

MTBE IN NEW JERSEY'S ENVIRONMENT



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List of Abbreviations Used

BASIC	Best Available Scientific Information Based Criterion
BEERA	NJDEP Bureau of Environmental Evaluation and Risk Assessment
BTEX	Benzene, Toluene, Ethylbenzene, Xylene
BUST	NJDEP Bureau of Underground Storage Tanks
CO	Carbon Monoxide
DWQ	NJDEP Division of Water Quality
EOHHSI	Environmental and Occupational Health Sciences Institute
GFC	General Fuel Clean-up
GPPC	General Petroleum Product Clean-up
GWQS	Ground Water Quality Standard
MCL	Maximum Contaminant Level
MTBE	Methyl tertiary butyl ether
NAAQS	National Ambient Air Quality
NAWQA	National Water-Quality Assessment Program
NESCAUM	Northeast States for Coordinated Air Use Management
NJDEP	New Jersey Department of Environmental Protection
NJPDES	New Jersey Pollution Discharge Elimination System
NO _x	Nitrogen Oxide
NTP	National Toxicology Program
PHG	Public Health Goal
RFG	Reformulated Gasoline
SIC	Standard Industrial Classification
SWQS	Surface Water Quality Standard
TRI	Toxic Chemical Release Inventory
UATMP	Urban Air Toxics Monitoring Program
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey
UST	Underground Storage Tank
VOCs	Volatile Organic Contaminants

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INTRODUCTION

Methyl tertiary butyl ether (MTBE) is a synthetic chemical which is added to gasoline as a fuel oxygenate. It has been used in gasoline since 1979 as an octane enhancer to replace lead. More recently, it has been used to reduce emissions of carbon monoxide and formation of ozone, under the Clean Air Act (discussed in more detail below).

In terms of annual production in the United States, MTBE ranks among one of the highest chemicals. In 1995, MTBE was the third most produced organic chemical in the United States, behind ethylene and propylene, with 17.6 billion pounds produced (Gullick and LeChevalier, 2000).

The use of MTBE pursuant to the Clean Air Act has been associated with anecdotal reports of health symptoms such as headaches and dizziness, prompting concerns among citizens about the use of MTBE, although research studies have been unable to consistently confirm that such exposures can cause these effects.

More recently, there have been numerous reports of the occurrence of MTBE as a water contaminant from several areas of the country, including California and the New England states. Concerns about these findings have resulted in significant responses by the federal and state governmental bodies (discussed in more detail below). In 1999, a number of bills were introduced in Congress which proposed limitations on the use of MTBE in gasoline. In July 1999, the Blue Ribbon Panel on Oxygenates in Gasoline, an advisory panel appointed by the United States Environmental Protection Agency (USEPA), recommended that water supplies be protected from contamination by fuel additives, while the clean air benefits gained from these additives be maintained (discussed in more detail below). Similar recommendations were issued by NESCAUM (NESCAUM, 1999), an organization of Northeast States for Coordinated Air Use Management. NESCAUM asserted that since the use of MTBE was a federal initiative, a federal solution would be optimal, but if the federal government did not take action, a Northeast regional solution to the problem would be pursued. Several states, including Maine and California, sought to ban the use of MTBE in gasoline. In December 1999, the California Air Resources Board approved rules to implement an executive order by the Governor of California to eventually abolish the use of MTBE in gasoline. On March 20, 2000, the Clinton-Gore administration announced that it would take action to significantly reduce or eliminate the use of MTBE and increase the use of alternatives such as ethanol (USEPA, 2000). Finally, in May 2000, legislation was signed by New York's governor which bans the use, sale, or importation of fuels containing MTBE in the state beginning in 2004.

The recent attention on these issues has resulted in the need to summarize and evaluate the available information relevant to the use of MTBE in New Jersey and its occurrence in New Jersey's environment. This report focuses on the federal requirements for use of MTBE as an oxygenate in New Jersey, New Jersey regulatory standards, permit limits, monitoring

requirements for MTBE, and data on occurrence of MTBE in New Jersey's air and water. Background information is also provided on environmental fate and transport, health effects, and regulatory actions of the USEPA and other states regarding MTBE. The voluminous body of information on occurrence of MTBE in the environment of other states is beyond the scope of this report.

It should be noted that the extent of MTBE contamination in New Jersey's environment constitutes only one part of the information relevant to policy decisions regarding the use of MTBE in the state. The other major topics for which information is required for such policy decisions include the effectiveness of oxygenated fuel in reducing air pollution from motor vehicles, and the relative merits of MTBE compared to other available oxygenates. These issues are not covered in this report.

PROGRAM REQUIREMENTS

1. Background

New Jersey, as well as the rest of the United States, is highly dependent on motor vehicles for transportation. According to the USEPA Office of Mobile Sources, emissions from motor vehicles contribute almost half of the total pollution in the air (USEPA Office of Mobile Sources, 1998). Gasoline itself, as well as emissions resulting from the use of gasoline, are some of the most prevalent hazardous substances to which individuals are exposed in their every day lives.

Under the Clean Air Act, the USEPA regulates mobile source air pollution, particularly six leading criteria air pollutants by establishing standards called National Ambient Air Quality Standards (NAAQS). The primary NAAQS are based on human health effects, while the secondary NAAQS are based on protection of crops, the environment, and quality of life.

Areas that do not meet or attain the primary NAAQS are designated as non-attainment areas. USEPA requires such non-attainment areas to use cleaner burning oxygenated fuels such as wintertime oxygenated fuels and/or federal reformulated gasoline (RFG) as a means of reducing the levels of criteria air pollutants from mobile sources and reach attainment of the health standard (NAAQS). The oxygen requirements (% by weight) and equivalent MTBE content (% by volume) for wintertime oxygenated fuel and reformulated gasoline (RFG) are shown below:

Oxygen Requirements and MTBE Content of Oxygenated Fuels

<u>Type of Fuel</u>	<u>Oxygen Requirement</u> (% by weight)	<u>MTBE Content</u> (% by Volume)
Wintertime Oxygenated Fuel	2.7 %	15%
Reformulated Gasoline (RFG)	2 %	11%

It should be noted that RFG differs from traditional gasoline in ways other than the presence of MTBE, such as limits on the amount of the carcinogen benzene and the requirement that no heavy metals such as lead, manganese, and others be present.

It is important to note that Federal Clean Air Act regulations which require oxygenated fuel do not specifically require MTBE to be added to gasoline. A number of oxygenates or blends are permitted; the gasoline industry is given the flexibility to choose the oxygenate or blend which is most feasible for them, provided that EPA's oxygen content requirement is met. Some of the USEPA approved oxygenates include: di-isopropyl ether, tertiary amyl methyl ether, ethyl tertiary butyl ether, tertiary amyl ethyl ether, ethanol, tertiary butyl alcohol, and methyl tertiary butyl ether (MTBE).

In the Northeastern part of the United States, including New Jersey, MTBE is by far the most prevalent oxygenate in gasoline. In other parts of the country, particularly in corn growing states in the Midwest, ethanol is more commonly used.

In addition to its use as an oxygenate for the Wintertime Oxygenated Fuels program and the Reformulated Gasoline program, MTBE has been used as an octane enhancer in traditional gasoline for twenty years. Levels in conventional premium grade gasoline range from 2 to 8 percent, while regular grades may contain lower concentrations.

2. Wintertime Oxygenated Fuels Program:

Carbon monoxide (CO) is a colorless, odorless gas that enters the bloodstream and inhibits the blood's capacity to carry oxygen to organs and tissues. Exposure to CO levels below those which cause overt toxicity can impair functions such as learning, visual perception, and exercise capacity. The NAAQS for CO is 9 ppm (parts per million) for an 8-hour non-overlapping average not to be exceeded more than once per year, and 35 ppm averaged over a 1-hour period.

Transportation sources are responsible for 77% of the nation's CO emissions (USEPA Office of Mobile Sources, 1999). CO is produced by the incomplete burning of carbon in hydrocarbon-based fuels and is emitted directly from the tailpipe. Extra oxygen enhances fuel combustion, which tends to be less efficient in cold weather and also helps offset fuel-rich operating conditions, particularly during vehicle start ups which are more prevalent in the winter. A gasoline blend containing 2.7% oxygen by weight (oxygenated fuel or ~~A~~oxyfuel®) has been reported to result in approximately 17% reductions in CO emissions compared to emissions when traditional gasoline is used (USEPA Office of Mobile Sources, 1998).

Section 211 (m) of the Clean Air Act (CAA) requires states with CO non-attainment areas to implement a wintertime oxygenated fuel program. In 1990, the USEPA established an oxygen content requirement of 2.7% by weight (equivalent to 15% MTBE by volume) for gasoline which is to be sold during the winter months to be in compliance with the wintertime oxygenated fuels program.

Approximately 39 urban areas throughout the country had unacceptable levels of CO (including New Jersey), and were required to implement the wintertime oxygenated fuels program. The length of the control period was established by the USEPA Administrator. Initially, Northern New Jersey implemented the wintertime oxygenated fuels program for a six month control period, from October 1, 1992 until March 31, 1993; and southern New Jersey implemented the program for a four month control period, from November 1, 1992 until February 28, 1993.

The counties which were included in the Northern New Jersey wintertime oxygenated fuels program were Sussex, Passaic, Bergen, Warren, Morris, Essex, Hudson, Union, Hunterdon, Somerset, Middlesex, Monmouth, and Ocean. The counties which were included in the Southern New Jersey wintertime oxygenated fuels program were Mercer, Burlington, Camden, Gloucester, Salem, Atlantic, Cumberland, and Cape May.

At this time, the Wintertime Oxygenated Fuels Program has been discontinued in all parts of New Jersey. In 1995, the it was repealed in southern New Jersey, due to the attainment of the NAAQS for CO. Based on attainment of the NAAQS for CO, coupled with the findings of MTBE in certain water supplies across the country and citizen concerns about the use of MTBE in gasoline, the DEP in 1997 submitted formal requests to USEPA Region 2 to end the Wintertime Oxygenated Fuels Program in northern New Jersey, and this request was approved in June 1999. Under the agreement, reformulated gasoline (2% oxygen, 11% MTBE) will be sold all year throughout New Jersey.

3. Federal Reformulated Gasoline

In addition to carbon monoxide, gasoline fueled motor vehicles are also responsible for emissions of other volatile organic compounds (VOCs) and nitrogen oxide (NO_x), via the combustion process. VOCs and NO_x react in the presence of heat and sunlight to form ground level ozone. When inhaled, even at very low levels, ozone can cause respiratory effects such as inflammation of the lung tissue and aggravation of asthma. New Jersey is in non-attainment of the ozone NAAQS.

Since the largest contribution of ozone forming constituents comes from highway motor vehicles, cleaner-burning reformulated gasoline (RFG) is used as a means of reducing emissions of the contaminants which lead to ozone formation. RFG is formulated to differ from conventional gasoline with respect to several parameters which are not related to the presence of oxygenates. The formulation of RFG is intended to reduce evaporative emissions and exhaust emissions of ozone precursors, such as VOCs. Additionally, RFG is formulated to reduce emissions of air toxics including benzene, 1,3-butadiene, formaldehyde, and acetaldehyde. Compared to conventional gasoline, RFG has a lower vapor pressure (for reduced evaporative emissions), reduced sulfur content (to prevent inactivation of catalytic converters), and reduced aromatic and benzene content (Keller et al., 1998).

The CAA requires areas of the country with the highest levels of ozone air pollution (severe non-attainment of the NAAQS) to implement the RFG program. As of January 1, 1995, nine severe ozone non-attainment areas (including New Jersey) were required to implement this program. Although optional for Cape May and Atlantic counties, New Jersey implemented the RFG program statewide, for ease of gasoline distribution.

The federal RFG program has two phases which include the following performance standards:

RFG Phase I (1995-1999 implementation) - maximum (cap) of 1% by volume benzene, minimum of 15% annual air toxics reductions, minimum of 15% VOC emission reductions during ozone season, no NO_x increase from baseline gasoline, CO reductions in the winter, no heavy metals, and a minimum of 2.0% oxygenate (by weight).

RFG Phase II (2000-2010 implementation) - maximum (cap) of 1% by volume benzene, approximately 22% annual air toxics reductions, 27-29% VOC emission reductions during ozone season, 7% NO_x reductions, aromatics control, reduction in emissions that cause acid rain formation, no heavy metals, and a minimum of 2.0% oxygenate (by weight).

Following implementation of the federal RFG program, the USEPA has noted considerable reductions in VOCs, NO_x, and air toxics, including 38% reductions in benzene, a known human carcinogen (USEPA Office of Mobile Sources, 1999). USEPA further noted that a vehicle operating on RFG emits about one third less toxic pollutants and 12% less carcinogens compared to the same vehicle operating on conventional gasoline (USEPA Office of Mobile Sources, 1998). It should be noted that these benefits arise from the use of RFG, and are not specifically attributable to the use of MTBE or any other particular oxygenate.

FATE AND TRANSPORT

1. Potential for transport in groundwater

MTBE has higher water solubility, exhibits lower adsorption to soil, and is more resistant to chemical degradation than the other common groundwater contaminants from gasoline - benzene, toluene, ethylbenzene, and xylene (BTEX compounds). Its water solubility of about 50 g/L makes it about 25 times more soluble than benzene, the most soluble of the BTEX constituents (Squillace et. al, 1997). This implies that MTBE should be more readily leached to groundwater, and transported more quickly and further in groundwater, than the BTEX compounds. Its adsorption to soil is so low that it should transport nearly as rapidly as the groundwater itself. This behavior has been observed in aquifers (Squillace et al., 1997). For this reason, MTBE has been used as an indicator compound to determine if a plume of gasoline-contaminated groundwater is approaching a groundwater monitoring location. How much more quickly and how much further MTBE travels relative to other gasoline compounds is under some debate, however. Benzene, while having a lower soil adsorption coefficient than MTBE, nonetheless exhibits minimal adsorption to soil and is quite mobile. A recent

report from Lawrence Livermore laboratories (Happel et al., 1998) indicated that measured MTBE plumes for several case studies were no more extensive than benzene plumes. However, the investigators also stated that the measured benzene plumes quite possibly resulted from earlier spills than those responsible for the MTBE plumes, and that they believed that the MTBE plumes would grow over time relative to the benzene plumes. This hypothesis is further supported by the fact that MTBE is more resistant to degradation than benzene, which would tend to allow its transport for longer distances prior to being attenuated via degradation.

2. Potential contribution of atmospheric MTBE to groundwater

Much of the interest in possible MTBE washout from the atmosphere to groundwater stems from recent publications by the U.S. Geological Survey (Pankow et al., 1997; Baehr et al., 1999a). The papers discuss levels of MTBE found in shallow groundwater, and possible sources for the observed levels. Possible sources discussed were leaking storage tanks, stormwater runoff, and precipitation.

The possibility for MTBE deposition onto the soil surface and its subsequent leaching to groundwater stems from the low Henry's law constant for this chemical. The Henry's law constant determines the tendency of a chemical to transfer from air to water or vice versa. The Henry's law constant for MTBE is low relative to the BTEX compounds (about 14 times lower than that of benzene), which signifies that it has a greater tendency to wash out of the atmosphere in precipitation and to leach to groundwater than do the BTEX compounds.

Direct experimental measurements of MTBE deposition have not been conducted, because such experiments are difficult to conduct with volatile organic chemicals. However, theoretical calculations have been made to estimate maximum MTBE concentrations in shallow groundwater resulting from washout and leaching of measured air levels of MTBE in New Jersey. It was determined that maximum concentrations of MTBE that might occur in shallow groundwater as a result of atmospheric deposition would be approximately 1 ug/L. Since many groundwater samples collected both in New Jersey and other parts of the United States have been observed to contain MTBE in sub-ug/L levels, the possibility of some of these observations being due to atmospheric washout cannot be eliminated, at least in the case of shallow groundwater samples. Concentrations higher than 1 ug/L in groundwater apparently result from local spillage or leaking of underground storage tanks, rather than atmospheric deposition.

3. Potential for accumulation in lakes

Data pertaining to MTBE fate and transport in lakes has recently become available, and include studies on lakes in New Jersey and California (See Occurrence section below for data on MTBE in New Jersey lakes). The University of California, Davis, is conducting the largest-

scale studies on this topic at the present time. In their study at Donner Lake, CA, motorized watercraft were identified as the principle source of MTBE contamination (Reuter et al., 1998). Personal watercraft (jetskis) and many other motorized watercraft use 2-stroke engines, which run on a oil/gasoline mixture. As much as 30% of this fuel is discharged directly into the waterbody.

Two factors may account for the buildup of MTBE in lakes during the boating season. First, MTBE is present in gasoline as a higher percentage than the BTEX compounds. Additionally, BTEX chemicals have much higher Henry's law constants than MTBE; these compounds volatilize fairly rapidly from the water body while MTBE has a much greater tendency to remain in the water. The time resolution of the Donner Lake study was such that a spike in MTBE levels was observed over the July 4th weekend of 1997. MTBE levels as high as 12 ug/L in the lake were measured just after this holiday. Also observed was the dissipation of MTBE after the boating season. Although volatilization of MTBE is slow, it was adequate to remove measurable MTBE from the lake prior to the next boating season. Thus, no carryover from the prior year was observed. UC Davis, along with the U.S. Geological Survey, is conducting research on a much larger lake, Lake Tahoe, CA (USGS, 1998). Significant near shore levels of MTBE up to 4.2 ug/L have been measured, presumably due to boating activity. In deeper waters of the lake, MTBE has not been observed, apparently due to dilution of MTBE into the very large volume of this lake. Other lakes in the vicinity without watercraft activity were also sampled and no measurable MTBE was found.

Information on MTBE occurrence in New Jersey lakes is presented later in this report.

4. Degradation of MTBE

Atmosphere - Like many gasoline components, MTBE degrades rather rapidly in the atmosphere. The primary degradation product is tertiary-butyl formate. Half-lives of MTBE in the atmosphere can be as short as 3 days. The primary reactant in the atmosphere responsible for the degradation is the hydroxyl radical. In urban areas, degradation may be lower due to lower concentrations of the hydroxyl radical being present. Nonetheless, MTBE is not thought to persist, and measured concentrations result from a steady-state between vehicular emissions and degradation in the atmosphere.

Soil and groundwater **B** Research into MTBE degradation in soil and groundwater is under extensive investigation at the present time. Evidence to date indicates that MTBE degrades much slower than the BTEX compounds, and, therefore, may travel further and persist longer in groundwater plumes. The primary reaction product is tertiary-butyl alcohol, which is another constituent of gasoline commonly found in conjunction with MTBE. The ultimate degradation products have been confirmed to be carbon dioxide and water.

While natural field degradation of MTBE by microorganisms is rather slow, it is measurable, and particular species have recently been identified that are able to utilize MTBE as a sole-

carbon source. Recent research in bioremediation of MTBE implies that degradation can be greatly accelerated by inoculating water or soil with MTBE-acclimated microorganisms. Thus, while natural degradation of MTBE may be slow, there is a good potential for using enhanced biodegradation as a remediation technique. Spontaneous development of higher degradation rates has also been observed in one California wastewater treatment plant. Factors controlling the rate of biodegradation of MTBE appear to be site-specific, and are not well understood at this time.

HEALTH EFFECTS

The discussion of health effects below is divided into three sections dealing with acute health effects, longer term health effects, and taste and odor (in water). Concerns about acute health effects are relevant primarily to concerns about symptoms arising from exposure to vapors from gasoline containing MTBE, such as while refueling automobiles, while longer term health effects and taste and odor in water relate primarily to exposure via drinking water.

1. Acute Health Effects

Like other ethers, inhalation of high levels of MTBE by animals or humans results in depression of the central nervous system. Symptoms observed in rats exposed to 4000 or 8000 ppm in air included labored respiration, ataxia, decreased muscle tone, abnormal gait, impaired treadmill performance, and decreased grip strength. These symptoms were no longer evident 6 hours after exposure ceased. A lower level of MTBE, 800 ppm, did not produce apparent effects (Daughtrey et al., 1997).

A number of investigations have been conducted to examine the self-reported acute effects, such as headache, eye and throat irritation, and dizziness, which have been attributed to exposure to MTBE in gasoline vapors during use by consumers. This research includes both epidemiological studies and studies involving controlled exposure of volunteers to MTBE at concentrations similar to those encountered in refueling an automobile (Reviewed in USEPA, 1997, and California EPA, 1998)

In general, the studies involving controlled human exposures in chambers to levels of MTBE similar to those experienced during refueling and driving an automobile have not shown effects of MTBE on physical symptoms (e.g. irritation), mood, or performance based tests of neurobehavioral function.

The studies involving symptoms reported by individuals with different degrees of MTBE exposure, as estimated by their exposure to gasoline in their daily activities, are more difficult to interpret, because they do not take place in the controlled environment used in the chamber studies. In particular, it is difficult to separate effects of exposure to MTBE from those of gasoline itself. In an attempt to address this issue, Mohr (1994) compared New Jersey

Department of Transportation garage workers and service station attendants from areas of the state where MTBE was present and absent from gasoline, and found no effects attributable to MTBE. The California EPA (1998) concluded that, "Several studies undertaken over the past four to five years were unable to find any correlation between reported acute health effects and MTBE exposures experienced by the general public, mainly through inhalation, from the use of MTBE in gasoline."

An important question regarding acute effects of MTBE is whether certain sensitive individuals may experience effects which do not occur in the general population. The study conducted by the Environmental and Occupational Health Sciences Institute (EOHSI), discussed below, attempted to address this issue.

New Jersey Citizen Complaints Received by NJDEP Bureau of Transportation Control

The first complaints (primarily from gasoline and refinery workers) about the wintertime oxygenated fuels (oxyfuel) program in the United States began directly after implementation of the program in Alaska. The people with complaints believed that the oxyfuel was responsible for their adverse health symptoms such as headaches, nausea, dizziness, eye and throat irritation. This spurred numerous health studies, some of which revealed that Alaska's crude oil (or base stock) which was used to blend with MTBE, became extremely odoriferous when combined with MTBE - much more so than other states' crude oil. The east coast did not use the same crude oil as Alaska, and therefore, did not experience the same intense unpleasant odor changes that Alaska's oxyfuel exhibited. Soon after implementation of the wintertime oxygenated fuels program and refinery/gasoline worker complaints, Alaska discontinued the use of MTBE as their oxygenate.

Immediately following the Alaska incident, phone calls of complaints and concerns about oxygenated fuel began in New Jersey, and later in Wisconsin. However, New Jersey's bordering state, Pennsylvania, where most residents self-refuel, did not experience phone calls about health complaints or concerns following implementation of their oxygenated fuels program. It should be noted that, unlike Pennsylvania, New Jersey residents are prohibited by law from self-refueling; therefore, New Jersey's general population had less exposure to MTBE as compared to Pennsylvania residents who were self-refueling. The MTBE complaints (phone calls and letters) received from New Jersey residents are tabulated below.

New Jersey Citizen Complaints Regarding MTBE

Winter Oxyfuel Season	Written Complaints	Telephone Complaints
1992 - 1993	13	38
1993 - 1994	27	51
1994 - 1995	44	44

1995 - 1996	8	17
1996 - 1997	11	5
1997 - 1998	5	3
1998 - 1999	11	5

It should be noted that the total numbers of complaints above is actually lower than the sum of the number of written complaints and the number of telephone complaints. This is due to the fact that many of the citizens who telephoned in their complaint also sent a written letter to the NJDEP and/or the Governor. Also, some citizens sent more than one letter during the same oxyfuel season, some letters were merely inquiring about oxyfuel/MTBE and not registering a complaint. (The phone database did, however, screen out duplicate calls from the same individuals during the same oxyfuel season, and inquiries without any complaints.)

The NJDEP made note of the fact that in 1995 when RFG was implemented statewide (at 2.0% oxygen, equivalent to 11% MTBE), no telephone complaints were received by the NJDEP during the spring and summer months. In fact, citizens who called NJDEP during the fall stated that they felt great during the spring and summer months of that year when 11% MTBE was used, but became sick again in the fall when the wintertime oxygenated fuels program with 15% MTBE resumed.

EOHSI MTBE Chamber Study

In response to the health complaints and concerns about MTBE in gasoline, New Jersey's Environmental & Occupational Health Sciences Institute (EOHSI) conducted a controlled experiment to evaluate the association, if any, between the reported health symptoms and the use of MTBE in gasoline. The study was funded from the State of New Jersey (through NJDEP) and ARCO Chemical Company (now Lyondell).

EOHSI's MTBE chamber study involves a controlled exposure facility (CEF) or chamber where volunteers were exposed to clean air, gasoline alone, and gasoline with 11% and 15% MTBE in air at levels typical of those encountered during vehicle refueling. The participants included volunteers of two types: healthy individuals who believed they were sensitive to MTBE (self-reported sensitives), and healthy individuals (normals/controls) who believed they were not sensitive to MTBE. The study involved nineteen control subjects and twelve self-reported sensitive subjects. Although the initial protocol specified that a greater number of subjects would be used, this was the number remaining after screening for medical conditions and willingness to participate.

Exposures were conducted in random order in a double-blind fashion one week apart for each individual. The exposure period was fifteen minutes long. Three types of parameters were evaluated in the study participants. These were psychophysiological responses, such as pulse and

blood pressure; neurobehavioral performance involving perception, response time, and basic motor skills, as measured by computer simulated driving tests; and symptoms, as measured by completion of a questionnaire before and after the exposure in the chamber.

Results of the study have been accepted for publication to Environmental Health Perspectives (Fiedler et al., 2000), and were released in a press conference in February 2000. In summary, no significant differences were seen in comparisons of self-reported sensitives and controls responses to the four exposure conditions for psychophysiologic parameters or for neurobehavioral performance (simulated driving test).

The only significant differences found between self-reported sensitives and controls were in reported symptoms: self-reported sensitives had a much higher baseline (prior to exposure) score for reported symptoms than controls. (Average symptom score, based on a combination of number and severity of symptoms, for controls was approximately 1.5 versus approximately 14.5 for self-reported sensitives). This was said to suggest a generic non-specific sensitivity.

The change in symptom score was obtained by subtracting the pre-exposure score from the post-exposure score. A statistical method called a permutation analysis was used to compare differences between controls and self-reported sensitives and between exposure conditions to obtain a single value of statistical significance (p value). The conclusion from this analysis was that self-reported sensitives reported significantly more total symptoms than controls when exposure to 15% MTBE was compared to Clean Air or to 11% MTBE. The symptom score for exposure to 15% MTBE compared to exposure to gasoline alone was not significant ($p < 0.08$), while comparisons of 11% MTBE to clean air or gasoline alone were not significant.

Further analysis of symptom subscales (MTBE symptoms, anxiety symptoms, depression symptoms, breathing symptoms, and solvent symptoms) indicated lack of specificity of statistical significance to the symptoms associated with MTBE exposure.

The authors concluded that the present study did not support a dose-response to MTBE exposure, nor the specific symptoms associated with MTBE that were suggested in previous epidemiologic studies.

2. Subchronic and Chronic Health Effects

Summary of Available Studies

Information on longer term health effects of MTBE comes from studies in laboratory animals, rather than from exposed humans. Cancer bioassays of MTBE have been conducted by the oral route in rats and by inhalation in rats and mice. The studies described below are those which are relevant to the chronic risk assessment of MTBE.

Oral Studies

An oral subchronic study in rats conducted by USEPA (Robinson et al., 1990) indicated that

MTBE is not highly toxic. The animals were given 0, 100, 300, 900, or 1200 mg/kg MTBE in corn oil for 90 days. Effects observed in treated animals included increased kidney weight, increased relative liver weight, and some changes in blood chemistry and enzyme parameters. The only histological change attributed to MTBE treatment was in the renal tubules of the highest dose male rats.

Belpoggi et al. (1995) administered 0, 250, or 1000 mg/kg MTBE in olive oil to rats each day for two years. A dose related increase of leukemias and lymphomas was seen in the female rats, and an increased rate of testicular Leydig cell tumors in high dose male rats was reported. The results of this study have been questioned because, although it was published in a peer reviewed journal, a detailed technical report of the bioassay has not been released. The National Research Council (1996) raised a number of technical issues about this study, and requested that the researchers allow for an independent review of the data. In 1998, Belpoggi et al. published the results of a further review of the pathology results by pathologists at the Cancer Research Centre in Bentivoglio, Italy, where the study was conducted. This review confirmed the previously reported results. To date, requests to the researchers for permission to conduct an independent review of the pathology and other aspects of the study have not been successful, so the concerns remain.

Inhalation Studies

Rats were exposed to 0, 400, 3000 or 8000 ppm MTBE by inhalation 6 hours per day, 5 days per week, for two years (Chun et al., 1992). In exposed males and females, an increased in chronic, progressive nephropathy was observed. Survival time was reduced in treated male rats, and body weights were reduced in the high level males and females, indicating that the Maximum Tolerated Dose was exceeded.

The combined incidence of renal tubular adenomas and carcinomas was significantly increased in males of the two highest treatment groups. The issue of whether these tumors occur by a mechanism known to not be relevant to human cancers (alpha-2-microglobulin) remains unresolved, as detailed mechanistic studies have provided ambiguous results. Additionally, a statistically significant increase in testicular Leydig cell tumors was seen. This type of tumor has a very high background rate in the strain of rats (F344) used in the study, and the rate of these tumors was not significant when compared to historical controls.

Mice were exposed by inhalation to 0, 400, 3000, or 8000 ppm MTBE 6 hours/day, 5 days/week for 18 months (Burleigh-Flayer et al., 1992). Survival and body weight were reduced in the high dose groups, indicating that the Maximum Tolerated Dose was exceeded. A significant increase in hepatocellular carcinomas in male mice and hepatocellular adenomas in female mice occurred only in the high dose group.

Risk Assessment Issues

Due to the toxicological issues associated with all three long term carcinogenicity bioassays of MTBE which are discussed above, the classification of MTBE as to carcinogenicity is not a clear

cut decision. This is reflected in the differing risk assessment conclusions arrived at by various agencies, as summarized below.

USEPA has refrained from formally classifying MTBE as to carcinogenicity, but states that the weight of evidence indicates that MTBE is an animal carcinogen, and the chemical poses a carcinogenic risk to humans (USEPA, 1997). USEPA's Office of Water has developed both cancer and non-cancer risk assessments for MTBE, but has based its drinking water guidance on neither of these, and instead has used taste and odor thresholds as the basis for its guidance. It should be noted that, if the results of the carcinogenic risk assessment were to be used, the carcinogenic potency of MTBE is calculated to be much lower than that of most other carcinogens.

In 1998, the National Toxicology Program (NTP) Board of Scientific Counselors Report on Carcinogens Subcommittee voted against listing MTBE as a reasonably anticipated to be a human carcinogen in its Report on Carcinogens, Ninth Edition (NTP, 1998). The NTP is required to prepare this report annually, and is required to list all substances known to be or reasonably anticipated to be human carcinogens to which a significant number of persons living in the United States are exposed. Listing as a reasonably anticipated to be a human carcinogen is based on scientific judgement after considering all relevant human and animal toxicity data, including supporting information such as mechanistic studies.

Investigators from the University of California, in a report to the legislature (Froines et al., 1998) concluded that MTBE is carcinogenic in rats and mice, with the potential to cause cancer in humans, while the California EPA's Office of Environmental Health Hazard Assessments Proposition 65 Committee recently decided not to list MTBE as a carcinogen in December, 1998.

The New Jersey Drinking Water Quality Institute (1994) recognized the uncertainties regarding the carcinogenicity of MTBE, specifically by oral exposure, and classified MTBE as a possible human carcinogen (equivalent to USEPA Group C). This classification forms the basis for New Jersey's Drinking Water Health-based Maximum Contaminant Level (MCL) for MTBE. The Health-based MCL is based on the subchronic oral study in rats conducted by USEPA which was described earlier in this section (Robinson, 1990), and the endpoint of concern was increased relative kidney weight. An additional uncertainty factor of 10 was incorporated to account for possible carcinogenic effects, following USEPA's and New Jersey's approach for drinking water risk assessment of possible human carcinogens.

In contrast to New Jersey, California EPA finalized a drinking water Public Health Goal (PHG) for MTBE of 13 ug/L in 1999, which was based on low dose extrapolation to lifetime risk level of one in one million. It should be noted that the PHG is not a standard, but a health-based goal which will be taken into consideration when developing the drinking water standard (Maximum Contaminant Level). California's risk assessment was based on combining the incidence of tumors observed in the chronic oral study in rats, and the inhalation studies in mice and rats. Physiologically based pharmacokinetic modeling was used

to extrapolate the results of the inhalation study to oral exposure.

The New Jersey NJDEP, Division of Science, Research, and Technology (July 10, 1998) commented on the California PHG document (California EPA, 1998) after its proposal. It was noted that both New Jersey and California had reviewed the same toxicological data in developing their health-based drinking water levels. The two states differed as to the appropriateness of performing quantitative risk assessment for MTBE based on linear low-dose extrapolation of carcinogenic effects, based on the concerns discussed above. It should also be noted that toxicologists familiar with the toxicology literature from several other states have questioned whether the cancer data on MTBE would be more appropriately modeled using a non-linear approach under USEPA's proposed revisions to its guidelines for carcinogen risk assessment (Andrew Smith, State Toxicologist, Maine NJDEP, personal communication).

Finally, California and New Jersey differ in the exposure assumptions used for drinking water risk assessment. California assumes exposure to 3 liters of water each day, while New Jersey and USEPA assume 2 liters. If 2 liters of water per day were to be assumed in California's risk assessment, the drinking water level would be 20 ug/L rather than 13 ug/L.

USEPA Office of Research and Development has published a report entitled "Oxygenates in Water: Critical Information and Research Needs" (December 1998). In the section entitled Health Effects, the uncertainties in the toxicological data on MTBE were noted, particularly in regard to the oral route of exposure. Pharmacokinetic studies are currently underway which will provide information on the appropriateness of extrapolation from inhalation to oral exposure. Additional subchronic oral studies were recommended to provide additional data and help validate any model developed for route-to-route extrapolation. The report also states that if these studies are not successful in providing the needed information, a new chronic oral bioassay may be needed to reduce uncertainties as to the human health risks of chronic exposure to MTBE from drinking water

3. Organoleptic Properties

Water contaminated with MTBE may have an altered taste or odor (referred to as "organoleptic properties"). Organoleptic properties cannot be used by New Jersey or by USEPA in development of enforceable drinking water standards, but are of concern because they may make the water distasteful for potable use. At the time when New Jersey's Health-based Maximum Contaminant Level Support Document for MTBE was developed, available information indicated that organoleptic properties of MTBE would not be expected to be of concern at levels below 100 ug/L. Since that time, a number of additional studies have been conducted which investigated the taste and odor threshold for MTBE in water, some of which indicate that the threshold may be lower than 100 ug/L. These studies are reviewed in the USEPA Drinking Water Advisory (USEPA, 1997) and the California Public Health Goal document (California EPA, 1998). As would be expected, there is a wide range in the ability of individuals to detect MTBE in water, and results for a particular individual may vary over time. Ability to detect MTBE in water is also affected by many factors including other substances present in the water and temperature of the

water.

Based on review of available data, USEPA concluded that 20 to 40 ug/l is an approximate threshold for organoleptic response, but that some individuals will be able to detect MTBE at lower levels. EPA's guidance for MTBE in drinking water is based on this 20 to 40 ug/L range for MTBE detection. California finalized its secondary Public Health Goal for MTBE in January 1999 at 5 ug/L, based on the ability of sensitive individuals to detect MTBE.

REGULATION AND GUIDANCE BY NJ, USEPA, AND OTHER STATES

1. Regulation by New Jersey

Drinking Water Standard

The New Jersey Drinking Water Quality Institute's development of a drinking water standard (Maximum Contaminant Level, MCL) for MTBE began in the mid-1980's in response to its detection in New Jersey drinking water surveys (discussed below). This was prior to MTBE's use as an oxygenate for reduction of air pollution; it was added to gasoline as an octane booster at this time. The development of an MTBE standard by New Jersey was particularly necessary because, as discussed below, no federal drinking water standard was available, and such a standard has not yet been developed by USEPA at this time.

New Jersey's Maximum Contaminant Level (MCL) of 70 ug/L for MTBE was promulgated in 1996, pursuant to the A-280 Amendments to the New Jersey Safe Drinking Water Act, and monitoring by all water supplies for MTBE was required at this time. The Health-based Maximum Contaminant Level, which forms the basis for the standard (MCL) is based on a subchronic oral study in rats conducted by USEPA (Robinson, 1990). The endpoint of concern was increased relative kidney weight. MTBE was classified as a possible human carcinogen, and an additional uncertainty factor of 10 was incorporated to account for possible carcinogenic effects.

Ground Water Quality Standard (GWQS) (N.J.A.C. 7:9B6)

There is no specific ground water quality criterion for MTBE in the current GWQS which were readopted without change on January 18, 1996. There is an interim specific criterion (ISC) (N.J.A.C. 7:9 B6.7(c)2.) of 70 ug/L for Class II-A areas which will be replaced with a specific criterion as soon as reasonably possible by rule. The ISC of 70 ug/L is based on the Health-based Maximum Contaminant Level for drinking water discussed above.

Surface Water Quality Standards (SWQS) (N.J.A.C. 7:9B)

There is no surface water quality criterion for MTBE in the current SWQS (April 17, 1998). However, provisions are provided under N.J.A.C. 7:9B-1.5 that whenever a parameter specific criterion has not been developed, the Department will utilize the best available scientific information based criterion (BASIC) in the development of chemical specific water quality based effluent limitations for point source discharges. In the case of MTBE, a BASIC

criterion of 70 µg/L, based on the human health-based drinking water standard, is being used by the permitting group. That BASIC reflects the criterion for MTBE proposed for all FW2 waters which DEP intends to propose in upcoming revisions to the Surface Water Quality Standards (N.J.A.C. 7:9B).

Currently, water quality criteria for MTBE for the protection of freshwater or marine aquatic life have not been developed. Testing is currently underway to complete the acute and chronic aquatic toxicity data sets needed to derive these criteria (USEPA Office of Research and Development, 1998).

2. Regulation and Guidance by USEPA and Other States

USEPA Office of Water

USEPA has neither proposed nor promulgated a drinking water standard for MTBE. MTBE is listed on the drinking water Contaminant Candidate List for further evaluation as to whether a drinking water standard is necessary. USEPA has determined that additional health effects research and occurrence data are needed before a regulatory determination can be made.

MTBE is included in the Unregulated Contaminant Monitoring Rule (USEPA, September 17, 1999), which will require that all large public water systems and a statistical sample of small and medium public water systems monitor and report the presence of MTBE in their water supplies.

In December 1997, USEPA issued a document entitled "Drinking Water Advisory: Consumer Acceptability and Health Effects Analysis for MTBE" (USEPA, 1997). This document provides guidance for situations of water contamination by MTBE. In contrast with USEPA's Drinking Water Health Advisories which provide such guidance for many other contaminants, the MTBE document's recommendations were not derived from a health-based risk assessment, but are based on organoleptic (taste and odor) effects. The Advisory states that its recommended range of 20-40 µg/L based on taste and odor will also protect against any potential adverse health effects with a very large margin of safety.

USEPA Blue Ribbon Panel

In November 1998, USEPA established a Blue Ribbon Panel of leading experts in fields relevant to MTBE concerns to focus on issues posed by the use of MTBE and other oxygenates in gasoline. The panel will evaluate such issues as the role of oxygenates in meeting clean air standards, environmental fate and transport of oxygenates, health effects of oxygenates, causes of water contamination by gasoline, and cleanup technologies for water and soil.

The panel's findings and recommendations were released in July 1999. In summary, recommendations were made in two general areas, Enhanced Water Protection, and Blending of Fuel for Clean Air and Water:

In the area of Enhanced Water Protections, recommendations were made for enhancement of Federal and State Underground Storage Tank Programs; implementation of Federal and State Safe Drinking Water Act programs in the areas of source water assessment, monitoring for MTBE, and wellhead protection; restriction of use of gasoline motorboats on water bodies used as drinking water sources; increased efforts in assessment of private wells and education of private well users; increased public education regarding proper use of gasoline; research into behavior of gasoline components in groundwater, and increased funding and research for treatment and remediation.

In the area of Blending Fuel for Clean Air and Water, recommendations were made for substantial reduction in the use of MTBE and for quick Congressional action to clarify state and federal authority in regulating gasoline additives which threaten the drinking water supply.

Additionally, it was recommended that Congress act to remove the current 2% oxygen requirement in RFG to provide flexibility in cost-effective fuel blending while reducing MTBE use, and that EPA ensure that there is no loss of current air quality benefits if the current RFG requirements are revised.

NESCAUM Report

In August 1999, NESCAUM (The Northeast States for Coordinated Air Use Management), whose members include the New England states, New York, and New Jersey, issued a report entitled *RFG/MTBE, Findings and Recommendations* (NESCAUM, 1999). This study was undertaken in response to a request from New Hampshire Governor Shaheen in November 9, 1998, on behalf of the New England Governor's Conference.

NESCAUM's recommendations were basically consistent with those of the Blue Ribbon Panel.

They stated that a federal solution to address the problem would be preferable, but that a regional solution would be pursued in the Northeast no appropriate federal action takes place. The recommendations include legislative and regulatory initiatives to reduce the amount of MTBE in gasoline, including Congressional action to lift the federal RFG oxygen mandate and a three year phase down and cap on MTBE in gasoline; USEPA regulatory revision to prevent decreased air quality from an MTBE phase-down; enhancements in gasoline storage tank programs; development of a regional database for air and water quality data; scientific assessment of potential MTBE alternatives; analysis of the impacts on fuel supply and price of decreased MTBE use; and public education regarding the impact of gasoline spills.

Recent Federal Actions

On March 20, 2000, EPA Administrator Browner and Agriculture Secretary Glickman announced actions by the Clinton Administration to significantly reduce or eliminate the use of MTBE, and increase the use of ethanol as a fuel oxygenate (USEPA, 2000). The actions include two parts, a legislative framework which is being sent to Congress and regulatory action by USEPA to reduce or phase out MTBE. These actions will not result in immediate cessation of the use of MTBE, and reductions are expected to occur over a longer time frame, such as several years.

The legislative framework includes three recommendations, as follows: Congress should amend the Clean Air Act to provide authority for significant reduction or elimination of MTBE; Congress should ensure that air quality gains are not reduced as MTBE use decreases; and Congress should replace the oxygenate requirement in the Clean Air Act with a renewable fuel standard.

The regulatory actions being taken by USEPA include issuing an Advance Notice of Proposed Rulemaking under the Toxic Substances Control Act, and a full proposal to ban or phase down MTBE in expected within six months.

Standards and Guidance Values of Other States:

Provided below are a table of drinking water standard and guidance values for MTBE obtained by the New York Department of Environmental Conservation, as well as a map of MTBE Groundwater Clean-up Regulations obtained from the USEPA Office of Underground Storage Tanks website.

New York Department of Environmental Conservation Survey

The table below was modified from a table generated by the Divisions of Water and Environmental Remediation, New York Department of Environmental Conservation (DEC), based on web sites, E-mail and telephone research during the week of September 8, 1998. It was revised to reflect new information from California and New Hampshire; other states reflect information as of September 1998.

Drinking water standards or guidance values were reported by 17 states of approximately 35 responding to the survey. It is likely that many states which have not developed specific values do not regulate MTBE in drinking water, and use the USEPA Drinking Water Advisory as guidance when advice on MTBE is requested by citizens.

Of the states included in this survey, the standards and guidance values range from California's secondary standard of 5 ug/L (which is based on taste and odor) and its Public Health Goal (PHG) of 13 ug/L, to 240 ug/L used by Michigan. It should be noted that California's Public Health Goals are based on public health considerations only and are not regulatory in nature. The final California Maximum Contaminant Level (drinking water standard) has not yet been proposed, and will consider costs and technical feasibility in addition to the Public Health Goal.

A number of states have based their MTBE standard or guidance on the same subchronic study (Robinson, 1990), toxicological endpoint, and uncertainty factors as were used by New Jersey to derive its MCL. In some cases when the toxicity basis is the same as New Jersey's, the standard or guidance value developed may differ because of differing exposure assumptions, some of which may not be applicable in New Jersey (personal communication with Andrew Smith, State Toxicologist, Maine NJDEP).

In contrast, California's drinking water Public Health Goal is based on a carcinogen risk assessment utilizing a slope factor for low-dose extrapolation to a risk level utilized of 1×10^{-6} . New York has recently adopted an ambient water quality criterion of 10 ug/L for MTBE, based on a carcinogenic endpoint with low-dose extrapolation to a 1×10^{-6} risk level. The drinking water standard, however, remains at 50 ug/L. In New Hampshire, a legislation was passed in the summer of 1999 requiring that a drinking water standard be set, and mandating that the basis for California's Public Health Goal be examined. A drinking water standard of 13 ug/L based on low-dose extrapolation of carcinogenic effects to the 1×10^{-6} risk level has been proposed in New Hampshire.

STATE DRINKING WATER STANDARDS OR GUIDANCE VALUES (ug/L) September 1998*	
STATE	STANDARD OR GUIDANCE
Arizona	35 (guidance)
California	5 (secondary MCL) 13 (public health goal)
Connecticut	100 (action level)
Florida	50 (guidance)
Georgia	20-40 (guidance)
Illinois	70 or 230 (guidance)
Iowa	200 (guidance; 20 if EPA cancer class C accepted)
Maine	35 (MCL)
Maryland	Use EPA Advisory (20-40)
Massachusetts	70 (guideline)
Michigan	240 (standard)
Missouri	30-35 (guidance)
New Hampshire	13 (proposed)
New Jersey	70 (MCL)
New York	50 (MCL)
North Carolina	70 (enforced)
Rhode Island	40 (guidance)
South Carolina	40

*California value revised as of May 1999 and New Hampshire as of February 2000; all others reflect information as of September 1998.

Map of MTBE Groundwater Cleanup Regulations

The map on the next page was obtained from the USEPA Office of Underground Storage Tanks Website. It is current as of March 2000. Shown are state's regulations applicable to the cleanup of MTBE from contaminated groundwater. In some states other than New Jersey, the cleanup values may differ from the health-based drinking water standards for the same contaminant.

PERMIT LIMITS and MONITORING REQUIREMENTS

1. Air

The Bureau of Air Quality Evaluation has not been able to identify any requirements (neither permit limits nor monitoring requirements) related to MTBE in any Air Pollution Control permit. A thorough search for such requirements was not possible because the Air Program is in a transition from the old Data General permitting information system (which has been inaccessible for over 2 years) to the new AIMS system (which has incomplete information). However, an informal survey of the permit evaluators who are most likely to have put MTBE conditions into past permits did not reveal any possible sources. Eventually the refineries in NJ will include their MTBE emissions in their new Operating Permits, but these are still in the early stages of development.

2. Discharges to Surface Water

As mentioned above, there is no surface water quality criterion for MTBE in the current SWQS adopted on April 17, 1998. However, provisions are provided under N.J.A.C. 7:9B-1.58 6. that whenever a parameter specific criterion has not been developed, the Department will utilize the best available scientific information based criterion (BASIC) in the development of chemical specific water quality based effluent limitations for point source discharges. In the case of MTBE, the BASIC of 70 ug/L, based on human health effects, reflects the criterion for MTBE which the DEP intends to propose for all FW2 waters in the upcoming revisions to the Surface Water Quality Standards (N.J.A.C. 7:9B).

The Division of Water Quality (DWQ) typically encounters MTBE when it is associated with a discharge from a leaking underground gasoline storage tank (see Underground Storage Tank section below) and the facility chooses to remediate the discharge by using technology that incorporates a discharge to surface water. If the facility chooses to dispose of the remediated groundwater by discharging it to surface water, it is very likely that MTBE will be present at detectable quantities in both the influent and the effluent from the treatment system. Because MTBE can comprise up to 15% of the total volume of gasoline, monitoring well data at a site impacted by a leaking underground storage tank can show significant concentrations of MTBE.

The DWQ administers a master general NJPDES permit for discharges to surface water of remediated ground water associated with petroleum products. This permit is called the general petroleum product clean-up (GPPC) permit. This GPPC permit was originally issued for a five-year term with an effective date of December 1, 1993 and an expiration date of November 30, 1998. A renewal was recently issued on December 1, 1998 also with a five-year term. The original December 1, 1993 general permit did not contain requirements for MTBE where the December 1, 1998 renewal does contain effluent limitations and/or monitoring requirements for MTBE. This December 1, 1993 general permit served to renew and expand the scope of discharges authorized under the previous December 1, 1988 general fuel clean-up (GFC) permit.

Facilities have been reluctant to monitor for MTBE despite efforts by the NJDEP's Bureau of Underground Storage Tanks (BUST) requesting this information. For two years prior to issuance of the December 1, 1998 GPPC permit, the DWQ encouraged facility representatives to voluntarily submit MTBE effluent data in an effort to develop an appropriate MTBE effluent limitation. However, not a single facility submitted information. Conversations with facility representatives indicated that they were concerned with public image problems associated with high MTBE levels at their facilities and, as a result, were concerned about submitting any site-specific MTBE information to the Department. In addition, MTBE is a troublesome pollutant to treat as compared to historical gasoline constituents (benzene, toluene, ethylbenzene and xylene). Significant treatment costs are associated with treating MTBE as well as time intensive maintenance issues. After several outreach meetings attended by Department representatives from the DWQ, BUST, permittees, consultants and the NJ Petroleum Council, the Department was given non-site specific treatability information and MTBE influent and effluent data. This data was collected from a variety of treatment trains where this treatment is considered best available technology. Considering this data, existing available treatment technology can achieve an 85% removal efficiency for MTBE considering both maximum and average data. This information was considered in developing the master GPPC permit.

As stated previously, the GPPC permit contains effluent limitations and/or monitoring requirements for MTBE. Although a promulgated NJ surface water quality standard does not currently exist for MTBE, a promulgated Maximum Contaminant Level (MCL) for drinking water purposes does exist at 70 µg/L. The GPPC permit is structured so that discharges upstream of a surface water intake with a passing flow less than a certain level are subject to an effluent limitation of 70 µg/L. An effluent limitation of 70 µg/L also applies to dischargers to designated shellfish harvesting areas as well as water bodies classified as Category One and Pinelands. All other dischargers are required to meet a minimum MTBE percent removal limitation of 85%. MTBE is required to be monitored on a monthly basis for all discharge scenarios where applicable effluent limitations are imposed with a six month compliance schedule. Currently 117 facilities are authorized under the master GPPC permit.

The Department has imposed the MTBE MCL for drinking water purposes where an impact to the water quality at surface water intakes could occur. The Department is not applying the MCL for drinking water purposes to all dischargers. In doing so, the Department has significantly reduced the possibility of responsible parties abandoning their treatment systems due to an inability to meet the MCL, imposed as a NJPDES permit limit, on a consistent basis.

Once the GPPC permit is in effect for several months, the Department will have a substantial database of the actual discharge levels of MTBE to surface water throughout the state. There should also be a better understanding of the treatment capabilities of numerous water treatment systems. It is anticipated that once this information is compiled and analyzed, the Department will be in a much better position to gauge the presence of MTBE in these discharges to the surface waters of the state.

OCCURRENCE OF MTBE IN AIR AND WATER IN NEW JERSEY

Contamination of water supplies from gasoline has occurred since its use in transportation began a century ago. Gasoline derived pollutants such as benzene, toluene, ethylbenzene, and xylene (jointly referred to as the BTEX compounds) have long been monitored and regulated in ground water, surface water, and drinking water. Sources of MTBE and BTEX compounds in water include leaking underground storage tanks and pipelines, accidental spills, stormwater runoff, the use of gasoline engines in boats, and, potentially, air deposition.

1. MTBE in Ground Water

There are several types of data on MTBE in ground water including information from contaminated sites, primarily involving underground storage tanks; information from public water supplies; information on private wells; and data from other studies on ambient ground water.

Underground Storage Tanks and MTBE in New Jersey

Over the past 11 years, the Department has registered over 84,000 underground storage tanks (USTs) in New Jersey representing a combined storage capacity of over 420 million gallons of hazardous substances. Estimates of UST annual throughput can conservatively range to 10 times the estimated storage capacity.

Over the years, 34,000 of these USTs were reported to contain gasoline. With an average UST size of 5,000 gallons, this represents a combined gasoline storage capacity of 170 million gallons and conservative annual throughputs ranging up to 1.7 billion gallons. As an oxygenate, MTBE at a minimum represents 11% of the volume of gasoline. This translates into an annual throughput ranging up to 187 million gallons of MTBE in USTs in New Jersey .

While these figures are estimates, they demonstrate the magnitude of MTBE used and stored in New Jersey gasoline USTs. While the uses of gasoline in vehicles, motors and businesses are just as vast, USTs represent a starting point source for most of these uses.

Due to its high solubility, it is not surprising that MTBE is routinely found in ground water during the investigation of leaking UST systems. It has been New Jersey's experience that half of the USTs closed in the state resulted in a reported discharge of hazardous substances and half of the reported discharges result in an impact to ground water. In response to a national study on MTBE occurrence conducted by the University of Massachusetts, the NJDEP Bureau of Underground Storage Tanks (BUST) reported that MTBE is present in groundwater at concentrations exceeding 70 ug/L in 80% of the 2400 leaking underground storage tank cases in which groundwater is being remediated.

The remediation of MTBE has led to some unique challenges. Its high solubility and resistance to degradation allows it to move with ground water with very little retardation. Alterations of natural ground water flow patterns due to local ground water usage in areas of MTBE ground water contamination increase the likelihood for impacts to potable wells from MTBE. Currently, there are more cases in BUST at which a potable well was impacted by MTBE than any other gasoline related compound. In addition, some potable wells impacted by MTBE are reported to the Department based on taste and odor problems at levels below the MCL of 70 ug/L.

Given the unique characteristics of MTBE, a fate and transport model called DISPERSE was developed by BUST to more accurately predict the extent and duration of MTBE plumes than could be predicted using existing models that were developed for degradable gasoline compounds. The DISPERSE model utilizes only dispersion as the attenuation factor, and is therefore a conservative model for prediction of the extent and duration of the contaminant plume.

MTBE's high affinity for water (low Henry's Law Constant) also makes treating MTBE very costly. While carbon canisters series are routinely selected for water treatment in private home applications at concentrations less than 300 ug/L, higher concentrations or higher water volume users require stripping towers and blowers that create a high air-to-water ratio.

On many occasions BUST has noticed spikes in MTBE contamination associated with ongoing routine monitoring of existing cases involving groundwater contamination. For example, quarterly monitoring data might show consistent MTBE levels of 100-200 ug/L over many sampling events, followed by a sudden increase in MTBE concentration of one to two orders of magnitude or more. The UST systems are generally tested for leaks following such occurrences, and usually found not to be leaking. The criteria for this test are that it must be capable of detecting a 0.1 gallon per hour leak rate, from any portion of the UST that routinely holds product, with a probability of detection of 0.95 and a probability of false alarm of 0.05. In one instance, a damaged monitoring well collar was found to be allowing surface water runoff contaminated with routine gasoline dispenser spillage, such as the drips and minor spills from the nozzle when an automobile gasoline tank is overfilled to enter the monitoring well and in another instance, a leaking water knockout (the device which removes water vapors) in a stage II vapor recovery line of the gasoline dispensing system, a non-product bearing portion of the UST system, was found to be the source of the MTBE spike. Some gasoline companies have initiated comprehensive studies to identify the source of MTBE spikes. It has been hypothesized that vapor releases from UST systems may be the cause of some MTBE spikes.

Public Drinking Water Supplies

The detection of MTBE in surveys of New Jersey drinking water during the 1980's prompted the New Jersey Drinking Water Quality Institute to recommend the development of a drinking water standard for this contaminant, which, as discussed above, was promulgated in 1996. Data collected during A-280 sampling of public water supplies in 1985-1986 showed MTBE concentrations up to 81 ug/L.

Following adoption of the standard for MTBE, the Bureau of Safe Drinking Water has been collecting data on MTBE in public water supplies since 1997. The data presented here are from approximately one year of sample results (7/97-9/98). During this time period, approximately 400 of 614 public community water supplies and approximately 400 of 1100 non-transient non-community water supplies submitted sampling results. The regulations require that samples are to come from the point of entry to the distribution system.

MTBE Detections in New Jersey Water Supplies in 7/97- 9/98

<u>MTBE Concentration Range</u> (ug/L)	<u>Community Water Systems</u>	<u>Nontransient Noncommunity</u> <u>Water Systems</u>
below detection limit (< 0.5 ug/L)	341 (85%)	333 (84%)
0.5 to 20 ug/L	59 (15%)	62 (16%)
20 to 70 ug/L	0	1 (0.25%)
over 70 ug/L	0	1 (0.25%)

For community water systems, MTBE was found above the detection limit of 0.5 ug/L in samples from 59 community water systems out of approximately 400 that sampled (15%). (About 200 community water systems were not required to sample in this time period.) Samples from public community water supplies are normally finished water. The MTBE concentrations in the community supplies ranged up to 8.4 ug/L, and none approached the drinking water MCL of 70 ug/L.

For non-transient non-community systems, there were detections in 64 systems out the 397 systems reporting. In these systems, there is likely to be no water treatment. The highest MTBE concentration detected was 130 ug/L, and this was the only sample that exceeded the MCL of 70 ug/L.

An investigation conducted by BUST of community and non-transient non-community water systems with detections of MTBE revealed no obvious source of contamination for about one third of the systems. Many of these detections involved very low concentrations of MTBE at or near the detection limit of 0.5 ug/L.

The data presented above reveals that MTBE is not commonly found at levels near or above

the drinking water MCL of 70 ug/L, which is based on protection from health effects, and therefore its occurrence in public water supplies does not represent a public health concern at this time. However, it is the most frequently detected volatile organic chemical in public water supplies with detection, at generally very low levels, in about 15% of these supplies. This finding indicates a relatively rapid increase in its prevalence in the water supply, since it has only been used for a relatively short period of about 20 years. During the same period for which data are shown above (7/97-9/98), the next most frequently found volatile organics (trichloroethylene, tetrachlorethylene, and 1,1,1-trichloroethane) were each detected in 8%-9% of public water supplies.

Treatment Removal from Drinking Water

MTBE is more difficult to remove from drinking water than other gasoline components and other many other volatile organics. Technologies used to remove MTBE from drinking water include air-stripping, adsorption to activated carbon and other sorbents, and advanced oxidation processes using ultraviolet light or ozone-hydrogen peroxide (reviewed by Gullick and LeChevalier, 2000). When using air-stripping, a much higher air-to-water ratio is required to remove MTBE than other volatile organics. Activated carbon is often not a cost effective removal approach, and other volatile organics which are present may preferentially bind to the carbon, preventing MTBE removal; the use of other sorbents for this purpose is currently being studied. Air-stripping to remove some MTBE and most of the other VOCs present followed by activated carbon to remove the remainder can be the most efficient treatment approach in some cases. Advanced oxidation processes have been reported to be a cost-effective approach for MTBE removal.

Private Wells

Much of the available information on the occurrence of MTBE in domestic private wells in New Jersey comes from situations in which the wells have been tested because of a potential contamination problem. There is only limited information on the occurrence of MTBE in randomly selected domestic private wells, and more data are necessary to define the overall prevalence of MTBE contamination in domestic private wells in the state.

Furthermore, an integrated data management system for private well data obtained by various DEP programs, as well as counties and municipalities, does not exist at this time. For this reason, it is not possible to develop aggregated statistical data on the number of private wells or cases of contamination in which MTBE has been detected in New Jersey during investigations by DEP. The available information and potential sources of information on MTBE contamination of private wells are summarized below:

The United States Geological Survey (USGS) has conducted random surveys of private wells in New Jersey as part of its National Water Quality Assessments (NAWQA) and Toxics programs. These include randomly selected wells in several areas of New Jersey: the New

England physiographic province (Highlands), the Piedmont, the Kirkwood-Cohansey aquifer in southern New Jersey, and the crystalline rock aquifer surrounding Cranberry Lake in Sussex County (Baehr et al., 1999 and Baehr, personal communication.) The results of these studies are summarized below. With a detection limit of 0.1 ug/L, MTBE was detected in wells in all four areas sampled, at frequencies ranging from 7 percent in the Highlands to 93 percent near Cranberry Lake, but most of the detections were very low and none of the levels approach the drinking water standard of 70 ug/L.

MTBE Detections in Domestic Wells Sampled by USGS

(Detection limit in these studies was 0.1 ug/L)

<u>Sampling Area</u>	<u>Number of wells</u>	<u>% of wells with MTBE detections</u>	<u>Median concentration detected (ug/L)</u>	<u>Range of concentrations detected (ug/L)</u>
Highlands	30	43%	1.16	0.13-30.2
Piedmont	30	28%	0.13	0.10-0.33
Kirkwood-Cohansey	30	7%	0.17	0.15-0.19
Cranberry Lake*	14	93%	0.44	0.12-19.8

*The Cranberry Lake data shown are from Summer 1998. Resampling of these wells in 1999 gave similar results, with detections in 13/14 (93%) of wells sampled and a range of 0.1-113.2 ug/L. Wells in the vicinity of Lackawanna Lake were also sampled, and MTBE was detected in 4 of 5 wells at low concentrations (0.05-0.2 ug/L).

MTBE is routinely seen in private wells sampled as part of cases involving the Division of Site Remediation's Spill Fund. Significant levels of MTBE may occur at wells near gasoline stations and other uses of gasoline (see discussion of use of gasoline powered boats on . For example, MTBE was detected in a number of wells sampled by NJDEP in the vicinity of Cranberry Lake, a lake on which gasoline powered boats are used (see below), at concentrations up to several hundred micrograms per liter (Robert Gallagher, NJDEP, personal communication). As discussed in more detail above, in cases handled by the Bureau of Underground Storage Tanks, MTBE impacts more potable wells than does any other gasoline related contaminant. However, the Division of Site Remediation does not have any quantitative data on the number or percent of potable wells found to be contaminated by MTBE, or the concentrations of MTBE found in potable wells.

The Bureau of Safe Drinking Water maintains a log and copies of letters dating back to 1995 which were sent regarding contamination detected in domestic private wells in response to cases originating from BUST, BEERA, Bureau of Publicly Funded Site Remediation, and Bureau of Community Relations. Testing is done because the potential for contamination is anticipated due to the well's proximity to a spill, leaking underground storage tank, or a contaminated site. The letters are sent to local health officers, with copies to residents, homeowners (if different), responsible parties, and the consultant for the cleanup, and contain information on what was found in the raw well water, whether treatment was installed in response to the testing results, and results of testing of treated water.

As the letters are intended to follow up on specific cases and ensure safe drinking water on an individual well basis, the log of letters is handwritten and is not currently data managed. Therefore, they cannot be used to evaluate the extent of MTBE contamination of private wells in a quantitative manner. However, it has been noted that MTBE is one of the most frequently found contaminants in the cases for which letters are sent, and that MTBE concentrations up to several thousand ug/L have been reported (Personal communication, Fred Dickert, BSDW)

In 1997, the Passaic County Health Department (1997) conducted a study of private wells in West Paterson in the vicinity of two homes for which complaints about well contamination were received. Of 132 wells tested, MTBE was detected in 23. (The detection limit for MTBE is not stated in the study report, but was below 1 ug/L.) Most of the levels were below 1 ug/L, while 7 were above 1 ug/L. Two of these wells had MTBE levels greater than 10 ug/L, and the highest level detected was 40 ug/L, which is below the MCL of 70 ug/L.

The state of Maine has conducted an extensive study of MTBE in randomly selected private wells (Maine BHDHS, et al., 1998). In the summer of 1998, water samples were taken from 946 randomly selected private wells, and analyzed for five components of gasoline (MTBE, benzene, toluene, ethyl benzene, and xylenes). The detection limit for MTBE was 0.1 ug/L. MTBE was the most common gasoline component detected, and was found at some level in 15.8% of the samples. In over half of these detections (8.1%), the level was below 1 ug/L. It was found above Maine's drinking water standard of 35 ug/L in 1.1% of the samples. MTBE was found in both areas where reformulated gasoline (RFG) is required and in other areas, although it occurred more frequently in the RFG areas. Regarding the frequency of occurrence of MTBE compared to other gasoline components, MTBE (15.8%) was found much more frequently than any other contaminant in private wells, followed by toluene which was detected in 2.1% of private wells.

Other Studies on MTBE in Ambient Groundwater

NJGS Ambient Ground Water Network

The New Jersey Geological Survey has conducted analysis of groundwater from wells including monitoring wells, public water supply wells, and private domestic and non-domestic wells in various parts of the state as part of the Ambient Ground Water Quality Network. This network has sampled many wells to determine groundwater quality as a function of geology and some wells to evaluate the quality of shallow groundwater near surface-water bodies. MTBE has been analyzed in network well samples since 1995 with a detection limit of 0.2 ug/L.

MTBE was detected in 11 of 43 wells (26%) tested for it in three different areas of the state. The detailed results are as follows: In 1995, nine wells in Northern Bedrock and Glacial Fill were tested. MTBE was detected in five of nine wells, at levels of 0.2, 0.3, 0.3, 0.8, and 2.3 ug/L. In 1996, fifteen wells in the Barnegat Bay region were tested. MTBE was detected in

two of fifteen wells at levels of 0.6 and 1.7 ug/L. In 1997, nineteen wells in the Rancocas area were tested. MTBE was detected in four of nineteen wells at levels of 0.4 ug/L, 0.5 ug/L, 0.9 pp, and 5.4 ug/L. These data are shown in tabular form below:

MTBE Detections in NJGS Ambient Groundwater Network

MTBE Concentration Range (ug/L)	Number of Wells (%)
below detection limit (> 0.2 ug/L)	32 (74%)
0.2 to 1 ug/L	8 (19%)
> 1 ug/L (highest level was 5.4 ug/L)	3 (7%)

USGS Glassboro Comprehensive Urban Study

From September-December 1996, the USGS conducted a study in the vicinity of Glassboro, NJ (USGS, 1997; Baehr et al., 1999). Three types of groundwater samples were collected: ground water from 78 shallow monitoring wells, 30 intermediate depth monitoring wells targeting 10-15 year-old water in the Kirkwood-Cohansey aquifer, and untreated samples from 30 public supply wells in the Kirkwood-Cohansey aquifer.

The 78 shallow monitoring wells were randomly distributed among three land use categories: urban, agricultural, and undeveloped. MTBE was the second most frequently detected VOC in the shallow groundwater survey. It was detected in 35 of the 78 wells (45%), with a detection limit of 0.1 ug/L. The median concentration in wells in which detection occurred was 0.2 ug/L, and the maximum concentration was 44 ug/L. The higher concentrations were associated with urban land use, although MTBE was found in shallow wells associated with agricultural and undeveloped land uses.

MTBE was detected less frequently in the intermediate depth wells targeting 10-15 year-old

water than in the public supply wells or shallow monitoring wells. The more frequent detection in the public supply wells is not unexpected, because much of the water in these wells would have been recharged during the past 10 years of heavy MTBE use (Baehr et al., 1999).

Untreated Samples from Public Supply Wells

The concentration of MTBE was equal or greater than 0.2 ug/L in 38% of untreated water samples from 34 unconfined public supply wells across New Jersey sampled in 1998 as part of the USGS Drinking Water Initiative (E.F. Vowinkel, USGS, personal communication).

2. MTBE in Surface Waters

There are two major sources of information about MTBE concentrations in surface waters in New Jersey: 1) data from monitoring studies in streams and rivers and 2) data collected in lakes where gasoline power engines are used.

Monitoring of Streams and Rivers

The United States Geological Survey has conducted several studies in New Jersey rivers and streams which measured volatile organic chemicals, including MTBE. Sampling sites in these studies include a variety of land uses, so that both ambient and non-ambient samples are included. These studies indicate that although MTBE is among the most commonly detected volatile organic in surface waters, the concentrations found are generally very low, and fall far below the drinking water Maximum Contaminant Level of 70 ug/L. The studies also demonstrate that greater frequencies of detection and higher concentrations tend to occur in urbanized areas.

In Spring 1994, a fourteen site synoptic survey was conducted on the Hackensack River, a highly urbanized area (USGS, 1997a). MTBE was detected at all fourteen sites in at which samples were taken, with a median concentration of 1.3 ug/L and a maximum of 30 ug/L. Reconnaissance sampling of nine streams located in a variety of land-use types across the state was conducted in winter and early spring of 1996 (USGS, 1997a). In this study, MTBE was detected in ten of eleven samples, with a detection limit of 0.2 ug/L. The concentrations ranged from 0.2 to 4.9 ug/L, and higher concentrations were found in more urbanized areas.

Sampling for volatile organics in seven New Jersey streams representing a variety of land uses was conducted from April 1996 to April 1997 (Reiser and O'Brien, 1998). MTBE was found in 78% of 112 samples, and was the most frequently detected of 47 volatile organics which were found. The median concentration was 0.42 ug/L and the highest level seen was 4.8 ug/L, with a detection limit of 0.1 ug/L. The highest rate of occurrence and median levels were seen in Bound Brook, a highly urbanized area. Higher frequency of detection and concentrations were observed in cooler months, perhaps resulting from lower volatility and/or greater use of MTBE during the winter.

MTBE was found in 100% of samples taken from 42 stream sites in Long Island and New Jersey on January 27-30, 1997 (USGS, 1997b). The median concentration detected was 0.36 ug/L and the maximum was 8.7 ug/L. With one exception involving a site in southern New Jersey, the highest concentrations occurred in areas with highly developed land use.

Contamination of Lakes

The U.S. Geological Survey sampled four lakes in Sussex county, New Jersey in 1998 during the boating season: Cranberry Lake, Lake Lackawanna, Forest Lake and Stag Lake. The first two lakes allow motorized watercraft, and MTBE was found in these lakes. The latter two lakes do not allow motorized watercraft, and MTBE was not detected. Thus, this study provides further evidence that motorized watercraft are a major source for MTBE in lakes, and that volatilization is not rapid enough to remove the chemical during boating season. The highest concentrations measured were 29 ug/L in Cranberry Lake and 14 ug/L in Lake Lackawanna after Labor Day weekend of 1998. Sampling of Cranberry Lake in June, November, and December of 1998 revealed lower levels than seen in September, indicating an increase in concentration during the boating season followed by a decrease after the boating season (Baehr and Zapecza, 1998,).

To the Workgroup's knowledge, reservoirs with direct drinking water intakes in New Jersey do not allow gasoline-powered boats. However, several lakes which feed into streams and rivers with drinking water intakes allow the use of such boats (Personal communication from Vincent Monaco, BSDW).

As discussed above, MTBE was detected at very high frequency in potable wells in the vicinity of Cranberry Lake and Lake Lackawanna. This contamination may result from spills of gasoline onto the ground during fueling of watercraft near the lake and/or from hydrogeologic interactions between the lakes and the wells (Baehr et al., 1999, Zapecza and Baehr, 1999).

MTBE in Cranberry Lake will be further studied during the second year of an ongoing research project being conducted by the Division of Science, Research, and Technology, Rutgers University, and USGS. The overall aim of the study is to develop a predictive modeling tool for assessing subsurface leaching of contaminants to surface water bodies. As part of the study, USGS will develop the use of MTBE as an indicator of non-point source pollution of both surface water and groundwater in the vicinity of the lake.

3. MTBE in Ambient Air

The suggestion has been made that ground and surface water supplies could be contaminated by air deposition of MTBE. There are two sources of data on concentrations of MTBE in air: (1) Ambient air data from an air monitoring station in Camden, New Jersey which is part of EPA's Urban Air Toxics Monitoring Program, and (2) A special study of MTBE in air carried out by

USGS in Gloucester County as part of the National Water Quality Assessment Program.

Urban Air Toxics Monitoring Program (UATMP)

NJDEP participates in the federal Urban Air Toxics Monitoring Program (UATMP) with a site located in the City of Camden. MTBE was recently added as an analyte in this program. The UATMP is designed to characterize the composition and magnitude of urban air pollution through extensive ambient air monitoring. The UATMP sites collect a 24-hour canister sample once every 12 days in or near 13 urban locations throughout the country. Each year of UATMP sampling begins in September and ends in August of the following calendar year.

Eastern Research Group (ERG) analyzes all air samples collected at the UATMP sites in the network using the Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air, gas chromatograph/mass spectrometer (GS/MS) method TO-15 which has a method detection limit of 0.03 ppb by volume (parts per billion by volume). The method detection limit (MDL) represents the smallest amount that the analytical method is capable of distinguishing the analyte (MTBE) from other similar compounds, with a degree of confidence and accuracy.

One complete year (September 1997 through August 1998) of MTBE ambient air data are available at this Camden, New Jersey site. During this period, 31 samples were analyzed for MTBE. Two samples were below the detection limit. The average concentration for the remaining 29 samples was 1.29 ppb by volume; with a range of 0.28 to 3.74 ppb by volume.

USGS NAQWA Study in Gloucester County

As part of a study to determine the cause, occurrence, and movement of MTBE and other VOCs through the urban hydrologic cycle, USGS collected air samples at three sites in Gloucester County (USGS, 1997). The samples were collected on a cartridge. The method differed from the UATMP study, but the detection level was similar at 0.02 ppb by volume.

During November 1996 through February 1998, atmospheric samples were collected for 12 days at three sites in the study area. The median concentration of MTBE in the atmosphere ranged from 0.11 to 0.48 ppb by volume. The USGS inferred from this study that the atmosphere could be one of several sources of low-level concentrations of MTBE in shallow ground water below 1 ug/L.

4. Facility Use and Release

As discussed in the Introduction to this report, MTBE is one of the most highly produced chemicals in the United States.

A New Jersey Release and Pollution Prevention Report (RPPR/DEQ-114) is required of all facilities that are subject to the reporting requirements of the Toxic Chemical Release Inventory (TRI), Section 313 of the federal Emergency Planning and Community Right-to-Know Act of

1986 (EPCRA). Through reporting year 1997, the requirements applied to facilities that:

- 1) are in the manufacturing sector Standard Industrial Classification (SIC) codes, major groups 20 through 39, and federal facilities; and
- 2) had 10 or more full-time employees (or the equivalent, i.e. a facility payroll of 20,000 work-hours or more) in the reporting year; and
- 3) manufactured (including imported), processed, or otherwise used a listed chemical in excess of 10,000 pounds over the course of the year.

Such facilities are required to report detailed data on chemical throughput, environmental releases and off-site transfers of all listed substances that exceed the thresholds. All data are reported in pounds per year.

The following graph shows the data on the total use, as well as release and discharge to air and water, of MTBE in New Jersey which was reported to the Bureau of Chemical Release Information and Prevention for the years 1992-1996. A total of 14 facilities reported MTBE data in these years, but all 14 did not report in a given year. In a given year, between 7 and 10 facilities reported MTBE data.

1992 was chosen to be the first year shown since this was the year in which oxygenated fuel requirements went into effect in New Jersey. Additional facility-specific information is available from the Bureau of Chemical Release Information and Prevention.

The following are definitions for terms used on the Figure below:

Stack Air Emissions: emissions that were released into the atmosphere from a readily- identifiable

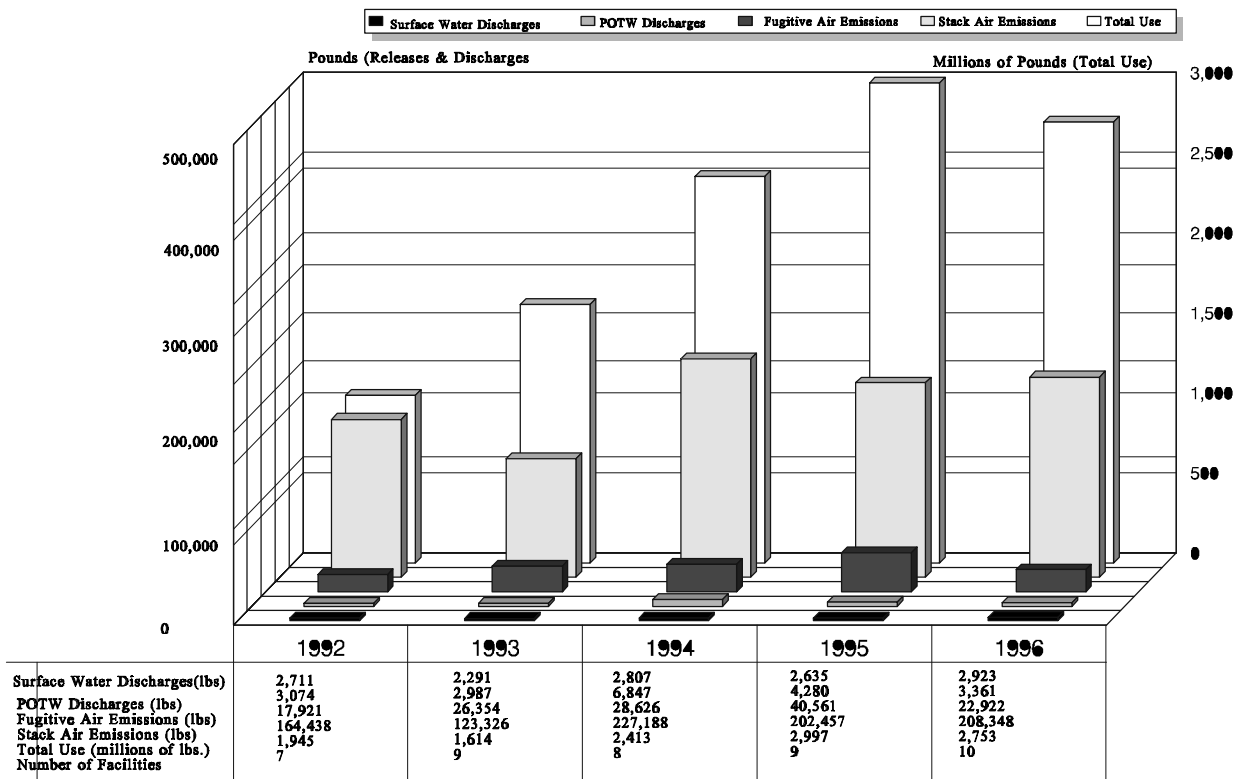
Fugitive Air Emissions: emissions that were not released through stacks, vents, ducts, pipes, or a leaking seals, pumps, flanges, valves, etc.; furnaces or kilns; open vats or pits; crushing, pelletizing or grinding operations; and, loading and unloading operations.

Surface Water Discharges: releases to water including discharges to streams, rivers, lakes, oceans and other bodies of water.

POTW: discharges into a municipal sewer system of one owned by a municipal utilities authority, sewerage authority, or regional utilities authority.

Total Use: the difference between the Input quantity and the ending inventory.

NJ Release & Pollution Prevention Report Data Methyl tert-Butyl Ether (1992-1996)



NJDEP Bureau of Chemical Release Information & Prevention - revised 3/2/99 (c:\upper\mthe9296.ppt)

CONCLUSIONS AND RECOMMENDATIONS

1. Conclusions

This report summarizes the available information on the regulation and occurrence of MTBE in New Jersey. Other major aspects of the MTBE issue involve evaluation of its effectiveness in reducing air pollution from motor vehicles, and the risks and benefits of available alternatives to the use of MTBE. These topics are beyond the scope of this report, but must be considered along with information on environmental occurrence in any policy decisions relating to MTBE use.

New Jersey has been aware of the presence of MTBE in groundwater since the mid-1980's, when it was detected in drinking water surveys. New Jersey was among the first states to develop a drinking water standard for MTBE, at a time when USEPA was not aware of MTBE as an important water contaminant.

As has been observed in other states, MTBE was detected in New Jersey groundwater and surface water bodies. This indicates that this contaminant has impacted New Jersey's environment during the relatively short time period (20 years) in which it has been used.

High concentrations of MTBE in ground or surface water are usually associated with an obvious source of contamination such as leaking underground storage tanks or the use of gasoline powered watercraft. Smaller spills of gasoline onto the ground may also result in MTBE contamination of groundwater. Washout of MTBE from the atmosphere in precipitation is predicted to result in MTBE levels in the range of 1 ug/L or lower in shallow wells, and this may be the source for some of the low level MTBE concentrations reported in New Jersey studies.

MTBE contamination is not currently a public health concern in New Jersey public drinking water supplies. In monitoring data from 400 of 614 public community drinking water supplies tested in 1997-1998, no sample had MTBE approaching the drinking water MCL of 70 ug/L. Of about 400 non-transient non-community water supplies, which are usually untreated, only one exceeded the MCL. However, MTBE is the most commonly detected volatile organic contaminant in public drinking water supplies, although it has been used for a relatively short period of about 20 years,

Data on the occurrence of MTBE in private wells in New Jersey presented in this report were obtained from various programs throughout NJDEP, from USGS, and from a study by a county Health Department. Much of this information is not data managed. For this reason, it is not possible to make quantitative evaluations of the number of wells affected or the levels of MTBE found, and only general conclusions can be made. MTBE is commonly found in private wells which are tested due to their proximity to cases involving gasoline spillage. Additionally, information on the overall frequency of MTBE in private wells throughout the state is limited.

The health-based MCL which was used to develop New Jersey's MCL for MTBE considered all

relevant toxicity information which is currently available. The appropriate carcinogenicity classification for MTBE is not a clear-cut decision, and various federal and state agencies have differed in their conclusions on this issue. New Jersey's health based drinking water value for MTBE is based on classification as a possible human carcinogen. The risk assessment was based on a non-carcinogenic endpoint, with an additional uncertainty factor for protection against carcinogenicity. A number of states have used an approach similar to New Jersey's for deriving a drinking water standard or guidance for MTBE, while California has recently adopted a Public Health Goal based on linear modeling of carcinogenic effects. Research currently being conducted by USEPA should clarify some of the uncertainties related to MTBE carcinogenicity.

2. Recommendations

Private Well Study

The inability to develop quantitative information on the number of private wells known to be contaminated by MTBE in New Jersey and the levels of MTBE found in these wells, highlights the necessity for an integrated data management system to coordinate private well data obtained by DEP programs, counties, and municipalities. Such a system would be of great use for evaluation of any drinking water contaminant of concern, not just MTBE.

In order to further evaluate the frequency of MTBE occurrence in private wells in New Jersey, a study involving wells throughout the state is necessary. Such a study would include wells randomly selected from two groups: those known to be located near a site of gasoline spillage and wells not known to be near such spillage. Information on the frequency of occurrence of MTBE as compared to other components of gasoline such as benzene, toluene, ethylbenzene, and xylene, should also be collected as part of this study. Such a study could possibly be coordinated with the Groundwater Monitoring Network, the Source Water Assessment Program, and the Watershed Management Program. The results of this study could be used to determine if recommendations for testing for MTBE should be made for private wells in certain aquifers, regions of the state, or land use areas.

Public Outreach and Education

Public outreach and education programs should be conducted to inform citizens about the importance of proper handling of gasoline. Many individuals may not know that spillage of gasoline onto the ground can cause contamination of wells and surface water bodies, and would likely change their behavior if they were aware of the potential consequences.

In particular, wells adjacent to lakes where gasoline-powered boats are used have been found to be contaminated with MTBE. Public education about the careful use of gasoline by boaters in these areas should receive particular emphasis.

Use of Gasoline-powered Boats on Lakes

It is apparent from data from New Jersey, as well as other parts of the country, that the use of gasoline-powered watercraft on lakes can result in significant contamination of the lakes with

MTBE. It should be noted that MTBE levels measured in lakes have not approached the drinking water standard (which is also being used as the surface water criterion) of 70 ug/L. However, the continued use of such watercraft on lakes which feed surface drinking water sources in New Jersey should be evaluated.

Status of New Jersey Health-based Maximum Contaminant Level

New Jersey's Health-based Maximum Contaminant Level for MTBE, which forms the basis for the New Jersey drinking water standard (MCL) for MTBE, is based on all currently available toxicological information. Research currently being conducted by USEPA may provide data which will clarify uncertainties about MTBE's potential carcinogenicity, particularly via oral exposure. New Jersey should continue to follow the progress of this research, and reevaluate its risk assessment if appropriate.

Need for Replacement Strategy

As discussed in this report, gasoline motor fuel is a pervasive chemical contaminant in New Jersey's environment. Therefore, it is not unexpected that MTBE, a gasoline component, which can enter the environment through refinery gasoline production and gasoline handling as well as motor vehicles and watercraft usage, is also ubiquitous. Experience gained during the use of MTBE as a fuel oxygenate has indicated that any additive to be substituted for MTBE, or replacement gasoline must be thoroughly evaluated to determine its potential for beneficial effects on automobile emissions as well as implications for human health and the environment. Such studies should include cost and energy implications, as well as emission characterizations (ozone generation, ozone precursors and air toxics) of the replacement strategy for production, storage, and distribution.

REFERENCES

Baehr, A.L. and Zapecza, O.S. (1998). Methyl tertiary-butyl ether (MTBE) and other volatile organic compounds in lakes in Byram Township, Sussex County, New Jersey, summer 1998. Water-Resources Investigations Report 98-4264. U.S. Geological Survey, December 1998.

Baehr, A.L., Stackelberg, P.E., and Baker, R.J. (1999a). Evaluation of the atmosphere as a source of volatile organic compounds in shallow groundwater. *Water Resources Research* 35 (1): 127-136.

Baehr, A.L., Kauffman, L.J., Charles, E.G., Baker, R.J., Stackelberg, P.E., Ayers, M.A., and Zapecza, O.S. (1999b). Sampling throughout the hydrogeologic cycle to characterize sources of volatile organic compounds in ground water. In: U.S. Geological Survey Toxics Hydrology Program-Proceedings of the technical meeting. Morganwalp, D.W. and Aronson D.A., eds. Charleston, S.C., March 8-12, 1999. Water-Resources Investigations Report 99-40xx, U.S. Geological Survey.

Belpoggi, F., Soffaritti, M., and Maltoni, C. (1997). Methyl tertiary-butyl ether (MtBE) - a gasoline additive - causes testicular and lymphohaematopoietic cancers in rats. *Toxicology and Industrial Health* 11 (2): 119-149.

Belpoggi, F., Soffritti, M., and Maltoni, C. (1998). Pathological characterization of testicular tumours and lymphomas-leukemias, and of their precursors observed in Sprague-Dawley rats exposed to methyl-tertiary-butyl-ether (MTBE). *Eur. J. Oncol.* 3 (3): 201-206.

Burleigh-Flayer, H.D., Chun, J.S., and Kintigh, W.J. (1992). Methyl tertiary butyl ether: vapor inhalation oncogenicity study in CD-1 mice. Report 91N0013A. Export, PA; Bushy Run Research Center.

California EPA (1998). Draft Technical Support Document on the Proposed Public Health Goal for Methyl Tertiary Butyl Ether in Drinking Water. Office of Environmental Health Hazard Assessment, June 1998.

Chun, J.S., Burleigh-Flayer, H.D., and Kintigh, W.J. (1992). Methyl tertiary ether: vapor inhalation oncogenicity study in Fisher 344 rats. Export, PA; Bushy Run Research Center; report 91N0013B.

Daughtrey, W.C., Gill, M.W., Pritts, I.M., Fielding-Douglas, J., Kneiss, J.J., and Andrews, L.S. (1997). Neurotoxicological evaluation of methyl tertiary-butyl ether in rats. *Journal of Applied Toxicology* 17 (S1): S57-S64.

Froines, J.R. et al. (1998). An evaluation of the scientific peer-reviewed research and literature on the human health effects of MTBE, its metabolites, combustion products and substitute

compounds. In: Health & Environmental Assessment of MTBE. Report to the Governor and Legislature of the State of California as Sponsored by SB 521. November 1998.

Gullick, R.W. and M.W. LeChevalier (2000). Occurrence of MTBE in drinking water sources. *Journal of the American Water Works Association* 92 (1): 100-1113.

Happel, A.M., Beckenback, E.H., and Halden, R.U. (1998). An evaluation of MTBE impacts to California groundwater resources. Report submitted to California State Water Resources Control Board, Department of Energy, and Western States Petroleum Association.

Keller, A., Froines, J., Koshland, C., Reuter, J., Suffet, I., and Last, J. (1998). Health & Environmental Assessment of MTBE. Report to the Governor and Legislature of the State of California as sponsored by SB 521. November 1998.

Maine BHDHS (1998). The presence of MTBE and other gasoline compounds in Maine's drinking water, a preliminary report. Bureau of Health, Dept. of Human Services; Bureau of Waste Management & Remediation, Dept. of Environmental Protection; Maine Geological Survey, Dept. of Conservation. October 13, 1998.

Mohr, S., Fiedler, N., Weisel, C., Kelly-McNeil, K. (1994). Health effects of MTBE among New Jersey garage workers. *Inhalation Toxicology* 6 (6): 553-562.

National Research Council (1999). Ozone-forming potential of reformulated gasoline. National Academy Press.

National Toxicology Program (1998). Report on Carcinogens Background Document for Methyl tertiary-Butyl Ether, Draft. Meeting of the NTP Board of Scientific Counselors Report on Carcinogens Subcommittee, Dec. 2-3, 1998.

NESCAUM (1999). Northeast States for Coordinated Air Use Management. RFG/MTBE, Findings and Recommendations. August 1999.

New Jersey Drinking Water Quality Institute (1994). Maximum Contaminant Level Recommendations for Hazardous Contaminants in Drinking Water. Submitted to State of New Jersey Department of Environmental Protection. September 29, 1994.

Pankow, J.F., Thomson, N.R., Johnson, R.L., Baehr, A.L., and Zogorksi, J.S. (1997). *Environmental Science and Technology* 31 (10): 2821-2828.

Passaic County Health Department (1997). Report - West Paterson ground water contamination. Presented to Board of Chosen Freeholders, Health and Human Services Committee, by John F. Ferraioli, Health Officer. August 27, 1997.

Reiser, R.G. and O'Brien, A.K. (1998). Occurrence and seasonal variability of volatile organic

compounds in seven New Jersey streams. United States Geological Survey WRIR 98-4074. May 1998.

Reuter, J.E., Allen, B.C., Richards, R.C., Pankow, J.F., Goldman, C.R., Scholl, R. L., and Seyfried, J.S. (1998). Concentrations, sources, and fate of the gasoline oxygenate methyl tert-butyl ether (MTBE) in a multiple-use lake. *Environmental Science and Technology* 32 (23): 3666-3672.

Robinson, M., Bruner, R.H., and Olson, G.R. (1990). Fourteen and ninety day toxicity studies of methyl tertiary-butyl ether in Sprague-Dawley rats. *Journal of the American College of Toxicology* 9 (5): 525-540.

Squillace, P.J., Pankow, J.F., Korte, N.E., and Zogorski, J.S. (1997). Review of the environmental behavior and fate of methyl tert-butyl ether. *Environmental Toxicology and Chemistry* 16 (9): 1836-1844.

Stackelberg, P.E., Hopple, J.A., and Kauffman, L.J. (1997). Occurrence of nitrate, pesticides, and volatile organic compounds in the Kirkwood-Cohansey aquifer system, southern New Jersey. United States Geological Survey. Water-Resource Investigations Report 97-4241.

USEPA (1997). Drinking Water Advisory: Consumer Acceptability Advice and Health Effects Analysis on Methyl Tertiary-Butyl Ether (MtBE). Office of Water. EPA-822-F-97-008. December 1997.

USEPA Office of Mobile Sources (1998). Questions and answers about methyl tertiary butyl ether. July 29, 1998. (<http://www.epa.gov/OMSWWW/consumer/fuels/mtbe/mtbe-qa.htm>).

USEPA Office of Research and Development (1998). Oxygenates in water: critical information and research needs. EPA/600/R-98/048. December 1998.

USEPA (2000). Clinton-Gore administration acts to eliminate MTBE, boost ethanol. Headquarters Press Release, March 20, 2000.

USGS (1997a). Spatial variability of volatile organic compounds in streams on Long Island, New York, and in New Jersey. U.S. Geological Survey Fact Sheet FS-194-97.

USGS (1997b). Occurrence of volatile organic compounds in streams on Long Island, New York, and New Jersey. U.S. Geological Survey Fact Sheet FS-063-97.

USGS (1998). Volatile organic compounds in Lake Tahoe, Nevada and California, July-September 1997. U.S. Geological Survey Fact Sheet FS-055-98.

Zapczka, O.S. and Baehr, A.L. (1999). MTBE in lakes in Byram Township, Sussex County, New

Jersey, 1998, and vulnerability of ground water in lakeside communities. In: U.S. Geological Survey Toxics Hydrology Program-Proceedings of the technical meeting. Morganwalp, D.W. and Aronson D.A., eds. Charleston, S.C., March 8-12, 1999. Water-Resources Investigations Report 99-40xx, U.S. Geological Survey.

Zogorski, J.S. et al. (1997). Fuel oxygenates and water quality. In: Interagency Assessment of Oxygenated Fuels, National Science and Technology Council, Chapter 2.