

Impacts of MTBE on Groundwater

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I.0 INTRODUCTION

Senate Bill 521 was introduced February 24, 1997 in response to a growing awareness of the possible environmental and health effects associated with the use of Methyl Tertiary Butyl Ether (MTBE) as an oxygenate blending agent in gasoline fuels throughout California (Appendix A). Since 1979, MTBE had been used in the State as a replacement for tetraethyl lead and as an octane booster. Although used in California since 1979 in volumes ranging from 0.5 to 3.5 percent, the volumes of MTBE in gasoline have increased to 11 percent since 1996. SB 521, which became effective January 1, 1998, called for the University of California to perform an assessment of the benefits and risks associated with the uses of MTBE in California.

This assessment report addresses: 1) the current impacts of MTBE to the state's groundwater used for drinking; 2) risks to the state's groundwater resources associated with MTBE leaking from storage tanks and other petroleum storage and conveyance facilities; and 3) potential future risks to the state's groundwater should MTBE continued to be used.

The general approach was to compile statewide data on the occurrence of MTBE groundwater contamination. The data consisted of MTBE detections and concentrations at leaking underground storage tank sites from Regional Water Quality Control Boards and MTBE detections and concentrations in water supply wells based on information from the Department of Health Services, Local Primacy Agencies, and Regional Water Quality Control Boards. We used various modeling approaches to then assess potential future impacts of MTBE on groundwater resources, focusing primarily on plume behavior in aquifer systems consisting of alluvial materials (i.e., sand, gravel, silt and clay). This report also includes specific information on MTBE impacts on groundwater in the Tahoe Basin.

A recent investigation into the impacts of MTBE on California groundwater by Happel et al. (1998) provided an important foundation for this study. The analysis of groundwater impacts contained herein complements the work of Happel et al. (1998) by accumulating more recent statewide information with broader geographic coverage. Moreover, we use plume length statistics compiled by Happel et al. (1998) as a basis for calibrating models that simulate future MTBE plume growth.

I.1 SOURCES OF MTBE IN GROUNDWATER

MTBE sources of groundwater contamination include leaking underground fuel tanks (LUFT's), above ground storage tanks, farm tanks, leaking petroleum fuel pipelines, underground storage tanks containing fuels other than gasoline, surface spills due to automobile or tanker truck accidents, surface spills due to abandoned or parked vehicles, MTBE contaminated surface water, and precipitationatmospheric sources. The LUFT sites are numerous, widely dispersed, proportional to the state's population, and involve enormous volumes of fuel products. As of June 30, 1998 there were 32,779 known sites where chemical compounds, including gasoline and non-gasoline products, were discharged to the environment from underground storage tanks. Ninety percent of these discharges involve petroleum products.

Although specific information about the operation of above ground storage tanks and pipelines were not available, information contained in the Regional Water Quality Control Board (RWQCB) water purveyor reports indicate that leaking underground storage tanks are the most numerous sources of MTBE contamination. Furthermore, most of the gasoline stored in above ground storage tanks or transmitted through petroleum pipelines ultimately is stored in underground storage tanks prior to final distribution to motor vehicles.

Only a small portion of the MTBE consumed, 0.33 percent (OEHHA, 1998), is released to the atmosphere. Depending on local conditions, a fraction of the 0.33 percent is available to leach into groundwater. MTBE released into the atmosphere has been implicated as a non-point source of MTBE contaminating shallow urban groundwater at very low levels. In the U.S. Geological Survey's National Water Quality Assessment (NAWQA), 97 percent of the samples from shallow urban wells detected MTBE at concentrations of less than $20 \mu\text{g}\cdot\text{L}^{-1}$ (Pankow et al., 1997). MTBE is detected at leaking underground storage tanks at concentrations many orders of magnitude higher. Based on information available early in our assessment, approximately 75 percent of those groundwater sites that were tested had concentrations in excess of $20 \mu\text{g}\cdot\text{L}^{-1}$, further emphasizing the importance of leaking underground storage tanks as the primary source of acute MTBE groundwater contamination. Accordingly, most of our efforts in this 8 month study focused on MTBE contamination from LUFT sites. Future studies should continue to evaluate long-term impacts of point- as well as non-point sources of MTBE.

1.2 GENERAL CHARACTERISTICS OF MTBE TRANSPORT IN GROUNDWATER

Transport of MTBE in groundwater is controlled by the rate of groundwater movement, concentration and longevity of the source, and dispersion (i.e., the process whereby concentration of a dissolved chemical is reduced by dilution and the contaminant front spreads faster than the average rate of groundwater movement). Unlike petroleum hydrocarbons such as benzene, transport of MTBE does not appear to be limited appreciably by sorption (i.e., temporary retention of the contaminant on soil and sediment particles) or biodegradation by native microorganisms. Consequently, MTBE will potentially move with the groundwater in a manner similar to subsurface transport of, for example, chlorinated organic compounds such as TCE (trichloroethene). Extensive TCE groundwater plumes are often observed – on the order of 1,000's of feet in length. MTBE plumes will potentially be even larger on the average, because it is more mobile and recalcitrant to biodegradation than TCE. Owing to MTBE's high solubility and rather large volumetric fraction in reformulated gasoline (~11 percent), concentrations in groundwater saturated with California reformulated gasoline can be very high – on the order of $6,000,000 \mu\text{g}\cdot\text{L}^{-1}$ (Zogorski et al., 1996; Happel et al., 1998).

2.0 REGIONAL DATA SOURCES

Numerous data sources were used, primarily from the State Water Resources Control Board (SWRCB), the nine Regional Water Quality Control Boards (RWQCB), the Department of Health Services (DHS), the 34 DHS Local Primacy Agencies (LPA's) [and the California Air Resources Board](#).

2.1 STATE WATER RESOURCES CONTROL BOARD

Efforts were made as early as 1995 to characterize the extent of MTBE contamination statewide. The State Water Resources Control Board has not established any requirement for the testing or reporting of MTBE, except prior to closing LUFT sites (i.e., prior to ceasing site investigation and active remediation). However, guidance documents have been distributed to the nine Regional Boards and to the twenty Local Oversight Program Agencies (LOP's). On July 31, 1996, the SWRCB distributed the memo "Groundwater Monitoring Information on Methyl Tert Butyl Ether (MTBE) From Open UST Cases" which requested that MTBE be added to the list of gasoline components in contaminated groundwater that are monitored at open (i.e., still being investigated or actively remediated) LUFT sites. The memo indicated that EPA Method 8020 should be used, followed by EPA Method 8260 for detection of false positives. On June 8, 1998, a Local Guidance Letter was forwarded to Local Implementing Agencies notifying them of the requirement to test for MTBE and submit the results to the Regional Boards prior to issuance of a closure letter requiring no further action at sites where petroleum releases have occurred. Beginning January 1, 1998, closure letters could not be issued unless MTBE analysis was performed, when applicable. The requirement for MTBE testing is only at sites where applicable, which is understood to mean, sites where gasoline releases have occurred.

Information requests to the SWRCB were made verbally and in correspondence. The information requested from the Underground Storage Tank Section consisted of copies of the SWRCB LUSTIS (Leaking Underground Storage Tank Information System) databases and quarterly reports for first and second quarter 1998, the number of active and upgraded underground storage tanks, and policies and procedures which have been developed related to MTBE contamination. The information requested from the Above Ground Storage Tank Section consisted of an inventory of the above ground tanks in each county and confirmed releases of petroleum products. Information was not made available regarding releases from above ground storage tanks. The information requested in correspondence with the Underground Storage Tank Cleanup Fund Unit consisted of a database including the status of cleanup claims, the LUSTIS site code and Cleanup Fund claim number. Time did not permit checking cleanup fund status for sites where MTBE contamination exists, primarily for two reasons. First, only a portion of the Cleanup Fund database contained the LUSTIS site code used by the SWRCB and RWQCB's, and second, the MTBE site data from many of the RWQCB's

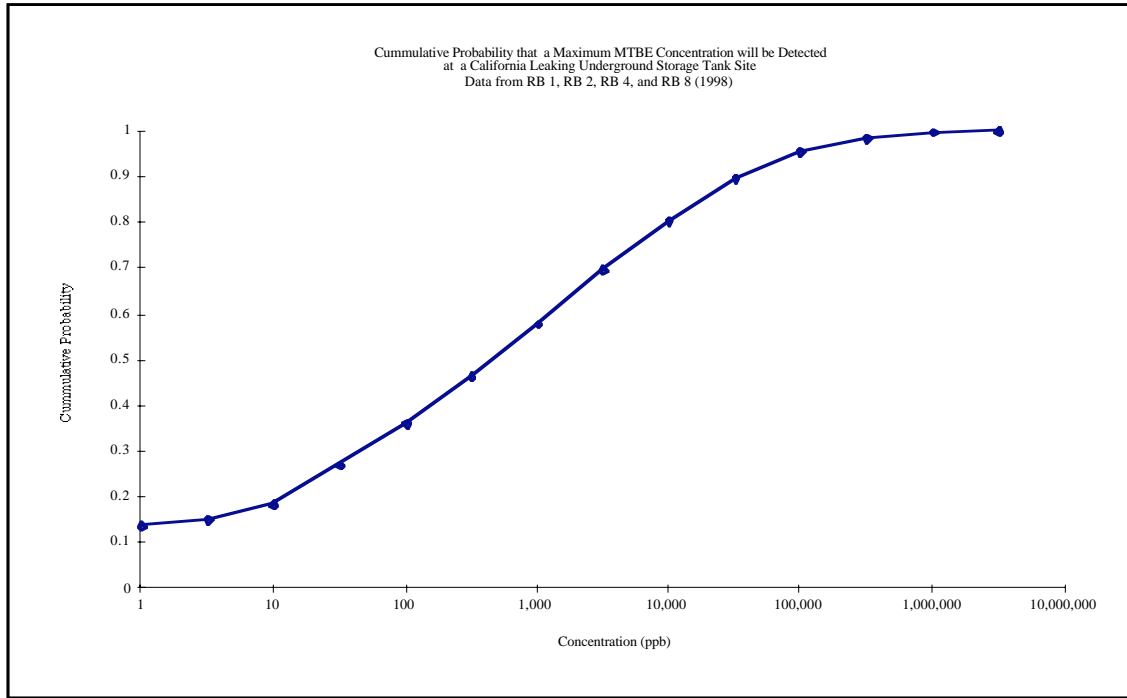


Figure 6. Cumulative probability plot of MTBE maximum concentrations at LUFT sites.

Figure 6 shows, for example, that 36 percent of the sites reporting MTBE groundwater contamination had concentrations less than $100 \mu\text{g}\cdot\text{L}^{-1}$, 48 percent had concentrations less than $500 \mu\text{g}\cdot\text{L}^{-1}$, 80 percent had concentrations less than $10,000 \mu\text{g}\cdot\text{L}^{-1}$, and 4.5 percent had maximum concentrations greater than $100,000 \mu\text{g}\cdot\text{L}^{-1}$. The high concentrations found at many sites are not surprising, given the high solubility of MTBE in water ($50,000 \text{ mg}\cdot\text{L}^{-1}$; Zogorski et al., 1996), the low sorption potential of MTBE, and its recalcitrance with respect to biodegradation.

3.2.5 CLOSED LUFT SITES

There are 3,432 gasoline contaminated groundwater sites that have been closed, requiring no further actions (SWRCB, 1998b, July). Insufficient data are available to assess the numbers of closed sites that have been contaminated with MTBE, because it was only recently that the Health and Safety Code was amended (SB 521) to require MTBE analysis prior to issuance of a closure letter. Once a closure letter is issued, no further action at the site is required, unless there is an indication that changing site conditions or additional information warrants the re-opening of the site.

The exact number of MTBE contaminated closed sites reported by region cannot be estimated at this time because Regional Boards do not all report in the water purveyor's reports whether a site is open or closed, and many Regional Board's did not provide data electronically to perform matching with the LUSTIS database. The available data suggested that a significant proportion of the closed gasoline contaminated sites with reported test results had detectable concentrations of MTBE (169/286 Los Angeles (4) and 38/65 Central Valley (5)). It is not likely that

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The 13,920 wells on the DHS Inventory are regulated by the DHS (8,957 wells) and the 34 Local Primacy Agencies (4,963). Various amounts of MTBE testing of public water wells has occurred throughout the state. In counties reporting the most frequent detections of MTBE in public water wells, there has been the highest frequency of testing for MTBE.

In February 1997, monitoring of MTBE as an unregulated compound was required by the DHS (DHS, 1997). Criteria was established by the DHS to assess vulnerability of a public water system well based on the well's location relative to a potential source of MTBE contamination. By this criteria, DHS recommended that only sites having known, fuel contamination should be considered "potential sources" (DHS correspondence, 1998). Wells located within 2,000 ft (or farther depending on local subsurface geology) of a gas tank, gas pipeline, refinery or farm tank that were in use after 1979, at which fuel contamination was known, were to be considered vulnerable. All systems that were deemed vulnerable by the regulating agency were required to test for MTBE by August 31, 1998 (September 11, 1997 Implementation Policy). LPA's which used known groundwater sites rather than tank or pipelines locations to determine vulnerability have significantly reduced the number of wells which were deemed vulnerable (Appendix G).

Local Primacy Agencies that submitted information for this assessment included:

Amador	Contra Costa	El Dorado	Imperial
Kings	Los Angeles	San Bernardino	Riverside
San Joaquin	San Luis Obispo	Tulare	Tuolumne
Yolo	Yuba		

1.5.2 DETECTS IN PUBLIC WATER SUPPLY WELLS

The DHS Water Quality Information (WQI) Database (September 1998) listed 32 public water supply (PWS) wells which have reported detections in excess of $0.5 \mu\text{g}\cdot\text{L}^{-1}$ of MTBE. In addition, information received from the 14 LPA's responding to our inquiries indicated that three public water system wells in San Luis Obsipo have ~~been impacted by MTBE detects. A total of 35 PWS wells have been impacted by MTBE to date, based on available information.~~To date, MTBE has been detected in a total of 35 PWS wells (Table 8; Fig. 7). If it is assumed that most of the ~~impacts-detects~~ that have been identified resulted from contamination entering the subsurface environment prior to 1996, then it can be expected that the impacts will continue to increase, regardless of whether MTBE's use is discontinued, because the use of MTBE has increased since 1996.

PWS wells with detections of contaminants undergo an assessment to determine the source of the contamination. In many cases this is complex because it involves issues of property damage with litigious implications. Agencies require a high level of certainty before identifying a responsible party. Additionally, some DHS districts are severely understaffed and not able to respond at the speed that new PWS wells are impacted by MTBE. Full site histories and characterizations of possible sources of the MTBE contaminants detected in these wells were not

The lower bound was used to estimate private well impacts primarily because it is anticipated that the majority of these wells are located in rural areas where there are not the density of underground storage tanks found in urban areas. Information on locations of the private wells is not available. Private wells located in urban incorporated areas have a greater likelihood of being impacted than wells in rural areas. The 0.3 percent that was used considered urban and rural influences, since the testing performed thus far has occurred primarily in urban areas, but the percentage is based on all wells in the counties, rural and urban, where testing occurred. The PWS well MTBE detect information suggests that on the order of 1,300 to 5,500 of the 464,621 private wells statewide may have been impacted with detectable concentrations of MTBE to date.

With only 21 percent of the groundwater systems reporting MTBE analyses and the increased use of MTBE since 1996, it is reasonable to expect that roughly 1,400 or more public and private water supply wells have detectable levels of MTBE.

The above ~~approximations appear reasonable, if not excessively low, in light of estimates are highly approximate, California would benefit from a more comprehensive study like the one conducted~~ by the State of Maine Bureau of Health, Department of Environmental Protection and Department of Conservation (State of Maine, 1998). The study randomly selected 951 household wells out of the 275,000 (0.34 percent) household wells reported during the 1990 Census. The study also sampled 793 of the 830 (95.5 percent) regulated nontransient public water supply wells. They found that MTBE was detected above $0.1 \mu\text{g}\cdot\text{L}^{-1}$ in 15.8 percent (150) of the private wells tested and in 16.0 percent (127) of the tested public supply wells. The frequency of higher concentration detections was much lower. 6.6 percent of wells sampled had MTBE concentrations between $1 \mu\text{g}\cdot\text{L}^{-1}$ and $35 \mu\text{g}\cdot\text{L}^{-1}$, and 1.1 percent of wells sampled had MTBE concentrations above $35 \mu\text{g}\cdot\text{L}^{-1}$. No public water well samples contained concentrations above $35 \mu\text{g}\cdot\text{L}^{-1}$; however, 6.1 percent had concentrations between $1 \mu\text{g}\cdot\text{L}^{-1}$ and $35 \mu\text{g}\cdot\text{L}^{-1}$. Direct comparisons between our results and those of Maine are difficult due to differences in detection limits and hydrological conditions. As indicated previously, the DHS has only recently reduced the reporting limit for MTBE from $5 \mu\text{g}\cdot\text{L}^{-1}$ to $3 \mu\text{g}\cdot\text{L}^{-1}$, while the detection limit used in the Maine study was $0.1 \mu\text{g}\cdot\text{L}^{-1}$. Concentrations in excess of $35 \mu\text{g}\cdot\text{L}^{-1}$ have been detected in California water supply wells. Another difference which does not allow direct comparison relates to the private well sampling that the State of Maine performed. The State of California has not performed an assessment of drinking water that includes the sampling of private wells.

5.5 ESTIMATE OF SUPPLY WELL IMPACTS BASED ON SITE SPECIFIC DATA

As noted in Table 9, a significant number of private wells statewide are anticipated to be contaminated by MTBE. Leaking underground storage tanks have been identified as the MTBE source for many PWS well MTBE detections. Private wells are not regulated and have no monitoring requirements, except in the rare instance when a leaking underground storage tank contaminates a private well. The State Water Resources Control Board Leaking Underground Storage Tank Information System (LUSTIS) Database identifies this type of site where a supply

6.1.2 SHALLOW GROUNDWATER SAMPLING

Procedure

We sampled shallow groundwater monitoring wells in the Tahoe Basin during July and August 1998 for MTBE occurrence. A total of 10 wells in Pope Marsh were sampled, along with a sample of Lake Tahoe water adjacent to Pope Marsh. Pope Marsh borders the southern shore of Lake Tahoe, on the California side of the basin, just west of the City of South Lake Tahoe. Several of the sampled wells were USGS monitoring wells; the remainder were monitoring wells installed during our previous investigations of this site (Green, 1998; Green and Fogg, 1997). All wells sampled in Pope Marsh had screened depths less than 20 ft below ground surface.

On the Nevada side of the Tahoe Basin, six shallow wells (less than 30 ft deep) and one spring were sampled for MTBE occurrence during August 1998. The USGS site numbers and names are #23 (Edgewood 1), #24 (Edgewood 4), #25 (Folsom Spring; located near Stateline), #28 (Zephyr 4), #30 (Glenbrook 2), #31 (Glenbrook 3), and #41 (Ivgid 3; located in Incline Village). These Nevada sites are part of the USGS groundwater monitoring network for the Lake Tahoe Basin (Boughton et al., 1997) and were sampled in cooperation with ~~Tim Rowe and Kip Allander~~[research staff](#) of the Carson City office of the USGS.

All well sampling was performed by first purging more than 3 wellbore volumes of water from the well, using either a clean stainless steel or polyethylene bailer. Well samples were recovered using factory-cleaned and clean-wrapped disposable teflon or polyethylene bailers, fitted with tips designed to dispense samples for VOC analysis (VOSS technologies, San Antonio, TX). Groundwater samples were dispensed into ~~45~~[40](#) ml amber VOA vials, which were filled to the rim such that no headspace was present in the capped vial. The Lake Tahoe sample was obtained by wading out into Lake Tahoe to a depth of about 5 ft, filling and capping the VOA vial at about 2 ft below the water surface. The Folsom Spring sample was obtained by immersing the VOA vial below the stream surface at about 2 ft downstream from the source of the spring.

A drop of 1:1 HCl was added to each sample before capping. Samples were immediately placed on ice, and stored in an ice chest and transported to a 4° C refrigerator until analysis for VOC's. Each sample was analyzed for both MTBE and BTEX by Alfa Analytical (Sparks, NV) using EPA method 524.2. Assay results were reported to a lower level of 0.1 $\mu\text{g}\cdot\text{L}^{-1}$ for both MTBE and BTEX, but were qualified to only 0.5 $\mu\text{g}\cdot\text{L}^{-1}$.

Results

During July of 1998, 6 wells in Pope Marsh were sampled for MTBE and BTEX. MTBE and BTEX were below detection (0.1 $\mu\text{g}\cdot\text{L}^{-1}$) for all samples except for a sample from well #20, for which 0.13 $\mu\text{g}\cdot\text{L}^{-1}$ MTBE and 0.21 $\mu\text{g}\cdot\text{L}^{-1}$ of toluene were detected. A replicate of this sample was re-assayed 6 weeks later, and found to contain 0.14 $\mu\text{g}\cdot\text{L}^{-1}$ MTBE and toluene below detection (0.1 $\mu\text{g}\cdot\text{L}^{-1}$). Toluene can diffuse through the VOA septa (Dr. Roger Shole, Alfa Analytical, personal communication), and thus may have been lost from the sample during sample storage.

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MTBE has contaminated three STPUD wells; Arrowhead wells #1 and #2 and Tata Lane well #4. Two LUFT sites have been identified as sources of MTBE contamination at these three STPUD drinking water wells. One of these LUFT sites is located 1,300 ft from Arrowhead wells #1 and #2 (combined pumping capacity 805 gpm). Two plumes originate at this LUFT site (Secor Intl. Inc., 1998). One of the plumes is oriented in the direction of the regional water table gradient. The direction of the second plume is oriented at a right angle to the direction of the first plume, with migration toward the Arrowhead wells. The presence of two plumes originating from the same LUFT is likely related to previous seasonal pumping patterns at the Arrowhead wells. The second LUFT site is located 1,500 ft from Tata well #4 (pumping capacity 70 gpm), at a 45 degree angle upgradient to the regional ~~surface water~~ gradient (Pinnacle Environmental Solutions, 1998). Tata well #4 is contaminated with MTBE, whereas Tata wells #1,2, and 3, located about 1,000 ft from Tata #4, are threatened by the same MTBE plume.

The Tata Lane well #4 was screened between 85 and 125 ft below ground surface (bgs), with a standing water level of 57 ft bgs, and a water level of 86 ft bgs when pumping at 60 gpm. Arrowhead well #1 was screened between 67 and 130 ft bgs, with a standing water level of 30 ft bgs, and a water level of 53 ft bgs when pumping at 180 gpm. Thus both Tata and Arrowhead wells draw some water from near the top of the aquifer while pumping. By contrast, Arrowhead well #2 was screened between 218 ft and 268 ft bgs, with a standing water level of 60 ft bgs, and a water level of 85 ft bgs when pumping at 630 gpm. However, a gravel pack extends from 55 ft to 268 ft bgs around this well, so that shallow groundwater can be drawn in through the gravel pack. Thus, all three wells have drawn from shallow groundwater. Additionally, a vertical (downward) component of movement of an MTBE plume has been documented (Pinnacle Environmental Solutions, 1998), with MTBE detected as far as 95 ft bgs (about 80 ft below the water table) at a distance of about 900 ft from a LUFT site and 600 ft from STPUD Tata Lane well #4.

6.2.4 SUMMARY OF LUFT SITE DATA IN TAHOE BASIN

Gasoline LUFT sites that have contaminated groundwater with MTBE are ubiquitous in the Lake Tahoe Basin. In the California side of the Lake Tahoe Basin, 29 of 43 active gasoline LUFT sites have reported MTBE in groundwater. Approximately 67 percent of these LUFT sites have been determined to impact or threaten surface water or ground water. Although Nevada has not required MTBE analysis at gasoline LUFT sites, analysis of MTBE levels was performed at two LUFT sites in the Nevada side of the Lake Tahoe Basin. MTBE was detected in groundwater at both of these sites.

Analysis of drinking water for MTBE has not been required in Nevada, and MTBE monitoring data for drinking water wells has not been received by the Nevada Bureau of Health Protection Services. On the California side of the Tahoe Basin, a few small water systems near LUFT sites have been monitored for MTBE, and MTBE levels have been below detection. However, eleven large public water wells operated by STPUD have been contaminated or threatened by MTBE plumes.

(1996): debris flow, 0.432 m/d; floodplain, 4.32E-05 m/d; levee, 0.173 m/d; and channel, 5.18 m/d. Boundary conditions of the flow model include recharge from above and general head boundaries on the remaining 5 sides of the domain, resulting in a regional horizontal hydraulic gradient of approximately 0.002. Recharge rate applied to the top of the model is 0.34 cm/yr. A pumping well located at the center of the 3-D block was continuously pumping at a rate of 75 m³/d. The groundwater flow model solved for a steady state velocity field, subsequently used in transport simulations to predict the migration of a non-sorbing, conservative contaminant, with the MTBE source located toward the upstream end of the domain near the water table. The source was released as an instantaneous pulse consisting of 60,000 particles.

Simulation results (Fig. 12) show significant vertical migration of the contaminant, despite the presence of many fine-grained layers to limit vertical flow. The leading edge of the plume represents a relative concentration of 10⁻⁵ (C/C₀). For MTBE source concentrations (C₀) on the order of 10⁵ μg·L⁻¹, C/C₀ = 10⁻⁵ represents a concentration (C) of 1 μg·L⁻¹. The plume seeks vertical pathways through the complex, alluvial network. Many alluvial aquifer systems in California have larger recharge rates and are much coarser-grained than the LLNL site used in this example. At such sites, the rates of vertical migration would be faster by factors of at least 2 to 10.

Despite the fact that the contaminant was released as a pulse rather than continuously in time, much contaminant mass lags back near the source location even after several decades of elapsed time (Fig. 12). This is the result of matrix diffusion into fine-grained strata, and is consistent with observations of contaminant distribution (TCE) at the LLNL site.

The plume in Figure 12 represents spatially continuous distributions of dissolved contaminant. The isolated “bubbles” represent areas where the number of “particles” per cell is approximately 1, such that the continuous plume characteristics are not fully mapped in the graphic.

Had the pumping well not been located near the plume, results of this simulation would have been different – not as much vertical transport would have occurred. Importantly though, most developed groundwater basins in California exhibit vertical hydrolic gradients similar to those in this simulation because of regional effects of pumping on hydrolic heads at the deeper horizons. Thus, one can expect the kind of behavior exhibited in Figure 12 in many groundwater systems, even when pumping wells are not close to the plume.

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Additional Errata submitted by Graham Fogg on 2/22/99

Volume IV, Page 7, paragraph 2, sentence 4:

Replace "Pankow et al, 1997" with "Squillace et al., 1995"

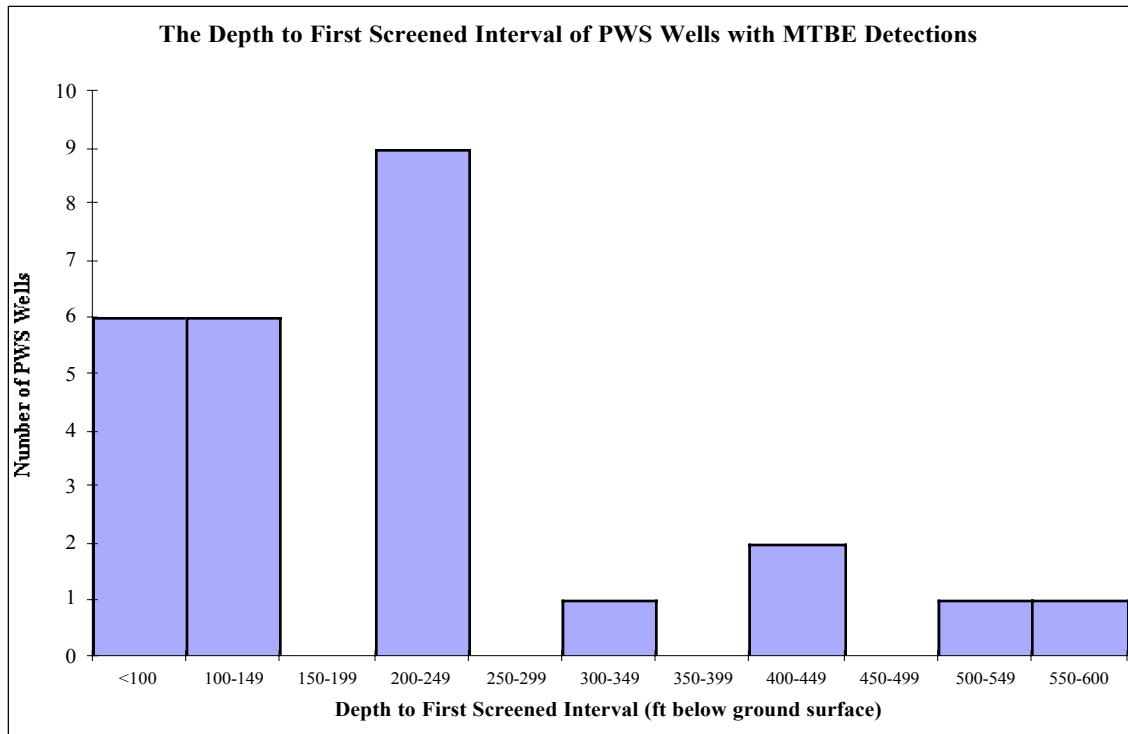


Figure 8. Depths to top of first screened interval among 26 of the PWS wells that have MTBE detects.

An upper bound on the probability that a PWS well has been impacted was estimated to be 1.2 percent (Table 9), using data from the number of wells with MTBE detections, 35 wells, and the total number of PWS wells tested, 2,988 (excluding abandoned, agricultural and inactive wells). Similarly, a lower bound was calculated to be 0.3 percent (Table 9) using data from the number of wells with MTBE detections, 35 wells, and the total number of PWS wells in the counties where testing has been performed, 13,161. The 1.2 percent is considered an upper bound because it is based only on those PWS wells that have been tested for MTBE. Much of that PWS testing has presumably targeted wells near suspected sources, hence it probably represents a biased sample. As of September 1998, 21 percent of California’s PWS wells had been tested for MTBE (Appendix G).

Counties where there is no record of testing PWS wells include Alpine, Colusa, Del Norte, Imperial, Modoc, Mono, Shasta, Sierra, Siskiyou, and Trinity. Statistics for testing and positive detections weigh heavily on results from Los Angeles County, which has sampled 76 percent of the PWS wells in the county, representing 28 percent of the wells tested in the state. The Los Angeles County sampling was evidently not biased toward PWS wells that were near suspected sources, because no small public water systems were deemed “vulnerable” by the Los Angeles County LPA (Los Angeles County Dept. of Health, 1998).