0.3	0.2	0.3	0.2	0.2
Percent detects (%): two-detection criterion	2.3	0.2	0.1	0.2	0.1	0.1	0.1	0.1
All sources with concentrations $\geq$ 13 μg/L								
Number of sources sampled	129	2,229	2,767	3,727	3,928	3,529	6,625	6,441
Percent detects (%): one-detection criterion	2.3	0.3	0.1	0.1	0.1	0.2	0.1	0.1
Percent detects (%): two-detection criterion	1.6	0.2	0.1	0.1	0.1	0.1	0.1	0.05
Subset of sources likely to reach consumers[a]								
Number of sources sampled	35	448	516	938	1,044	874	2,172	2,386
Percent detects (%): one-detection criterion	2.9	0	0.6	0.4	0.4	0.7	0.5	0.8
Percent detects (%): two-detection criterion	0	0	0.2	0.2	0	0.1	0.1	0.3
Subset of sources likely to reach consumers and concentrations $\geq$ 5 μg/L[a]								
Number of sources sampled	35	448	516	938	1,044	874	2,172	2,386
Percent detects (%): one-detection criterion	0	0	0	0.2	0	0.3	0.2	0.3
Percent detects (%): two-detection criterion	0	0	0	0.1	0	0.1	0.1	0.2
Subset of sources likely to reach consumers and concentrations $\geq$ 13 μg/L[a]								
Number of sources sampled	35	448	516	938	1,044	874	2,172	2,386
Percent detects (%): one-detection criterion	0	0	0	0	0	0.1	0.1	0.1
Percent detects (%): two-detection criterion	0	0	0	0	0	0	0.05	0.04

[a] Note that historical evaluations of the subset data (i.e., pre-2000) should be interpreted with some caution, given that the status of a drinking water source may have changed over time.

Table 3. *MTBE detection frequency in California drinking water from 1995 to 2002: Surface water sources*

	1995	1996	1997	1998	1999	2000	2001	2002
All sources								
Number of sources sampled	8	113	210	253	207	312	446	446
Percent detects (%): one-detection criterion	0	8.8	7.1	8.7	8.1	4.5	3.6	4.0
Percent detects (%): two-detection criterion	0	3.5	2.4	4.0	2.9	1.3	1.7	1.8
All sources with concentrations ≥ 5 μg/L								
Number of sources sampled	8	113	210	253	207	312	446	446
Percent detects (%): one-detection criterion	0	1.8	2.9	2.0	2.0	1.6	0.9	0.4
Percent detects (%): two-detection criterion	0	0	1.0	0.8	0.3	0.3	0.2	0.2
All sources with concentrations ≥ 13 μg/L								
Number of sources sampled	8	113	210	253	207	312	446	446
Percent detects (%): one-detection criterion	0	0	1.0	0.8	0.3	0.3	0	0
Percent detects (%): two-detection criterion	0	0	0	0	0	0	0	0
Subset of sources likely to reach consumers[a]								
Number of sources sampled	4	32	69	80	99	105	130	121
Percent detects (%): one-detection criterion	0	9.4	4.3	10	9.1	1.9	3.1	3.3
Percent detects (%): two-detection criterion	0	0	2.9	5.0	5.1	1.0	1.5	0.8
Subset of sources likely to reach consumers and concentrations ≥ 5 μg/L[a]								
Number of sources sampled	4	32	69	80	99	105	130	121
Percent detects (%): one-detection criterion	0	0	0	1.3	1.0	1.0	0	0
Percent detects (%): two-detection criterion	0	0	0	0	0	0	0	0
Subset of sources likely to reach consumers and concentrations ≥ 13 μg/L[a]								
Number of sources sampled	4	32	69	80	99	105	130	121
Percent detects (%): one-detection criterion	0	0	0	1.3	1.0	0	0	0
Percent detects (%): two-detection criterion	0	0	0	0	0	0	0	0

[a] Note that historical evaluations of the subset data (i.e., pre-2000) should be interpreted with some caution, given that the status of a drinking water source may have changed over time.

For surface water sources in California, the overall detection frequency for MTBE is significantly greater than for groundwater sources, although surface water source detections appear to have declined substantially since 1998 (see Table 3). For example, MTBE was detected at least once and at any level in approximately 7–9% of all surface water sources during 1996 to 1999 and in approximately 4% to 5% of all surface water sources during 2000 to 2002. No detections of MTBE were observed in 1995 but only eight surface water sources were sampled during that year. The surface water detection frequency for MTBE is about 2–4 times lower if a two-detection criterion is used (generally ranging from about 2% to 4% for 1996–1999 and 1% to 2% for 2000–2002). Similar to the groundwater sources data, markedly lower detection frequencies of MTBE are observed if evaluations are based on surface water drinking water detections at or above 5 μg/L (assuming a two-detection criterion) which generally range from about 0.8% to 1.0% (1997–1998) and 0.2% to 0.3% (1999–2002). In addition, MTBE was never detected in drinking water served by surface water at concentrations at or above 13 μg/L (assuming a two-detection criterion) for the entire data set or the subset of data for water that is currently likely to reach consumers. Therefore, MTBE is also found only rarely in surface sources of drinking water that are of greatest concern to regulators or the public.

Geographical analyses reveal that at least one groundwater source in all 58 counties in California and at least one surface water source in 54 counties has been sampled for MTBE during 1995 to 2002 (see Tables 4 and 5). Drinking water served by groundwater was the most frequently sampled for MTBE in the following 12 counties (where at least 100 groundwater sources were sampled for MTBE in three or more years): Fresno, Kern, Los Angeles, Orange, Riverside, Sacramento, San Bernardino, San Joaquin, Santa Clara, Sonoma, Stanislaus, and Tulare. MTBE was detected in one or more groundwater sources in 34 counties, but was only detected routinely (for three or more years) in 16 counties. These latter counties (8 of which were also the most frequently sampled) are Butte, El Dorado, Kern, Los Angeles, Mendocino, Orange, Riverside, Sacramento, San Bernardino, San Diego, San Luis Obispo, San Mateo, Santa Clara, Shasta, Tulare, and Yuba. Ten or fewer groundwater sources were found to contain MTBE in any given year or county, and with the exception of a few counties (e.g., El Dorado) the annual detection frequency for MTBE was typically less than 5%. Similarly, for drinking water served by surface water, 12 counties were the most frequently sampled for MTBE (where at least 10 surface water sources were sampled for MTBE in three or more years): Alameda, Calaveras, El Dorado, Los Angeles, Marin, Placer, Bernardino, San Diego, San Francisco, Santa Clara, Santa Cruz, and Solano. MTBE was detected in one or more surface water sources in 18 counties, but was only detected routinely (for three or more years) in 7 counties. These latter counties (4 of which were also the most frequently sampled) are Alameda, Lake, Los Angeles, Riverside, San Diego, San Francisco, and Ventura. It should be noted that although the annual surface water detection frequency for MTBE appears to be relatively

Table 4. MTBE detection frequency in California drinking water from 1995 to 2002 by county: Groundwater sources

Code	County	Population[a]	1995		1996		1997		1998		1999		2000		2001		2002	
			# Sources	% Detect	# Sources	% Detect	# Sources	% Detect	# Sources	% Detect	# Sources	% Detect	# Sources	% Detect	# Sources	% Detect	# Sources	% Detect
01	Alameda	1,475,800	13	0.0	15	0.0	24	0.0	26	0.0	28	0.0	24	0.0	37	0.0	38	0.0
02	Alpine	1,190							2	0.0	8	0.0			3	0.0	5	0.0
03	Amador	35,850			1	0.0	3	0.0	7	0.0	2	0.0	5	0.0	14	0.0	15	0.0
04	Butte	206,800			43	0.0	44	0.0	53	0.0	37	2.7	38	0.0	153	0.7	114	0.9
05	Calaveras	41,500			3	0.0	6	0.0	3	0.0	5	0.0	3	0.0	7	0.0	16	0.0
06	Colusa	19,300			1	0.0	1	0.0	3	0.0	10	0.0	4	0.0	16	0.0	24	0.0
07	Contra Costa	977,000					8	0.0	13	0.0	20	0.0	5	0.0	17	0.0	48	0.0
08	Del Norte	27,650							3	0.0	9	0.0	9	11.1	8	0.0	9	0.0
09	El Dorado	163,900			37	2.7	38	10.5	35	17.1	35	17.1	30	13.3	33	12.1	31	12.9
10	Fresno	822,000	1	0.0	140	0.0	89	0.0	266	0.0	107	0.0	93	0.0	405	0.0	343	0.6
11	Glenn	26,850			8	0.0	5	0.0	12	0.0	18	0.0	3	0.0	18	0.0	28	0.0
12	Humboldt	127,800					8	0.0	4	0.0	5	0.0	7	0.0	31	0.0	17	0.0
13	Imperial	149,900									3	0.0	1	0.0	2	0.0	4	0.0
14	Inyo	18,200			5	0.0					13	0.0	10	0.0	11	0.0	24	0.0
15	Kern	681,900			108	0.0	235	1.3	167	2.4	276	1.1	274	0.7	517	1.4	471	1.3
16	Kings	132,700			2	0.0	8	0.0	23	0.0	8	0.0	6	0.0	36	0.0	54	0.0
17	Lake	60,200					12	0.0	3	0.0	16	0.0	23	4.3	16	0.0	19	0.0
18	Lassen	34,350					1	0.0	5	0.0	2	0.0	6	0.0	38	0.0	42	2.4
19	Los Angeles	9,748,500	16	18.8	640	1.6	682	0.7	761	0.5	837	0.2	822	1.1	992	0.4	1000	0.5
20	Madera	130,000			33	0.0	16	0.0	57	0.0	107	0.0	44	0.0	134	0.7	79	2.5
21	Marin	248,900					5	0.0	2	0.0			2	0.0	14	0.0	3	0.0
22	Mariposa	17,000					9	0.0	14	7.1	17	0.0	8	0.0	32	0.0	17	0.0
23	Mendocino	87,500					10	0.0	6	0.0	18	0.0	39	7.7	38	2.6	25	4.0
24	Merced	216,400			24	0.0	22	0.0	45	0.0	56	0.0	25	0.0	82	2.4	94	4.3
25	Modoc	9,450							1	0.0	1	0.0	5	0.0	15	0.0	10	0.0
26	Mono	13,150							4	0.0	9	0.0			11	0.0	15	0.0
27	Monterey	408,000			61	0.0	85	0.0	69	0.0	71	0.0	55	0.0	126	1.6	116	2.6
28	Napa	128,100					2	0.0	5	0.0	6	0.0	12	0.0	3	0.0	32	0.0
29	Nevada	94,200					3	0.0	11	0.0	13	0.0	15	0.0	38	0.0	21	0.0
30	Orange	2,910,000	76	1.3	223	0.0	230	0.4	233	1.3	216	0.0	234	0.0	238	0.0	236	0.0
31	Placer	261,500			4	0.0	7	0.0	14	0.0	24	4.2	14	0.0	24	0.0	37	0.0
32	Plumas	21,000					4	0.0	12	0.0	27	0.0	6	0.0	61	3.3	54	0.0

33	Riverside	1,618,000			140	0.0	190	0.5	200	0.0	284	0.0	201	0.5	400	0.3	371	0.0
34	Sacramento	1,267,800	13	0.0	47	0.0	65	0.0	309	0.3	182	0.5	150	1.3	348	0.6	343	0.6
35	San Benito	55,200	2	0.0	11	0.0	13	0.0	8	0.0	31	0.0	16	0.0	35	2.9	53	1.9
36	San Bernardino	1,766,100	1	0.0	251	0.0	291	0.0	350	0.9	397	0.0	476	0.2	757	0.3	719	0.1
37	San Diego	2,890,600			5	0.0	29	0.0	34	0.0	38	2.6	48	2.1	56	1.8	57	1.8
38	San Francisco	789,600			1	0.0	1	0.0	1	0.0	1	0.0	1	0.0	1	0.0		
39	San Joaquin	590,900			50	0.0	74	0.0	136	0.0	68	0.0	65	0.0	336	0.0	221	0.0
40	San Luis Obispo	252,000			39	0.0	15	0.0	80	0.0	55	0.0	43	2.3	131	0.8	156	1.9
41	San Mateo	714,500	1	0.0	6	0.0	13	0.0	16	12.5	34	5.9	25	8.0	37	0.0	40	2.5
42	Santa Barbara	405,700			39	0.0	20	0.0	25	0.0	55	0.0	46	0.0	96	0.0	98	0.0
43	Santa Clara	1,706,400	1	0.0	135	0.0	173	0.6	193	0.5	181	0.0	141	0.7	219	0.0	181	0.0
44	Santa Cruz	258,500					40	0.0	36	0.0	56	1.8	31	0.0	66	0.0	82	0.0
45	Shasta	168,600							7	0.0	28	3.6	9	0.0	56	3.6	56	1.8
46	Sierra	3,550							2	0.0	11	0.0	5	0.0	15	0.0	13	0.0
47	Siskiyou	44,650					3	0.0			7	0.0	2	0.0	44	2.3	12	8.3
48	Solano	403,100	1	0.0	10	0.0	17	0.0	15	0.0	33	0.0	33	0.0	55	3.6	48	0.0
49	Sonoma	468,400			6	16.7	58	0.0	85	0.0	158	1.9	137	0.0	89	0.0	111	0.0
50	Stanislaus	465,600			6	0.0	60	0.0	117	0.0	22	0.0	56	0.0	123	0.0	227	0.0
51	Sutter	81,000					1	0.0	5	0.0	6	0.0	10	0.0	56	0.0	52	0.0
52	Tehama	56,500					2	0.0	13	0.0	8	0.0	4	0.0	90	1.1	82	0.0
53	Trinity	13,050									2	0.0	3	0.0	11	0.0	7	0.0
54	Tulare	375,800	1	0.0	100	0.0	88	0.0	102	0.0	110	1.8	93	1.1	238	0.4	236	0.4
55	Tuolumne	55,800			3	0.0	3	0.0	31	3.2	38	0.0	10	0.0	17	0.0	12	0.0
56	Ventura	773,900	3	0.0	29	0.0	40	2.5	70	0.0	80	0.0	58	0.0	109	0.9	103	0.0
57	Yolo	174,500					1	0.0	10	0.0	15	0.0	17	0.0	22	0.0	42	0.0
58	Yuba	61,300			3	0.0	13	7.7	23	0.0	24	4.2	27	3.7	48	2.1	78	0.0

Note: Data include all groundwater sources (regardless of current status) and MTBE detections at any concentration based on a one-detection criterion.
[a] Population statistics from July 1, 2001 (Department of Finance, Demographic Research Unit).

Table 5. MTBE detection frequency in California drinking water from 1995 to 2002 by county: Surface water sources

			1995		1996		1997		1998		1999		2000		2001		2002	
Code	County	Population[a]	# Sources	% Detect	# Sources	% Detect	# Sources	% Detect	# Sources	% Detect	# Sources	% Detect	# Sources	% Detect	# Sources	% Detect	# Sources	% Detect
01	Alameda	1,475,800	4	0.0	8	25.0	11	27.3	13	30.8	10	0.0	14	0.0	15	0.0	17	0.0
02	Alpine	1,190					1	0.0			1	0.0			2	0.0	1	0.0
03	Amador	35,850			3	0.0	2	0.0	3	0.0	7	0.0	6	0.0	8	0.0	9	0.0
04	Butte	206,800			2	0.0	1	0.0	3	0.0	7	0.0	3	0.0	7	0.0	6	0.0
05	Calaveras	41,500					10	0.0	11	9.1	6	16.7	6	0.0	11	0.0	14	0.0
06	Colusa	19,300											1	0.0			1	0.0
07	Contra Costa	977,000					2	50.0	2	50.0	4	0.0	2	0.0	8	0.0	9	0.0
08	Del Norte	27,650									1	0.0	2	0.0	1	0.0	1	0.0
09	El Dorado	163,900					3	0.0	4	0.0	10	0.0	14	0.0	24	0.0	18	0.0
10	Fresno	822,000			2	0.0	1	0.0	2	0.0	4	0.0	1	0.0	7	0.0	4	0.0
11	Glenn	26,850			1	0.0					1	0.0						
12	Humboldt	127,800									2	0.0	3	0.0	11	0.0	8	0.0
15	Kern	681,900			1	0.0	2	0.0	6	0.0	4	0.0	7	0.0	14	7.1	11	0.0
16	Kings	132,700			1	0.0	1	0.0			2	0.0	2	0.0	2	0.0	3	0.0
17	Lake	60,200					3	66.7	9	22.2	13	23.1	8	25.0	7	28.6	14	42.9
19	Los Angeles	9,748,500			17	5.9	19	5.3	21	9.5	26	3.8	40	10.0	39	23.1	41	22.0
20	Madera	130,000			1	0.0			2	50.0	1	0.0			1	0.0	1	0.0
21	Marin	248,900			8	0.0	20	0.0	13	0.0	11	0.0	17	0.0	22	0.0	15	0.0
22	Mariposa	17,000					1	0.0	1	0.0					2	0.0	1	0.0
23	Mendocino	87,500			1	0.0			2	0.0	9	0.0	8	0.0	8	0.0	11	0.0
24	Merced	216,400					2	0.0	2	0.0	2	0.0	1	0.0	3	0.0	5	0.0
26	Mono	13,150									4	25.0	2	100.0	2	0.0	2	0.0
27	Monterey	408,000							1	0.0					1	0.0	2	0.0
28	Napa	128,100					2	0.0	8	0.0	7	0.0	4	0.0	7	0.0	15	0.0
29	Nevada	94,200			6	0.0	3	0.0	1	0.0	13	7.7	9	11.1	10	0.0	4	0.0
30	Orange	2,910,000									1	0.0	3	0.0	4	25.0	4	0.0
31	Placer	261,500					11	0.0	5	0.0	3	0.0	12	0.0	23	0.0	11	0.0
32	Plumas	21,000									4	0.0	1	0.0	10	0.0	8	0.0

33	Riverside	1,618,000			2	50.0	4	25.0	4	25.0	7	14.3	2	0.0	10	0.0	11	9.1
34	Sacramento	1,267,800			3	0.0	4	0.0	5	0.0	2	0.0	4	0.0	6	0.0	7	0.0
35	San Benito	55,200			1	0.0	1	0.0			1	0.0			2	0.0	3	0.0
36	San Bernardino	1,766,100			6	0.0	17	0.0	20	0.0	25	0.0	14	0.0	21	0.0	25	0.0
37	San Diego	2,890,600	4	0.0	10	30.0	13	0.0	23	34.8	23	56.5	22	13.6	27	11.1	27	7.4
38	San Francisco	789,600			11	9.1	12	8.3	12	8.3	12	8.3	14	7.1	15	6.7	14	0.0
39	San Joaquin	590,900			3	0.0	5	0.0	5	0.0	3	0.0	4	0.0	6	0.0	7	0.0
40	San Luis Obispo	252,000			5	0.0	5	0.0	6	0.0	2	0.0	6	0.0	9	0.0	10	0.0
41	San Mateo	714,500			2	0.0	2	0.0	4	0.0	11	0.0	4	0.0	6	0.0	6	0.0
42	Santa Barbara	405,700			3	0.0	5	0.0	6	0.0	7	0.0	7	0.0	8	0.0	7	0.0
43	Santa Clara	1,706,400			2	0.0	12	33.3	6	0.0	17	0.0	17	0.0	13	0.0	14	0.0
44	Santa Cruz	258,500					6		3	0.0	6	0.0	11	0.0	12	0.0	18	0.0
45	Shasta	168,600			3	66.7	5	40.0	6	0.0	7	0.0	5	0.0	9	0.0	10	0.0
46	Sierra	3,550											1	0.0			1	0.0
47	Siskiyou	44,650					1	0.0					1	0.0	4	0.0	2	0.0
48	Solano	403,100			4	0.0	9	0.0	9	0.0	12	8.3	15	0.0	16	0.0	14	0.0
49	Sonoma	468,400							3	0.0	4	0.0	7	0.0	7	0.0	2	0.0
50	Stanislaus	465,600			2	0.0	2	0.0	2	0.0	3	0.0	1	0.0	2	0.0	3	0.0
51	Sutter	81,000							1	0.0	1	0.0			1	0.0	1	0.0
52	Tehama	56,500													1	0.0	2	0.0
53	Trinity	13,050					1	0.0			1	100.0	2	0.0	9	0.0	5	0.0
54	Tulare	375,800			2	0.0	5	0.0	3	0.0					5	0.0	6	0.0
55	Tuolumne	55,800			2	0.0	1	0.0	17	0.0	2	0.0	2	0.0	19	0.0	9	0.0
56	Ventura	773,900			1	0.0	3	0.0	7	14.3	6	16.7	5	20.0	4	0.0	2	0.0
57	Yolo	174,500					1	0.0	1	0.0	1	0.0	1	0.0	1	0.0	1	0.0
58	Yuba	61,300					1	0.0	1	0.0	1	0.0	1	0.0	4	0.0	3	0.0

Note: Data include all surface water sources (regardless of current status) and MTBE detections at any concentration based on a one-detection criterion.
[a]Population statistics from July 1, 2001 (Department of Finance, Demographic Research Unit).

high for most counties, this is largely a function of the limited number of sources sampled. For both groundwater and surface water sources, the detection frequency for MTBE appears to fluctuate over time for individual counties, and there is no clear increasing or decreasing trend in MTBE detections by county.

New Drinking Water Detections

The overall detection frequency for MTBE in any given year includes both drinking water sources that never had a prior detection of MTBE (i.e., new sources) and drinking water sources that previously had a detection of MTBE (i.e., existing sources). Therefore, separate analyses were performed to evaluate the number of new groundwater and surface water sources found to contain MTBE each year (see Tables 6 and 7). These analyses show that despite the significant increase in water sampling over time, the number of new drinking water sources found to contain MTBE each year has not increased at the same rate as the number of sources sampled. In addition, although the absolute number of new drinking water sources found to contain MTBE has generally fluctuated or increased over time (mostly due to increased sampling efforts), it appears to have remained relatively stable and even decreased for some evaluations since 1998 despite the increased sampling.

For example, assuming a two-detection criterion, 10 new groundwater sources were found to contain MTBE at any level in 1998 out of 3,727 sources sampled (see Table 6). However, only 7 new groundwater sources (out of 3,928) were found to contain MTBE in 1999, 7 new groundwater sources (out of 3,529) were found to contain MTBE in 2000, 9 new groundwater sources (out of 6,625) were found to contain MTBE in 2001, and 8 new groundwater sources (out of 6,441) were found to contain MTBE in 2002. The rate of new groundwater source detections per 1,000 sampled is therefore 2.7, 1.8, 2.0, 1.4, and 1.2 for 1998, 1999, 2000, 2001, and 2002, respectively. The rate of new source detections in groundwater is even lower if evaluations are based on drinking water detections at or above 5 μg/L or 13 μg/L or the subset of data for water that is likely to currently be delivered to consumers. Similar findings are observed for surface water sources (see Table 7).

Although some of these evaluations suggest that the number of new groundwater and surface water sources with detected concentrations of MTBE has declined in recent years, these observations are for a relatively short time horizon (about 7–8 years) and additional monitoring may be required to fully document the success of policies enacted to reduce MTBE drinking water contamination. This is particularly important for groundwater sources because the amount of time for MTBE in released gasoline from leaking underground tanks to reach groundwater used for drinking water depends on soil and release conditions and cannot be predicted easily. Therefore, new detections of MTBE in groundwater sources may continue to be found in future years despite recent and ongoing programs aimed at managing leaking underground gasoline storage tanks. The issue of time is not as relevant when evaluating the surface water data because recent policies aimed at reducing surface water contamination (e.g.,

Table 6. *New detections of MTBE in California drinking water from 1995 to 2002: Groundwater sources*

	1995[a]	1996	1997	1998	1999	2000	2001	2002
All sources								
Number of sources sampled	129	2,229	2,767	3,727	3,928	3,529	6,625	6,441
Number of new sources: one-detection criterion	4	9	14	20	15	24	27	26
Number of new sources: two-detection criterion	3	5	5	10	7	7	9	8
All sources with concentrations ≥ 5 μg/L								
Number of sources sampled	129	2,229	2,767	3,727	3,928	3,529	6,625	6,441
Number of new sources: one-detection criterion	3	4	5	10	5	10	11	11
Number of new sources: two-detection criterion	3	2	2	6	2	4	3	6
All sources with concentrations ≥ 13 μg/L								
Number of sources sampled	129	2,229	2,767	3,727	3,928	3,529	6,625	6,441
Number of new sources: one-detection criterion	3	4	4	2	1	5	4	4
Number of new sources: two-detection criterion	2	3	2	4	1	1	3	1
Subset of sources likely to reach consumers[b]								
Number of sources sampled	35	448	516	938	1,044	874	2,172	2,386
Number of new sources: one-detection criterion	1	0	3	3	3	6	7	15
Number of new sources: two-detection criterion	0	0	1	1	0	1	2	5
Subset of sources likely to reach consumers and concentrations ≥ 5 μg/L[b]								
Number of sources sampled	35	448	516	938	1,044	874	2,172	2,386
Number of new sources: one-detection criterion	0	0	0	2	0	3	4	6
Number of new sources: two-detection criterion	0	0	0	1	0	1	1	3
Subset of sources likely to reach consumers and concentrations ≥ 13 μg/L[b]								
Number of sources sampled	35	448	516	938	1,044	874	2,172	2,386
Number of new sources: one-detection criterion	0	0	0	0	0	1	1	2
Number of new sources: two-detection criterion	0	0	0	0	0	0	1	0

[a]For 1995, the number of new sources represents the total number of sources with detectable levels of MTBE for that year.

[b]Note that historical evaluations of the subset data (i.e., pre-2000) should be interpreted with some caution, given that the status of a drinking water source may have changed over time.

Table 7. *New detections of MTBE in California drinking water from 1995 to 2002: Surface water sources*

	1995[a]	1996	1997	1998	1999	2000	2001	2002
All sources								
Number of sources sampled	8	113	210	253	307	312	466	446
Number of new sources: one-detection criterion	0	10	8	15	10	7	9	5
Number of new sources: two-detection criterion	0	4	2	8	5	3	5	0
All sources with concentrations $\geq 5\ \mu$g/L								
Number of sources sampled	8	113	210	253	307	312	466	446
Number of new sources: one-detection criterion	0	2	4	3	4	1	2	0
Number of new sources: two-detection criterion	0	0	2	1	0	1	0	0
All sources with concentrations $\geq 13\ \mu$g/L								
Number of sources sampled	8	113	210	253	307	312	466	446
Number of new sources: one-detection criterion	0	0	2	1	1	0	0	0
Number of new sources: two-detection criterion	0	0	0	0	0	0	0	0
Subset of sources likely to reach consumers[b]								
Number of sources sampled	4	32	69	80	99	105	130	121
Number of new sources: one-detection criterion	0	3	3	5	4	2	3	1
Number of new sources: two-detection criterion	0	0	2	4	3	1	1	0
Subset of sources likely to reach consumers and concentrations $\geq 5\ \mu$g/L[b]								
Number of sources sampled	4	32	69	80	99	105	130	121
Number of new sources: one-detection criterion	0	0	0	1	1	1	0	0
Number of new sources: two-detection criterion	0	0	0	0	0	0	0	0
Subset of sources likely to reach consumers and concentrations $\geq 13\ \mu$g/L[b]								
Number of sources sampled	4	32	69	80	99	105	130	121
Number of new sources: one-detection criterion	0	0	0	1	1	0	0	0
Number of new sources: two-detection criterion	0	0	0	0	0	0	0	0

[a]For 1995, the number of new sources represents the total number of sources with detectable levels of MTBE for that year.
[b]Note that historical evaluations of the subset data (i.e., pre-2000) should be interpreted with some caution, given that the status of a drinking water source may have changed over time.

restrictions on watercraft with two-stroke engines or the phase-out of MTBE) are likely to have a more immediate impact on the possibility of MTBE-contaminated fuel releases.

Detected Concentrations in Drinking Water

Drinking water detections of MTBE, when found, are generally at levels below California's primary and secondary MCLs. For example, of those groundwater sources found to contain MTBE (at least once) from 1995 to 2002, over 80% had average detectable MTBE concentrations less than 13 μg/L and about 65% had average detectable MTBE concentrations less than 5 μg/L (see Figure 1). Interestingly, detected concentrations of MTBE are much lower for surface water sources than for groundwater sources. For example, of those surface water sources found to

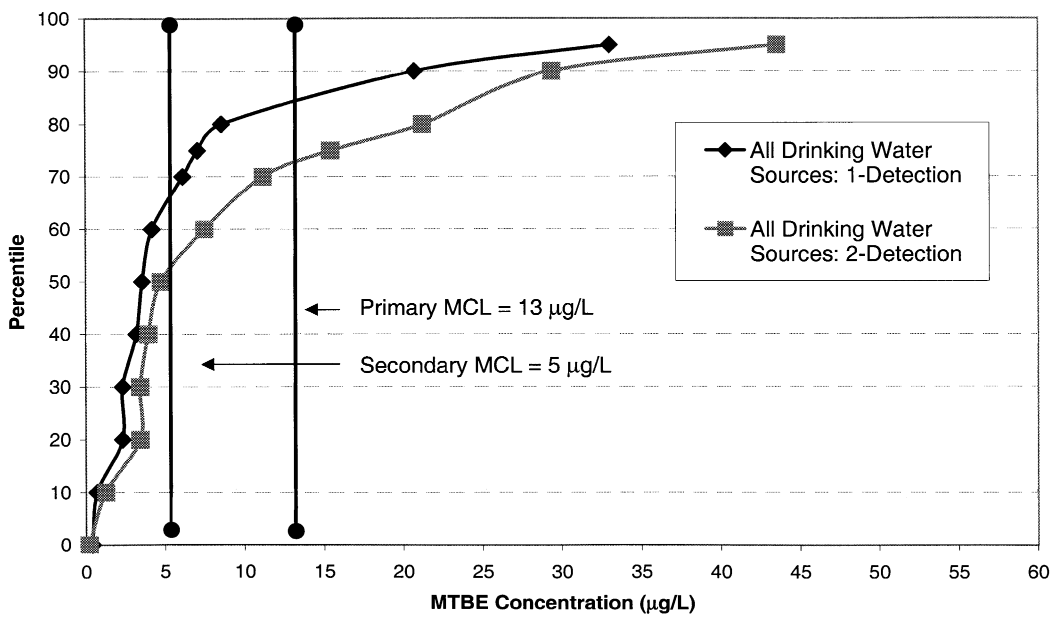

Figure 1. Distribution of average detected MTBE concentrations in California drinking water from 1995 to 2002: Groundwater sources.

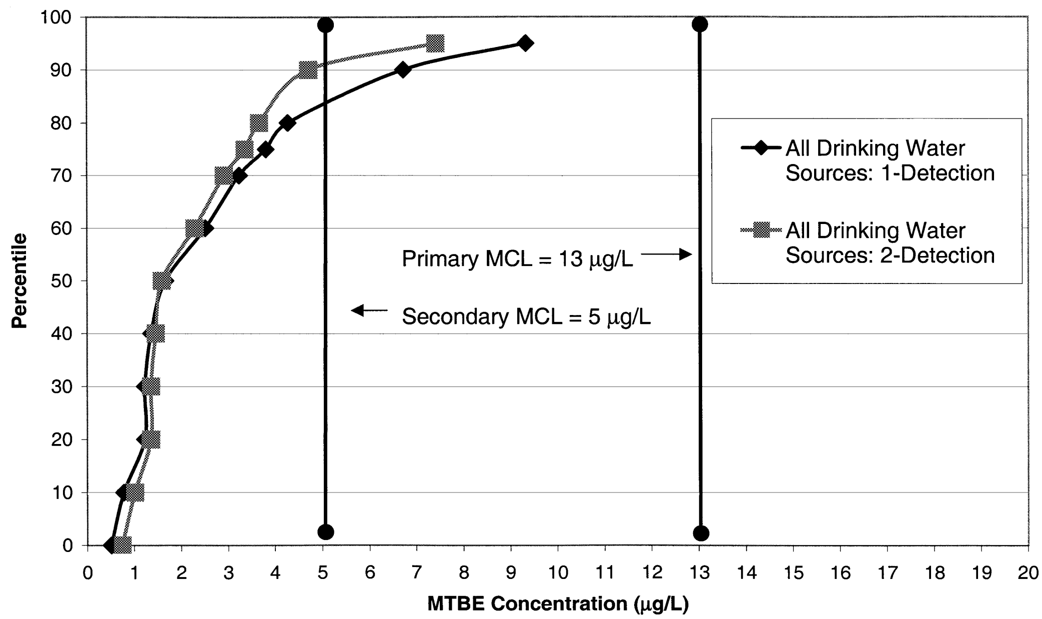

Figure 2. Distribution of average detected MTBE concentrations in California drinking water from 1995 to 2002: Surface water sources.

contain MTBE (at least once) from 1995 to 2002, over 95% had average detectable MTBE concentrations less than 13 μg/L and over 80% had average detectable MTBE concentrations less than 5 μg/L (see Figure 2). The concentration percentiles of MTBE were calculated by averaging the MTBE concentration of all detect samples per source over the 8-year time period and then calculating the cumulative distribution based on all drinking water sources.

It is noteworthy that the observed higher average concentrations of MTBE in groundwater sources are driven almost entirely by the results of sampling from a few drinking water wells in 1995 and 1996 that were known to have been affected by a nearby leaking gasoline tank release (e.g., Charnock and Arcadia wells in Santa Monica). It is also worth noting that evaluations based on the two-detection criterion tend to yield higher detected concentrations of MTBE than evaluations based on the one-detection criterion. This is primarily due to the fact that many single detections of MTBE are at very low concentrations (which may be due to false positive readings or transient effects).

Discussion

In this article we characterize the annual detection frequency, number of new source detections, and detected concentration of MTBE in California's groundwater and surface water sources of public drinking water from 1995 to 2002. Distinguishing between MTBE detections in groundwater versus surface water sources is important for several often overlooked reasons. First, reported MTBE sampling results typically represent combined groundwater and surface water data, making it impossible to identify the likely source of contamination (e.g., underground storage tanks or watercraft with two-stroke engines). Second, it appears to be a common perception (based on media and other reports) that groundwater sources are more vulnerable and likely to be affected by MTBE than surface water sources despite a lack of supporting data for this assumption. Third, the intense focus of the media and public on groundwater sources ignores the fact that public drinking water for some states or regions, such as California, is derived primarily from surface water sources. Fourth, MTBE risk management options, such as the implementation of underground storage tank system upgrades or limiting the use of inefficient two-stroke watercraft engines, and their time frame for success may differ substantially for groundwater and surface water sources. Finally, tracking the detection frequency of MTBE over time and by geographic location is likely to vary for drinking water served by groundwater versus surface water because of the differences in risk management approaches and fate-and-transport mechanisms.

Our evaluations of the CDHS (2003) groundwater and surface water data for MTBE were based on several approaches that either used the entire data set or focused on those drinking water sources of greatest concern to regulators or the public. In the first type of evaluation, a one-detection or two-detection criterion was used. The one-detection criterion is more conservative (i.e., yields higher detection frequencies for MTBE) and is more appropriate for screening-level analyses or if a drinking water source is only sampled once in a given year or time period. The two-detection criterion is more appropriate for identifying water sources that are affected by MTBE over a longer time period or where confirmation of contamination is required to support management decisions. Evaluations were also based on comparisons of MTBE drinking water detections at any concentration level versus those at or above 5 μg/L or 13 μg/L (state drinking water standards). Although the appropriateness of these approaches depends on the specific question of interest, the comparison of detections at any concentration may be useful for understanding the ultimate fate and transport of MTBE or for identifying possible gasoline releases (but will include many drinking water sources with essentially de minimus concentrations of MTBE), whereas comparison to the state standards will be most useful to delineate drinking water conditions of greatest concern to regulators (and ultimately consumers) in California because they are based on aesthetic and health-risk considerations. Finally, evaluations were based on all drinking water (regardless of the source's current status) versus drinking water that is likely to be used for current public consumption. Because the status of a drinking water source may change over time (e.g., an affected well may change from "active" to "inactive"), the latter comparison should be interpreted with some caution. This type of comparison is still useful, however, because it provides the most representative data on current MTBE exposure levels that can be used in health risk evaluations.

Based on these evaluations, we find that the overall detection frequency for MTBE has historically been greater for surface water than groundwater sources in California, although surface water source detections have clearly declined over the last few years (due in part to regulations banning two-stroke engines). This finding is of particular interest because, as mentioned, groundwater sources are commonly perceived as being more vulnerable and likely to be affected by MTBE. Recent national-level assessments have also found that the detection frequency for MTBE is nearly three times greater for surface water than for groundwater due to the use of two-stroke engines on these water bodies (Delzer et al., 2001; USGS, 2001). These findings suggest that relatively easy risk management solutions (e.g., ban on certain watercraft) could potentially have a significant and immediate impact on reducing the detection frequency and number of new detects of MTBE in drinking water in California and elsewhere. Other risk management approaches focused on groundwater (e.g., upgrading underground storage tanks) will also undoubtedly result in fewer drinking water detections of MTBE, but it may take longer to observe the success of these programs. Interestingly, California officials recently announced that the strong regulatory oversight of underground storage tanks by the state regional water quality boards is already having a positive impact on reducing MTBE groundwater detections (IWP, 2002).

An additional finding of the current analysis is that MTBE drinking water detections in California do not appear to have increased substantially over time as was predicted by some researchers a few years ago (UC, 1998; Johnson et al., 2000). On the contrary, the overall detection frequency for MTBE (as well as the rate of new source detections) has declined or remained relatively stable over the last eight years for both groundwater and surface water sources in California. MTBE has also rarely been found in public drinking water sources in California at the levels of greatest regulatory and public concern (i.e., ≥ 5 μg/L or ≥ 13 μg/L) or in the subset of data for drinking water that is likely to currently reach consumers. Recent statements made by regulatory officials at the U.S. EPA and USGS confirm that the number of national community water supplies threatened by MTBE, such as from leaking underground gasoline storage tanks, is likely to be far lower than what was predicted previously (Hirsch, 2001; Grumbles, 2002; Miller, 2002). Within the state of California, MTBE groundwater and surface water detections appear to be concentrated in about a dozen counties, although most of these contain more than 500,000 residents.

Detected concentrations of MTBE, when found, are generally below levels that would be likely to pose a public health or aesthetic concern. These latter findings are also consistent with other regional and national-level assessments in which average (or in some cases median) detected concentrations of MTBE in groundwater or surface water (including untreated drinking water, shallow aquifers, and nondrinking water wells) have been found to be less than 1 μg/L (Squillace et al., 1996, 1999; Delzer et al., 2001; Shelton et al., 2001). These findings suggest that the mere presence of MTBE in a drinking water source does not necessarily imply a public health hazard or that MTBE will render drinking water unpotable. In fact, recent studies have shown that many contaminants are frequently found in drinking water (Helperin 2001), some of which may pose a much greater health risk than MTBE (Williams et al., 2002, 2003). USGS officials have similarly concluded that MTBE levels are almost always below levels of concern from aesthetic and public health standpoints and that the health threat to water supplies from MTBE is small compared to other water-related issues (Hirsch, 2001; Miller, 2002).

Despite our rigorous evaluations of the water quality monitoring data in California, there are several important limitations associated with these data. In particular, the CDHS database only contains sampling data for public (not private) drinking water sources. In addition, not all of the public drinking water sources are routinely sampled over time, and some sources are sampled more frequently than others. The CDHS database also does not report the reasons why the status of a drinking water source has changed over time. Moreover, the state only requires that sampling data be reported in the database when detected concentrations of a chemical exceed a specified "detection limit for reporting" (currently this value is 3 μg/L), although many detections are voluntarily reported far below this level. Finally, as indicated above, there are many errors associated with the coding of detect and nondetect samples in the database, and the state provides no indication of the method or quality of data collection.

Nonetheless, a fairly large fraction of the drinking water sources in California have been sampled for MTBE at least once over the last 8 years, and these data provide useful information to regulators and the public regarding the nature and extent of MTBE contamination. Overall, our evaluations of the MTBE data suggest that even though a small number of public drinking water sources in California have certainly been affected by MTBE (e.g., the Santa Monica wells), such impacts do not appear to be significant on a statewide basis or when compared to other chemicals commonly found in drinking water. Detections of MTBE in drinking water, particularly for surface water sources, also appear to be decreasing over time. In addition, because the threat of MTBE contamination of public drinking water sources is primarily a function of leaking underground gasoline storage tanks and the use of watercraft with two-stroke engines, ongoing efforts to control these sources of gasoline releases should result in even fewer detections of MTBE in the future. However, additional monitoring data to be acquired over time will be necessary to fully document the success of federal and state regulatory programs in managing gasoline releases.

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