The Commonwealth of Massachusetts

Department of Environmental Quality Engineering

Tetrachloroethylene In Public Drinking Water Supplies

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Interim Report on Tetrachloroethylene Contamination of Public Drinking Water Supplies caused by Vinyl-Lined Asbestos Cement Pipe

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Dept. of Environmental Quality Engineering
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I - Problem Statement:

This past winter, Massachusetts and the other five New England States discovered a problem with the chemical tetrachloroethylene leaching into some of their drinking water because of the type of pipe used in some parts of the water distribution system.

Tetrachloroethylene is an organic chemical which is slightly soluble in water. It is used in a variety of ways including the dry cleaning process, as a degreasing solvent and as a heat transfer medium. The chemical has also been used in the manufacture of vinyl-lined asbestos cement pipes as a solvent or vehicle for the resin.

Asbestos cement (AC) pipes have been in use since the 1930's. The lined variety has been in use for approximately twelve years in New England. The vinyl lining reportedly was developed as a response to customer complaints about the taste and odor of water coming into contact with the asphaltic coating used on water supply pipes, especially on dead end situations.

In July of 1976, tetrachloroethylene was discovered in a distribution system in Newport, Rhode Island; An investigation to determine its source at that time was inconclusive and-the significance of the problem was not fully understood.

In 1978 and 1979, there was correspondence about Newport's problem between Johns-Manville officials and Rhode Island officials. The Rhode Island officials periodically updated the other New England states but information was meager and inconclusive. During this time, there was a growing feeling that the problem had something to do with' the manufacture of the pipe as opposed to installation practices.

By December, 1979 circumstantial evidence showed that lined AC pipes were leaching tetrachloroethylene. A piece of four inch lined AC pipe was shipped in December, 1979 from Newport to EPA's Municipal Environmental Research Laboratory in Cincinnati for testing. The experiment, run twice in January 1980, verified that tetrachloroethylene came from the lined pipe. At the end of January, this information went to each state in EPA Region I.

Discovery of the problem in Massachusetts came about in late January, 1980 as a result of DEQE testing in Westford to Detention the parameters of a water supply contamination problem. This was in connection with the discovery of a storage area containing barrels of chemical waste. Private wells in the vicinity of the storage area were sampled and a tap on the public supply was also sampled. The sample taken from the public supply showed over 1100 ppb of tetrachloroethylene. A second sample from the same tap showed over 1000 ppb. Other samples in town showed no amounts of the chemical.

Investigation showed that in 1977, the town had installed 8500 feet of 12 inch vinyl-lined asbestos cement pipe in the area in, which the tap at the end of the line was sampled by DEQE. Detention time in this segment was calculated to be eleven days. Samples were collected upstream of the line, midway, and at the end and showed concentrations of ppb, 40 ppb, and 1000 ppb, respectively. This led to the conclusion that tetrachioroethylene was leaching out of the pipe.

The Regional Offices of DEQE were instructed to immediately identify and sample several installations in their region where:

1) Lined AC pipe was in use.
2) The pipe was installed in a dead-end or low flow location.

In conducting this first testing, we were interested in determining as quickly as possible the extent and severity of the problem.

The results of this first sampling showed that the problem likely existed to some extent among all installations of lined AC pipe.

DEQE proceeded to mail a questionnaire to all water department superin-tendents throughout the state to determine the number of miles of this pipe in use and approximately how many "dead end" situations existed. It was deemed unlikely that this kind of pipe would have been installed by owners of property seved by private wells.

Data gathered from that questionnaire showed that parts of 83 public water supplies with a total length of over 700 miles of pipe were involved.

Massachusetts then requested a meeting with officials of Johns-Manville from the factory at Manville, New Jersey to get factual and first hand information on the manufacturing process. It was at this meeting on March 20, 1980, that it was de-finitely learned about the chemicals used, the mixing procedure and the application technique.

Another meeting was held between Johns-Manville officials from Denver, Colorado and Massachusetts officials on April 1, 1980 to obtain more information on the extent of the problem and to discuss possible solutions. Representative of the EPA and the other New England states were invited to this meeting. It is important to note that at all times during this process, there was a dialogue and exchange of information and experience going on not only within each state but between the states and EPA.

A previously scheduled meeting between EPA and the New England states was held in Boston on April 2 and 3. This problem was the main topic of discussion and it was agreed that since it was a region-wide problem, that a joint announcement and press conference would be appropriate. This was to be done on April 14 prior to which Massachusetts made plans to alert the affected water supply agencies, local officials and legislators beforehand on April 11 so they would be able to respond to the public in an informed manner. A question and answer package on tetrachloroethylene was developed for the media and the public at this time.

However, the press picked up the story in Connecticut on April 9 and it was reported in the Boston Globe on April 10.

Massachusetts also identified two other manufacturers, Certain-Teed and Capco which used this type of lining. Fortunately, their sales in the area were limited and identifiable.

From the time that the problem was first identified, DEQE regional field staff have spent considerable time working with each affected water supplier in an effort to:

(a) Pinpoint areas of concern.

(b) Provide advice and some laboratory testing' support to lower the levels of tetrachloroethylene and to monitor the effects of control efforts.

In addition, MEQE has initiated or participated in a number of studies designed to find short term and long term solutions to this problem.

The EPA has undertaken. several studies, provided guidance in the area of health risk associated with the problem and provided information on the effectiveness of carbon as a removal agent.

One of the studies which is still ongoing by EPA is to collect all the physical and analytical data from all the states on this problem and analyze this information by computer so see if any common trends are indicated.

II - Heath Effects

Tetrachloroethylene is rapidly absorbed through the lung and skin. Although no studies have been done on its absorption through the gastro-inestinal tract, chemical properties of tetrachloroethylene indicate that it should be rapidly and completely absorbed as well. The majority of absorbed tetrachloroethylene is rapidly eliminated from the body. Only a minor portion of the total (less than 2%) is retained in tissues.

Because of the nature of the tetrachloroethylene problem associated with vinyl lined pipes -- long term exposure to relatively low levels of the chemical - we are primarily concerned with chronic toxicity and potential carcinogenicity of tetrachloroethylene.

Exposure to tetrachloroethylene has been shown to cause damage to liver and kidneys as well as to affect the central nervous system, which is manifested by dizziness, headaches and fatigue. These effects are mild and in most inhalation studies, doses well in excess of 100 parts per million (100,000 ppb) were used before any toxic (poisonous) effects could be detected. Toxic effects of tetrachloroethylene are frequently reversible if the exposure is stopped.

The results of several studies conducted to assess the carcinogenic potential of. tetrachloroethylene are conflicting; the chemical gave positive response in some and negative in others. By far, the most comprehensive study was completed in 1977 by the National Cancer Institute {NCI). In that work massive doses of tetrachloroethylene were given to both laboratory mice and rats. The lack of carcinogenic response in rats should be interpreted with caution, however, since the survival of experimental rats was very poor due to the toxic effects of tetrachloroethylene.

There are three epidemiological studies. in progress concerning tetrachloroethylne. The results of one, conducted by the National Institute for Occupational Safety (NIOSH) are expected to be released at the end of calendar year 1980. Preliminary results of a second study by the NCI on dry cleaning workers in St. Louis indicate an increased risk for cancer within this occupational group (Blair, AM.J. Pubic Health 69,508 (1979). A third study conducted by Dr. Nabih Assad of Oklahoma University on dry cleaning workers in Oklahoma, indicates an increased death from kidney cancer. The results of the last two studies have to be considered as suggestive evidence because of several limitations of the studies.

In summary, the positive evidence provided by the NCI mouse study, suggestive evidence of the NCI epidemiological study and the similarity of tetrachloroethylene to the known chemical carcinogens vinyl chloride and vinylidene chloride, provide substantial evidence that tetrachloroethylene is likely to be a human carcinogen. (Roy Albert, Carcinogen Assessment Group, EPA, July 25, 1980).

Establishment of a SNARL (Suggested No adverse Response Level) by EPA for chronic exposure to tetrachloroethylene can be based either on its toxicity or carcinogenicity. In the latter approach, the results of the NCI study with mice which showed higher incidence of liver cancer than other animals were extrapolated to man. This was done by a complex extrapolation of the data, using computer programs based on the most conservative (linear) of many different mathematical theories of cancer formation. A level of 40 ppb resulted from these calculations. It means that drinking of 2 liters of water, containing 40 ppb of tetrachloroethylene per day, for 70 years will contribute to no more than one additional cancer in 100,000 people exposed.

In the approach to a SNARL setting based on toxicity of tetrachloroethylene the arithmetic is much simpler. A published study was chosen as a basis of the calculations, where inhalation of large doses of tetrachloroethylene had a detectable effect on the liver and kidneys of experimental rabbits. The animal data were then extrapolated to man taking into consideration: 1. route of exposure (ingestion versus inhalation); 2. body weight. (20 lb. child has to be protected); 3. daily intake (1 liter of water per ay per child); 4. absorption rate by the digestive system (to protect the public, 100% is assumed). The number arrived at-17,000 ppb, was then divided by 1000 to provide a wide safety margin and rounded up.

(For comparison, the average safety margin used by EPA in setting Air Quality Standard is less than 2.) The resulting SNARL of 20 ppb, based on toxicity of tetrachloroetyylene, turned 'out to be more' stringent than that based on carcinogenicity (40 ppb). Because tetrachloroethylene is not an overtly toxic chemical and because a 1000-fold, safety margin is built into the 20 ppb SNARL, the EPA's panel of scientists concluded that the potential carcinogenicity of this chemical (however, uncertain) is of greater concern to human health than its general toxicity at low levels. In addition, since the presence of tetrachloroethylene in drinking water means a short term rather than a lifetime exposure, EPA adopted the 40 ppb level for chronic exposure to tetrachloroethylene. Using similar procedures to that described for the chronic exposure SNARL, a one day SNARL of 2300 ppb and a ten day SNARL of 175 ppb were established by EPA.

SNARLS are not magic numbers. They are only an attempt made by a group of experts to express our present incomplete scientific knowledge in a numerical form. The degree of uncertainty and possible controversy in setting of those numbers can be illustrated by this example. A one-day SNARL for tetrachloroethylene for a 20 lb. child was set at 2300 ppb by the EPA and at 24,000 ppb by the National Academy of Sciences. The only difference in methodology was a choice of the scientific study on which the calculations were based resulting in a 10-fold difference in the final numbers.

It should be stressed, however, that all of the assumptions and generalizations made in the process of standard setting are made in such a way as to protect public health. This is the essence of the conservative approach of the government agencies in determining the safe levels of tetrachloroethylene and other chemicals.

Arthur D. Little Inc., is near completion of a comprehensive study on all environmental aspects of tetrachloroethylene for EPA. DEQE will obtain a copy of this report as soon as it is published and consider its findings and conclusions in a future update.

III Testing Program

The testing program conducted by DEQE has been undertakinein essentially 3 phases. The first was to quickly determine the extent of the problem, the second was to further identify areas where the problem might be most serious and the third was to support efforts and experiments to find solutions or determine effectiveness of control measures.

PHASE I:

Original testing eas performed in Westford on one section of the AC pipe with vinyl lining in late January, 1980, The analysis of samples collected showed levels of tetrachloroethylene exceeding 1,000 parts per billion of water (ppb). These few samples led to further testing in 23 communities.

Testing in these 23 communities was done on:

- unlined AC pipe
- lined AC pipe under normal flow conditions
- lined AC pipe under low flow conditions

Both ground and surface supplies were tested.

The analyses of samples collected showed that:

- unlined AC pipe gave no tetrachloroethylene
- lined AC pipe under normal flow conditions generally gave low or intermediate levels
- dead end or low flow conditions gave concentrations of tetrachloroethylene in the high hundreds to several thousands of parts per billion.

PHASE II:

Because of the concentrations of tetrachloroethylene discovered in phase one, each water supply system was contacted, and samples were collected where vinyl lined AC pipe was present in water distribution systems. The Department (DEQE) requested a distribution map from each water department in the affected communities to determine the location of the pipe, its age, and the number of customers served. Communities were ranked by DEQE for priority of assistance based upon mileage of the pipe and general response to the questionnaire sent out in April. DEQE met with the local water suppliers on the basis of this priority list and established a limited sampling program based on the analytical resources available to the Department.

Samples were also collected and analyzed to determine the effects of pipe age, detention time, or other conditions affecting tetrachloroethylene concentration. This phase of sampling eliminated many areas from future consideration because of the low level detected. It also showed some areas where the concentrations were above guidelines and indicated the need for looping, flushing, installation of bleeders or some other control measure. During this testing phase 75 water supply systems were sampled and 574 samples analyzed.

PHASE III:

Many samples were collected and analyzed to determine the effects of flushing, bleeding, use of faucet aerators, ph control, chlorination, cement lining, etc., on tetrachloroethylene concentrations. This phase will continue as required. Approximately 248 samples from 13 systems have been analyzed.

The original testing procedure used at the Lawrence Experiment Station involved the gas chromatograph. About 50 minutes were required for each sample. In addition, known standards had to be run for quality control and time had to be devoted to machine maintenance.

The Experiment Station has been able to develop an acceptable variation in the procedure and reduce the time needed to process a sample for tetrachloroethylene. The laboratory estimates that when down time, quality assurance, machine maintenance and other requirements are factored in about 50 tetrachloroethylene samples per week can be performed on a sustained basis. This commitment will require the assignment of a laboratory machine and a trained chemist to this program alone and will require a redefinition of priorities for the laboratory. This will mean a reduction in other samples being analyzed at the laboratory.

IV Studies and Solutions:

During the course of this problem, there have been many suggestions and recommendations about avenues which should be pursued in looking for a solution.

The following is an attempt to summarize the strengths and weaknesses of the various investigations which have been made.

Faucet Aeration

An attempt was made to determine the effect of faucet aerators on the tetrachloroethylene content of affected homes.

From this very limited study, it can be concluded that household aerators have no significant effect on tetrachloroethylene content.

Since the problem lies in the distribution system and not the source, the only reasonable place to consider aeration would be at the point-of-use.-

Dilution

Dilution is a very effective method of reducing the concentration of material in a water supply by mixing that water supply with another cleaner source of water.

In the situation before us, that is tetrachloroethylene emanating from the distribution system itself, it would seem that the only way to provide such dilution would be to lay a new pipeline of different material on each affected road and mix with the affected water. Naturally, if this were to be done it would be just as easy to eliminate the affected water by replacing the pipes.

There does not appear to be any practical way of providing dilution to solve this particular problem.

Cleaning and/or Lining

A research program was recently conducted by Haley and Ward, Inc., to find a cost-effective method of treating asbestos-cement vinyl lined (A.C.-V.L.) pipe to reduce the leaching rate of tetrachloroethylene thus reducing the concentrations.

A test site was constructed in Ashland, Mass., consisting of 156 linear feet of A.C.-V.L. pipe installed within an earthen berm, in four separate sections.

- Section "A" consisted of 52 L.F. of pipe, with the vinyl liner removed by wire brushing and a cement liner installed.
- Section "B" consisted of 52 L.F. in which the cement liner was installed directly over the vinyl liner.
- Sections "C" and "D", 26 L.F. each, were left in the original condition.

All sections were chlorinated, flushed and refilled with clean water, and samples were taken approximately every 7 days for a period of 60 days, with analyses done by the DEQE Laboratory at Lawrence. For this particular installation, a consistent 97-99% reduction in TCE concentration was realized for sections "A" and "B", compared to Sections "C" and "D". It should be understood that this was a short term test (60 days), for pipe 6-months old prior to installation and under static (no flow, no pressure) conditions. The results to date indicate that this method of treatment does show promise, and could be utilized at approximately 1/3 the cost of complete pipe replacement.

One concern has been expressed to a solution such as this where, in effect, another barrier membrane is being placed between the water and the vinyl lining. It is not known but it can be projected with some degree of confidence that the long term effect will be to lower the concentrations but extend the period of time over which the leachable tetrachloroethylene residual in the pipe will leach into the water. However, even if a pipeline originally showed levels of over 1000 ppb lining the pipe would probably keep the long term level below 40 ppb.

This experiment is continuing.

The method of placing a cement lining over the vinyl lining has been estimated to cost $10.00 per foot. To remove the vinyl lining from the pipe and then apply the cement lining could be done for approximately $15.00 per foot.

Additional testing was also attempted by Haley and Ward, at this site, on similar asbestos-cement vinyl lined pipe. The first test consisted of directing a high temperature (200°F), high pressure water jet from a machinery cleaning apparatus, on a specific location on the vinyl liner, for a period of 5-minutes. There was no measurable reduction in thickness. Sandblasting equipment was also available at the site, and an attempt was made to remove the liner with this equipment. Within one second of operation, the liner was removed but there was so much damage to the pipe itself that this method was judged impracticable and the test was suspended.

Flushing and/or Bleeding

Extensive sampling of vinyl lined pipes by the DEQE has revealed a definite and direct relationship between residence time (the length of time the water is in contact with the pipe) and the tetrachloroethylene level observed. Accordingly, it was logical to assume that reducing the residence time by flushing and/or bleeding would result in a reduction of the tetrachloroethylene level.

Almost from the outset, the DEQE was. aware that flushing would lower tetrachloroethylene levels but that the level would recover when flushing was terminated. Recognizing the need to be able to predict the rate, duration, and frequency of flushing required to maintain acceptable levels, the DEQE has participated in studies designed to provide such information. Data gathered to date relative to high velocity flushing (1 turnover per hour or greater) indicates that 2 complete turnovers will reduce the tetrachloroethylene level to less than 1% of the original level and that the maximum rate at which the tetrachloroethylene recovers to the initial level is approximately 10% per day.

Continuous bleeding at the terminus of dead ends at a rate of 1 turnover per day appears to be even more effective than high velocity flushing in that there is less fluctuation in the tetrachloroethylene level. Sampling results from approximately 10 locations show that continuous bleeding has consistently lowered the level to below 40 ppb which in most cases represents less than 10% of the original level.

This information on the effectiveness of installing a bleeder on the system is consistent with some work done by Johns-Manville (J-M) in Simsbury, Connecticut. There it was found that maintaining flow rates as low as 2 to 3 gallons per minute was adequate to maintain low TCE levels. The tests were all conducted on 8 inch lines but the J-M report indicates similar results could be expected for 10 and 12 inch lines. Pipes used in the J-M experiment were installed in 1977, 1978 and 1979.

Flushing and/or bleeding is reported to be the method employed in con-trolling this problem in the other New England States. This solution or control measure is not without its drawbacks. Water conservation is a stated goal and program of the Commonwealth. Continuous wasting of. water is inconsistant with that program. Many communities are water short and cannot afford to waste water. The question has also been raised about a bleeder being left running in the winter weather causing a safety hazard by forming ice in the street.

The Department has determined that a bleeder line may be discharged into a catch basin or similar receiving area without constituting a cross-connection if:

(1) The supplier provides the Department with a listing giving the location of each installation.
(2) A pressure type vacuum breaker is installed on the line.
(3) The water supplier periodically (at least bi-weekly) inspects the vacuum breaker to see that it is in operating condition.
(4) The supplier agrees to shut off and physically remove all piping. associated with the bleeder when the problem. is solved.

Attachement "C" to this report lists the provisionally approved types of vacuum breakers and outlines a simple testing procedure which requires no special equipment.

The question has been raised about the effect a flushing or bleeding program might have on other parts of the environment. The DEQE does not believe that there will be adverse effects, caused. by the discharge of this water to waste because of the low levels and the probable dilution in the ground.

Since vinyl lined pipe contains a finite amount of tetrachloroethylene, it follows that even normal water flow in the distribution system will eventually remove all of the chemical originally present. Evaluation of the results of 230 samples collected in S.E. Massachusetts shows that the tetrachloroethylene level decreases as the age of the pipe increases. The mean (average) level has been found to be less than 40 ppb in pipe which is 5 yrs., or older.. (See Attachment "A") Similar information compiled on 82 samples in the State of Maine supports this finding.

Carbon Filtration

It has long been the position of most state and federal agencies that the drinking water being delivered to the ultimate consumer should be safe and that the consumer should not have to install and/or operate any type of device at the point-of-use to insure this safety. If treatment of a public water supply is necessary, it should be accomplished at a central plant where the treatment is under the control of a trained operator.

This philosophy is still valid except that in the present situation, the contamination is occurring at discreet locations in the distribution system and not at the source.

Given the fact that the problem will eventually disappear through use and that ingestion of the water is the only real concern about its use, we can, by making some assumptions and using laboratory test data supplied by the E.P.A. suggest the following as one way the concerned individual home owner could address the problem.

EPA's Office of Drinking Water has very recently (July 1980) published a Fact Sheet/Update on their testing of Home Water Treatment Units. Under a contract some 30 commercially available activated carbon units were tested to determine their effectiveness in removing certain organics, bacteria and endotoxins. Of particular interest for this report is the fact that the removal efficiency. for tetrachloroethylene should be of the same. order .. of magnitude as that for trihalomethanes, which was actually one of the organics studied.

Thus, if a home owner chose to install a unit with a reported efficiency of 95% for example for trihalomethane (THM) removal, that unit should reduce water with a tetrachloroethylene level of 800 ppb down to 40 ppb for the indicated test life of the filter cartridge.

Assuming a family of four, the amount of water actually used for drinking and cooking purposes probably amounts to no more than five gallons per day. Thus if a carbon filter were installed just ahead of a faucet used only to obtain water for these purposes and the filter had an indicated test life of 500 gallons, the carbon cartridge would have to-be replaced. at approximately 3 month intervals. Use of this tap for other purposes such as dishwashing would reduce the useful life of the filter.

A copy of pertinent parts of this report is available from the Department or the Environmental Protection Agency on request.

Boiling:

EPA laboratories in Cincinnati and Lexington have done some experiments to determine the effectiveness of boiling water as a means of removing chemical contamination. The two compounds actually chosen for the experiment were trichloroethylene and tetrachloroethylene but it is reasonable to assume that other chlorinated hydrocarbons would follow the same trend.

The results show that after five minutes of a vigorous boil Less than 1%' of the tetrachloroethylene remained.

There are a number of cautions which should be observed in using this solution to the problem.

1. The person should not stand over the pot of boiling water where the vapors can be breathed.
2. A range hood should be used.
3. A timer is a must. An accurate time of boiling is difficult to judge.
4. The inorganic quality of the water should be considered. If the water is heavy with iron for example, boiling will tend to concentrate the iron.

For maximum effectiveness the depth of water should be no greater than 2 inches. Either glass or metal pans are suitable.

The Department feels that boiling can be an effective method of reducing the concentration of tetrachloroethylene in drinking-water, but that because of the variabilities with respect to original concentration and other cautions, it may not be a practical long term solution.

pH Adjustment

At the same time the presence of tetrachloroethylene in vinyl lined asbestos cement pipe was confirmed, a town in Central Massachusetts was about to begin the addition of potassium hydroxide to the town's water supply. This addition was for the purpose of corrosion control and was in no way related to the-tetra--chloroethylene problem. It was recognized that this afforded an excellent opportunity to study the effect of pH on the concentration of tetrachloroethylene.

The town has one vinyl lined asbestos cement pipe in a low flow location. This line is 1500 feet long, 10" diameter, and serves 5 houses. The calculated residence time is 4.9 days. Several samples. were collected from a hydrant at the end of this line before the KOH was added, with results as follows:

March 18	123 ppb
April 24	38 ppb (after flushing)

The addition of potassium hydroxide was begun on May 9, 1980 and the pH raised to 8.2. The line was flushed to waste for a period of two weeks to draw the high pH water through the line. At the end of that time samples were collected weekly, with results as follows:

May 9	150.4 ppb	-

May 16   Less than 5 ppb (while flushing)

June 3	3.3 ppb
June 10.	91.8 ppb
June 17	144 ppb
June 25	137 ppb
July 9	285 ppb
July 16	180 ppb
July 23	140 ppb

At the time of the latest sampling, the pH was 8.2 at the station and 8.9 at the hydrant.

It can be seen that within a short time, the level of tetrachloroethylene reverted to its original level and increasing the pH has no effect on reducing the tetrachloroethylene concentration.

SUPERCHLORINATION

Dufresne-Henry, Consulting Engineers for a town in Southeastern Massachusetts recently designed a water transmission main using vinyl lined. AC pipe. After installation, samples of water taken from the transmission line showed concentration levels of tetrachloroethylene above the recommended level. of .0 ppb.

To determine the effectiveness of superchlorination in reducing the tetrachloroethylene concentrations, the pipe line was chlorinated at a level. of 50 ppm and the chlorinated water allowed to flow through the pipe at 20 (gpm) gallons per minute for 16 days then allowed to stand in the pipe for 5 days. Chlorinated water was flushed out of the pipeline and the pipeline was periodically re-sampled.

The periodic sampling showed that tetrachloroethylene concentrations, after chlorination and flushing, returned to their original levels.

The Environmental Protection Agency has also done some bench studies on the effect of chlorination on vinyl lined asbestos cement pipe and has observed generally similar results.

Replacement

Asbestos cement, vinyl lined pipe is located in areas across the Commonwealth, from Clarksburg in the Berkshires to Provincetown on the tip of Cape cod, including the off shore islands. The sizes vary. from 6 inches up to 16 inches with the majority being 6 inches and 8 inches in size. Several lines are short spur lines that dead end, many less than 2400 feet in length. To replace this pipe, dig it up, would create a costly problem for the communities. Our best estimate of quantity is 644 miles or 3,400,320 feet of pipe in the ground.

Replacement of the pipe would entail more than just digging it up and relaying. Any house service on the existing line would have to be re-connected; this would also mean hydrant connections; plans and specifications would also have to be prepared for bidding; and engineering inspection for the contract would be another cost.

Currently, contractor bids for laying 6" mains are $35.00 per foot; 8" mains, are $40,00 per foot; and 10" mains are $45.00 per foot. Using the 10 inch cost per foot as an average, the raw replacement of the mains would be:

Total Replacement	644 miles	$153,014,400
75% Replacement	483 miles	$114,760,800
50% Replacement	322 miles	$ 76,507,200
25% Replacement	161 miles	$ 38,253,600

To these costs must be added the costs of:

1) Plans and Specifications
2) Bidding
3) House Service Connections
4) Hydrant Connections
5) Construction Inspection
and
6) Repair of streets, sidewalks and driveways affected.

There are no specific state or federal programs that exist for problems of this type for cost sharing, so the entire cost of replacement' must be borne by the water supplier.

Bottled Water -- Alternate Water Supply

Bottled water as an alternate supply is usually available in either one gallon plastic jugs at the supermarket or five gallon carboys from a company which will deliver to the home. The testing of bottled water is not as comprehensive a program as is the testing of public water supplies. '

In many communities there is no problem with tetrachloroethylene in any part of the water system and even in the affected communities not all parts of the system are affected. This raises the possibility of taps in public buildings (libraries, fire stations, the well or treatment plant) being made available to people who wish to draw water for drinking and culinary purposes.

Legal Responsibilities and Liabilities,

The Department has consulted with the Attorney General's Environmental Protection Division concerning possible legal action concerning tetrachloroethylene distribution pipes. The Attorney General's Office has determined that it will ask the manufacturers of the pipe to pay for remedial steps that are taken by the cities, towns and districts as a result of the problem. As soon as a program of remedial action is formulated, the manufacturers will be contacted.

If the manufacturers refuse to pay the costs of a reasonable remedial program, the Attorney General will institute legal action on behalf of the water suppliers. The Department and the Attorney General's Office believe that the manufacturers should reimburse the water suppliers for expenses in correcting the situation.

In order to prepare for such a case, the water suppliers should return the contract information forms which were distributed at the meeting of the water suppliers and the Attorney General on July 15, 1980.

Blank copies of the form can be obtained from Malcolm Pittman, Assistant Attorney General, Environmental Protection Division, Department of the Attorney General, I Ashburton Place, 19th Floor, Boston, Massachusetts 02108.

Water distributors should keep accurate records of the expenses of remedial actions to facilitate reimbursement from the manufacturers.

Conclusions and Recommendations

The problems are:

(1) This contaminant is in the distribution pipe and not the source.
(2) It is not amenable to treatment with another waterworks chemical, i. e., chlorination, corrosion control chemicals, etc.
(3) There is no Maximum Contaminant Level yet established which would provide a regulatory agency with an absolute number to determine whether or not a particular water is meeting the standard.
(4) Since the lining was applied by hand rather than an automated process, the amount of vinyl lining can vary. In at least one case it is reported that the local water department was dissatisfied with the amount of material on some pipe they bought and it was sent back to the factory to be lined. This, coupled with the varying age of pipe in the systems tested, the lack of knowledge about how old the pipe was before it was laid and the difference in flow patterns that the pipe is subject to in the systems, make it impossible to draw more than broad and general conclusions from the data. Significantly more amounts of testing probably will not allow us to be any more precise with general conclusions. The degree of the problem is to a large extent sie specific and must now be dealt with on that basis.

The possible solutions to the problem are several in number and the selection of the most advantageous one (or combination of several) must depend on :decisions made at the local level.

The possibilities to be considered include:

(a) Providing a program of bleeding and/or flushing.'
(b) Providing an alternate water supply.
(c) Providing for carbon filtration..
,(d) Looping dead end situations or making other structural changes to provide for a better flow of water. .
(e) Boiling water used for consumption.
(f) Scraping and/or relining pipe in place.
(g) Replacing the pipe.

The eventual goal is to provide water in all locations where samples of water in the pipes under normal use conditions is consistently less than 40 ppb. The sampling program could then be discontinued. Further use and aging of the pipe will eventually lower this level to 0 ppb, well within the 70 year time span on which the SNARL is based.

To solve the problem of tetrachloroethylene in water pipes, each supplier must submit a written action plan to the Department indicating how they propose, to address their problem.

The Department will assign one water supply engineer in each region whose priority responsibility will be to work with the water suppliers on this problem, to collect such additional samples as are felt necessary to assess the success of the efforts and to keep a current record on each affected supplier's efforts and the results of those efforts so that as areas of concern fall below the 40 ppb level, they can be eliminated from further testing. Samples collected by these engineers in furtherance of this effort will be analyzed by the Department. However, neither the Commonwealth nor the EPA have the laboratory capability to do all of the monitoring work that will be required.. Suppliers should contract with private laboratories to do the routine analytical work, keeping a record of all expenses incurred as recommended in the "legal" section.

It is the responsibility of the water supplier to provide the best possible quality of water to the consumers. If, despite his best efforts there is still a problem, the ultimate consumer must then be made aware of the quality of the supply by the water supplier. The consumer will at least then be aware of the problem and the factors which have gone into any decision and can make informed judgements about using or not using the water for various purposes.

Strategy for Dealing with the Problem

The following strategy is suggested as a possible plan of action.

1. Water suppliers identify all areas where vinyl lined AC pipes have been installed.
2. Those areas where the pipe is in a constant flow situation and those areas where the pipe is five years old or older be tested and eliminated from future testing of the concentration is 40 ppb or less.
3. Those areas where previous sampling has shown the concentration to be 40 ppb or less under normal use conditions be eliminated from future testing.
4. Those areas where previous sampling or new sampling shows the concentration to be between 40 ppb and 100 ppb under normal flow conditions be immediately flushed and equipped with a bleeder. The bleeder should be protected with a backflow device such as a pressure type vacuum breaker if necessary. One sample should be collected from these locations every six months to confirm that the level is being maintained below 40 ppb.
5. Those areas where the concentrations are above 100 ppb under normal use conditions to be identified and:

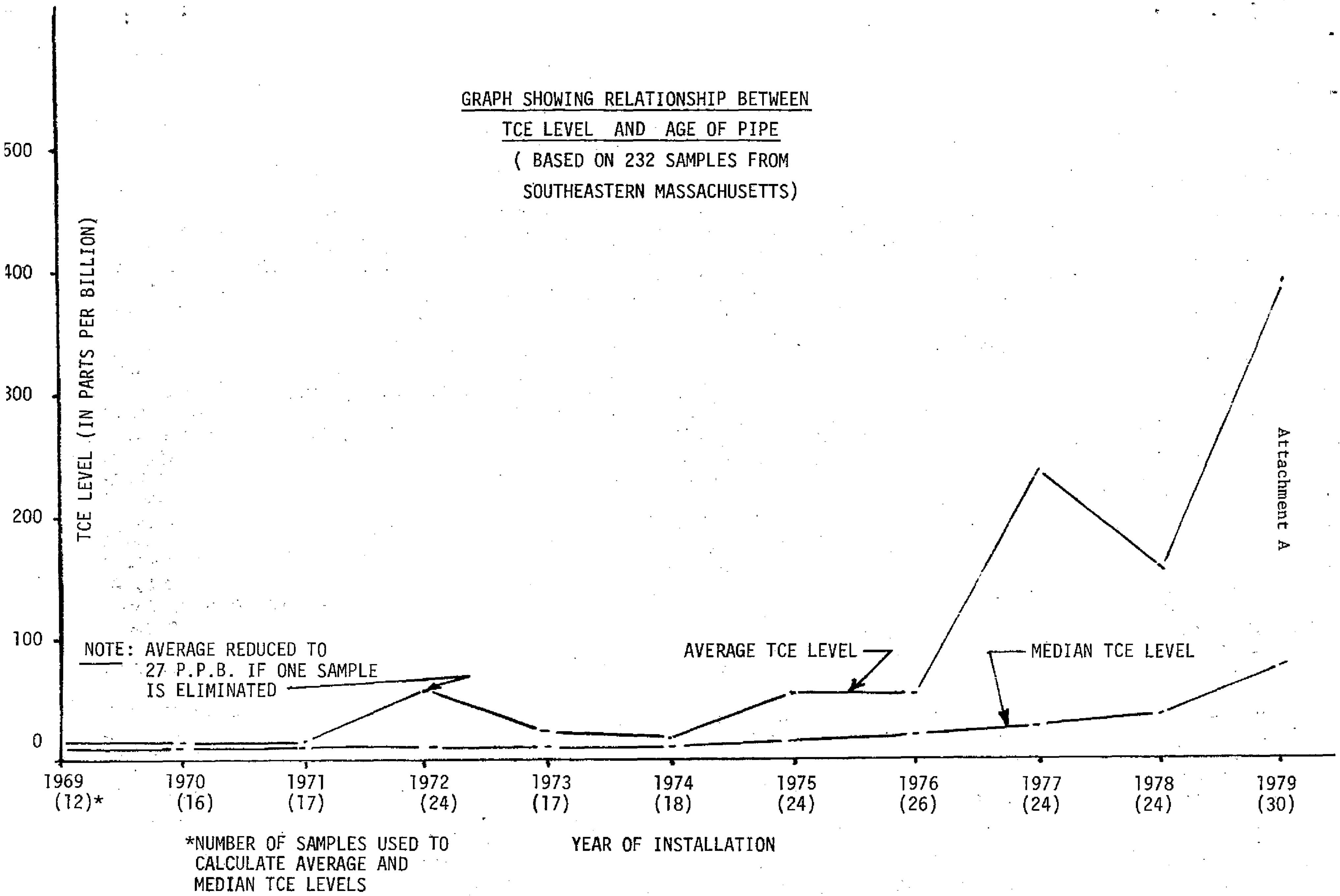
a) Flushed and bleeders installed where appropriate.
b) Sampled on a monthly basis by the water supplier. The frequency of this sampling can be reduced to once every 6 months, provided that 3 consecutive month's samples show tetrachloroethylene levels below 40 ppb.

If steps (a) and (b) show that the concentration is not being kept below an average of 40 ppb over a six month average, or if any monthly. sample exceeds 175 ppb which is the 10 day SNARL, then the supplier must initiate a program for the affected area whereby:

a) The consumers in. the affected area are formally notified of the problem and the water suppliers intended further actions to correct it.
-
b) The affected consumers be advised of possible alternative such as:
   - Obtaining water from another nearby source which is not affected.
   - Installation of an appropriate carbon filtration unit.
   - Boiling water used for consumption.

-As an indication of their concern and awareness of this problem, it is suggested that the supplier, as a matter of policy, keep the consumers affected by this problem informed about its prevalence within the system, the efforts being made to solve the problem, the outcome of these efforts, the results of testing, etc., as this information becomes known.

The essence of the program should be that the average level of tetrachloroethylene is maintained at, or below, 40 ppb even though the short-term (less than a month) levels may be higher than that. The Department believes that, despite these short-term variations in excess of 40 ppb, the long-term effects of tetrachloroethylene present no danger to the health of the exposed population, based on two liters of water ingested per day for 70 years.


GRAPH SHOWING RELATIONSHIP BETWEEN
TCE LEVEL AND AGE OF PIPE
(BASED ON 232 SAMPLES FROM
SOUTHEASTERN MASSACHUSETTS)
TCE LEVEL (IN PARTS PER BILLION)
500
400
300
200
100
0
NOTE: AVERAGE REDUCED TO
27 P.P.B. IF ONE SAMPLE
IS ELIMINATED
AVERAGE TCE LEVEL
MEDIAN TCE LEVEL
1969 (12)*
1970 (16)
1971 (17)
1972 (24)
1973 (17)
1974 (18)
1975 (24)
1976 (26)
1977 (24)
1978 (24)
1979 (30)
YEAR OF INSTALLATION
*NUMBER OF SAMPLES USED TO
CALCULATE AVERAGE AND
MEDIAN TCE LEVELS
Attachment A

WATER SUPPLIES WITH ASBESTOS CEMENT VINYL LINED PIPE

SOUTHEAST
Acushnet
Barnstable: Water Company
Bourne: Bourne Water District
North Sagamore Water District
South Sagamore Water District
Brewster
Bridgewater
Chatham
Dartmouth
Duxbury
East Bridgewater
Edgartown: Water Company
Fairhaven
Falmouth
Franklin
Gosnold: Water Company
Halifax
Hanover
Hanson
Harwich
Kingston
Marion
Marshfield
Mashpee: Highwood Water Company
Mattapoisett
Nantucket: Wannacomet Water Company
Norwell
Oak Bluffs
Pembroke
Plymouth
Provincetown
Raynham: Raynham Center Water District
North Raynham Water District
Sandwich
Scituate
Sharon
Taunton
Tisbury
Wareham: Wareham Fire District
Onset Fire District
West Bridgewater
Wrentham

WESTERN
Amherst: (Belchertown)
Bernardston: Fire & Water District
Chicopee
Clarksburg: Red Mills Water Supply
Deerfield: South Deerfield Water Dist.
Deerfield Fire District
Easthampton
Hatfield
Longmeadow
Northfield: Water District
Southampton
Sunderland

CENTRAL
Ayer
Brookfield
Boylston: Water District
Douglas
East Brookfield
Holden
Holliston
Littleton
Lunenburg
Maynard
Milford: Water Company
North Brookfield
Northborough
Paxton
Rutland
Shirley: Mass. Correctional Institute
Shrewsbury
Southborough
Sterling
Stow
West Boylston: Water District
West Brookfield
Westford
Westminster

NORTHEAST/METROPOLITAN
Arlington
Ashland
Burlington
Cohasset
Dracut
Essex
Hamilton
Haverhill
Ipswich
Lincoln
Norfolk
Rowley
Salisbury
West Newbury
Winchester
Woburn

Attachment B

Attachment C

PRESSURE TYPE VACUUM BREAKERS

The model and size of pressure type vacuum breakers listed below are not yet fully approved by the Department. In accordance with our policy of requiring evaluation under field conditions before full approval *is given they* will be allowed to be used on bleeder lines from public water supply distribution systems to lower the tetrachloroethylene levels. The water supplies must make application to the Department for each installation although no formal permit will be issued pr fee charged.

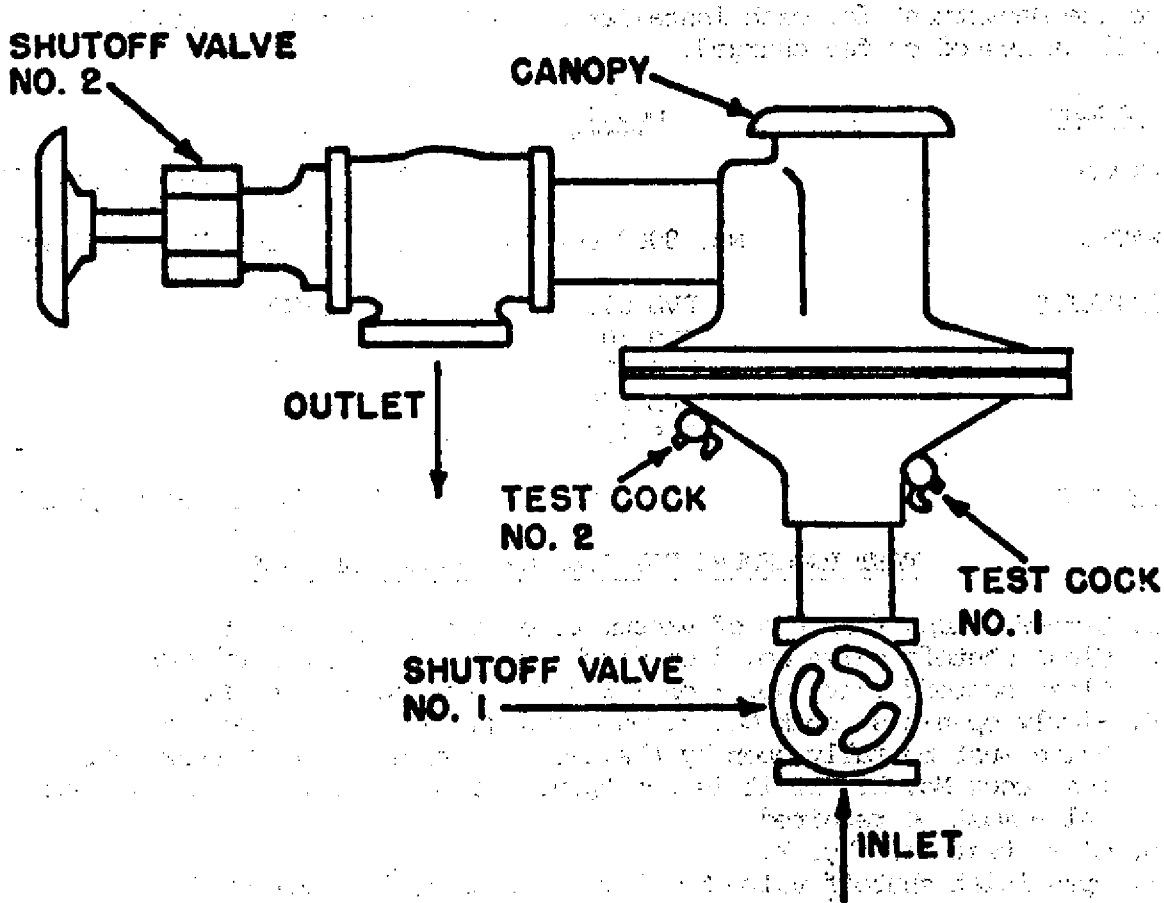
Company	Model	Sizes
FEBCO	765	1/2",3/4",l",1-1/4",1-1/2" and 2"
WATTS	No. 8000 series	3/4",l",1-1/4",1-1/2" and 2"
RAINBIRD	PUB 075	3/4"
	PVB 100	1"
	PVB 125	1-1/4"
	PVB 150	1-1/2"
	PVB 200	2"
NEPTUNE	720	1/2',3/4",1",1-1/4",l-l/2" and 2"

TEST PROCEDURE FOR **PRESSURE VACUUM** BREAKER

1. Remove canopy from top of vacuum to expose air inlet tube.
2. Close shutoff valve No. 2 on discharge side of vacuum breaker.
3. Close shutoff valve M . 1 on inlet side of vacuum breaker,
4. Slowly open test cock No. 2, watching guide in air inlet tube. Valve must be fully open by the time the water stops running from test cock No. 2 if it is not open, then air inlet is sticking and valve must be repaired.
5. Close test cock No. 2.
6. Open inlet shutoff valve No. 1 very slightly and allow water to fill to the top of the air chamber. Then close shutoff valve M . 1 tightly.
7. Open test cock No. 1.
8. The water level in the air inlet tube will drop initially due to the seating of the diaphragm. After the initial drop, the level of the water should remain fixed in the air inlet. If it continues to drop, then check valve is leaking and should be replaced.
9. If both 3 and 7 test satifactorily, restore all shutoff valves and test cocks to initial positions.

NOTES: Open shutoff valve No. 2 on the discharge side of the vacuum breaker before opening the shutoff valve No. 1. This eliminates any shook that might cause the diaphragm to blow due to the compressed air and resultant shock wave.

TEST PROCEDURE FOR PRESSURE VACUUM BREAKER



The Commonwealth of Massachusetts
Department of Environmental Quality Engineering

Status Report on Tetrachloroethylene Contamination Of Public Drinking Water Supplies caused by Vinyl-lined Asbestos Cement Pipe

June 1982

Department of Environmental Quality Engineering
Division of Water Supply

Edward J. King
Governor

John Bewick
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Anthony D. Cortese, Sc.D.
Commissioner
Department of Environmental Quality Engineering

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CONTENTS

INTRODUCTION AND SUMMARY

Since January 1980, the Division of Water Supply has been assisting communities in coping with contamination of their water-supplies with the organic chemical tetrachloroethylene. The source of the contamination proved to be vinyl-lined asbestos cement water mains. The tetrachloroethylene had been used by the pipe manufacturer as a solvent for the vinyl resin liner. In the coating process, the solution had been sprayed onto the interior walls of the pipe and allowed to dry. In some cases traces of the solvent remained in the resin lining or in the pores of the pipe walls up to the time the pipes were installed as water mains.

An extensive survey revealed that 660 miles of the pipe were used as water mains in the State with 91 different communities involved. It is significant that the larger cities in the Commonwealth had not installed any of the pipe. The area of the State most seriously impacted falls under the jurisdiction of the southeast Department of Environmental Quality Engineering (DEQE) office in Lakeville. Cities and towns within that area accounted for approximately 500 miles of the pipe, with 44 different communities contributing to the figure. Falmouth and Sandwich were each using about 50 miles of the pipe. No other communities had installed such a large amount.

Health studies discussed in the body of the report implicate tetrachloroethylene as a toxic material and a likely human carcinogen. Extensive testing of water quality where drinking water flows through the vinyl-lined asbestos cement pipe has shown that the level of tetrachloroethylene found in the water will naturally decrease with time. The Department anticipates the problem will be substantially absent after about five years. After considering the health studies, the Environmental Protection Agency (EPA) set a level of 40 micrograms per liter as a maximum level of the solvent which should be allowed in the water. Efforts of the DEQE in assisting communities have been directed toward establishing control procedures and schedules which assure compliance with that limit.

While the most obvious solution would appear to be replacement of the pipe, the cost of this would be so high that communities are not prepared to cope with it except where very short lengths were used. The cost of statewide replacement is estimated to be $157 million for pipe replacement alone, without including associated costs such as street repairs.

The most practical method to control levels of the impurity is to run some water to waste constantly. A flow of about 4 gallons per minute bled from the distribution system at appropriately chosen points will maintain the required water quality.

Three communities with only short lengths of pipe replaced the pipe. One, the Town of Hatfield, used its own labor force to replace 2700 feet of the pipe at a cost of $25,000, excluding about 166 man hours of labor costs.

Of the 91'communities involved, 33 met standards without corrective measures, 48 chose to control levels of the contaminant by continuous bleeding of water from the pipe, three replaced the pipe, one lined the pipe, and one controls the contaminant levels by flushing the pipe routinely. Five communities have not yet fully controlled the problem.

It is roughly estimated that the monitoring required of communities, the installation of equipment and devices necessary to control the contamination, and the wasting of water will cost the communities involved a total of some $6 to $8 million. Cost of the problem to DEQE to date has been at least $175,000.

In spite of dry weather conditions prevailing since discovery of the problem, most of the water supplies have had enough water available for distribution system bleeding necessary to maintain safe levels of the contaminant. Should the water shortage increase to the point where system bleeding is not possible, the communities would have to choose another alternative such as replacement or lining of the pipe, use of bottled water for drinking or use of activated carbon filters.

In September 1980 DEQE released a report covering the facts then known relating to contamination of drinking water from vinyl-lined asbestos cement pipes. This April 1982 revision updates the earlier report. Major new components are sections on health effects and giving the status of the problem in each of the 91 communities of concern.

I - Problem Statement

In January 1980 Massachusetts and the other five New England States discovered a problem with the chemical tetrachloroethylene leaching into some of their drinking water because of the type of pipe used in some parts of the water distribution system.

Tetrachloroethylene is an organic chemical slightly soluble in water used in a variety of ways including the dry cleaning process as a degreasing solvent and heat transfer medium. The chemical has also been used in the manufacture of vinyl-lined asbestos cement pipes as a solvent or vehicle for the resin.

Asbestos cement (AC) pipes have been in use since the 1930's. The lined variety has been in use for approximately twelve years in New England. The vinyl lining reportedly was developed as a response to customer complaints about the taste and odor of water coming into contact with the asphaltic coating used on water supply pipes, especially in dead end situations.

In July 1976 tetrachloroethylene was discovered in a distribution system in Newport, Rhode Island. An investigation to determine its source was inconclusive and the significance of the problem not fully understood.

In 1978 and 1979 correspondence about Newport's problem was exchanged between Johns-Manville and Rhode Island officials. Rhode Island periodically updated the other New England states but information was meager and inconclusive. During this time, feeling grew that the problem had something to do with the manufacture of the pipe as opposed to installation practices.

By December 1979 circumstantial evidence showed that lined AC pipes were leaching tetrachloroethylene. A piece of four inch lined AC pipe was shipped in December 1979 from Newport to EPA's Municipal Environmental Research Laboratory in Cincinnati for testing. The experiment run twice in January 1980 verified that tetrachloroethylene came from the lined pipe. At the end of January this information went to each state in EPA Region I.

Discovery of the problem in Massachusetts came about in late January 1980 as a result of DEQE testing in Westford to determine the parameters of a water supply contamination problem. This was in connection with the discovery of a storage area containing barrels of chemical waste. Private wells in the vicinity of the storage area were sampled and a tap on the public supply was also sampled. The sample taken from the public supply showed over 1100 parts per billion (ppb) of tetrachloroethylene. A second sample from the same tap showed over 1000 ppb. Other samples in town showed no amounts of the chemical.

Investigation in 1977 showed the town had installed 8500 feet of 12 inch vinyl-lined asbestos cement pipe in the area in which the tap at the end of the line was sampled by DEQE. Detention time in this segment was calculated to be eleven days. Samples were collected upstream of the line, midway, and at the end and showed concentrations of 0 ppb, 40 ppb, and 1000 ppb, respectively. This led to the conclusion that tetrachloroethylene was leaching out of the pipe.

DEQE regional offices were instructed to immediately identify and sample several installations in their region where:

1) Lined AC pipe was in use.
2) The pipe was installed in a dead-end or low flow location.

This first testing was conducted to determine quickly the extent and severity of the problem.

Results of this first sampling showed that the problem likely existed to some extent among all installations of lined AC pipe.

DEQE mailed a questionnaire to all water department superintendents throughout the state to determine the number of miles of this pipe in use and approximately how many "dead end" situations existed. It was deemed unlikely that this kind of pipe would have been installed by owners of property served by private wells.

Data gathered from the questionnaire indicated that parts of at least 83 public water supplies with a total length of over.. 700 miles of pipe were involved.

Massachusetts requested a meeting with officials of Johns-Mansville from the factory at Manville, New Jersey to get factual and first hand information on the manufacturing process. At this meeting in March 1980 officials learned about the chemicals used, the mixing procedure and the application technique.

Massachusetts also identified two other manufacturers, Certain-Teed and Capco which used this type of lining, whose **sales in** the area were limited and identifiable.

Another meeting was held between Johns-Mansville officials from Denver, Colorado and Massachusetts officials on April 1, 1980 to obtain more information on the extent of the problem and to discuss possible solutions. Representatives of EPA and the other New England states were invited to this meeting. It is important to note that at all times during this process, there was a dialogue and exchange of information and experience going on not only within each state but between the states and EPA.

At a previously scheduled meeting between EPA and the New England states held in Boston April 2 and 3, this problem was the main topic of discussion. Massachusetts made plans to alert the affected water supply agencies, local officials and legislators and a question and answer package on tetrachloroethylene was developed for the media and the public at this time.

From the time that the problem was first identified, DEQE regional field staff have spent considerable time working with each affected water supplier in an effort to:

(a) Pinpoint areas of concern.

(b) Provide advice and some laboratory testing support to lower the levels of tetrachloroethylene and to monitor the effects of control efforts.

In addition, DEQE has initiated or participated in a number of studies de-signed to find short term and long term solutions to this problem.

EPA has undertaken several studies, provided guidance in the area of health risk associated with the problem and provided information on the effectiveness of carbon as a removal agent.

II - Health Effects

Tetrachloroethylene is rapidly absorbed through the lungs and skin. Although no studies have been done on its absorption through the gastrointestinal tract, chemical properties of tetrachloroethylene indicate it should be rapidly and completely absorbed as well. The majority of absorbed tetrachloroethylene is rapidly eliminated from the body. Only a minor portion of the total (less than 2%) is retained in tissues.

Because of the nature of the tetrachloroethylene problem associated with vinyl-lined pipes -- long term exposure to relatively low levels of the chemical - we are primarily concerned with chronic toxicity and potential carcinogenicity of tetrachloroethylene.

Tetrachloroethylene affects liver and kidneys as well as the central nervous system, manifested by dizziness, headaches and fatigue. These effects are mild and in most cases reversible if the exposure is stopped. Experimental daily doses required to produce first signs of toxicity in animals were at least a thousand times higher than that consumed from drinking water containing 40 ppb of tetrachloroethylene.

The results of several studies conducted to assess the carcinogenic potential of tetrachloroethylene are conflicting; the chemical gave positive response in some and negative in others. The most comprehensive study was completed in 1977 by the National Cancer Institute (NCI). In that work massive doses of tetrachloroethylene were given to laboratory mice and rats. The lack of carcinogenic response in rats should be interpreted with caution since the survival of experimental rats was very poor due to the toxic effects of tetrachloroethylene at the doses applied.

NCI is currently conducting two more animal studies on the carcinogenic and teratogenic potential of tetrachloroethylene. The carcinogen bioassay results will become available by late 1982 and the teratogenicity study has recently begun.

Three epidemiological studies are in progress on dry cleaning workers who are exposed occupationally to tetrachloroethylene. The study conducted by the National Institute for Occupational Safety. and Health (NIOSH) will be completed the end of 1982. Preliminary results indicate no increased incidence of cancer, but this may change when the work is completed. Preliminary results of a second study by the NCI on workers in St. Louis indicate an increased risk of cancer, (Blair, Am J Public Health 69,508 (1979). This study will be completed in 1982. A third study conducted by Dr. Nabin Asal of Oklahoma University on dry cleaning workers in Oklahoma indicated increased death rates for kidney cancer in males. A case control study is ongoing. Preliminary results show a number of the 200 cases of kidney cancer were of persons who were dry cleaners by profession. Statistical analysis has not yet been completed, but final results should become available by March 1982. It should be stressed that tetrachloroethylene is only one of the solvents to which dry cleaning workers would be occupationally exposed. Therefore, even if excess cancer incidence was found in these studies it could not be conclusively linked to tetrachloroethylene.

In summary, positive evidence provided by the NCI mouse study, suggested evidence of the NCI epidemiological study and the similarity of tetrachloroethylene to the known chemical carcinogens vinyl chloride (human) and vinylidene chloride (animal) provide substantial evidence that tetrachloroethylene is likely to be a human carcinogen. (Roy Albert, Carcinogen Assessment Group, EPA, July 25, 1980.)

Statistical probability of developing cancer in man due to exposure to tetrachloroethylene has been calculated by the Committee on Safe Drinking Water with the NCI study with mice, which showed a higher incidence of liver cancer than other animals, to man. The method involved a complex mathematical handling of the laboratory data using a computer program based on a mathematical model of cancer formation. A level of 40 ppb resulted from these calculations. It means that drinking 2 liters of water containing 40 ppb of tetrachloroethylene per day for 70 years will contribute to no more than one additional cancer in 100,000 people exposed.

Suggested No Adverse Response Level (SNARL) which is based on toxic, not carcinogenic response, was established for tetrachloroethylene. A published study was chosen as a basis of the calculations, where inhalation of large doses of tetrachloroethylene had a detectable effect on the liver and kidneys of experimental rabbits. The animal data were extrapolated to man, taking into consideration: 1. route of exposure (ingestion versus inhalation); 2. body weight (20 lb. child to be protected); 3. daily intake (1 liter of water per day per child); 4. absorption rate by the digestive system (to protect the public, 100% is assumed). The number arrived at, 17,000 ppb, was divided by 1000 to provide a wide safety margin. The resulting number 17 was rounded up to 20 ppb. The SNARL of 20 ppb applies to chronic exposure. Using similar procedures to that described for the chronic exposure SNARL, a one day SNARL of 2300 ppb and a ten day SNARL of 175 ppb was established by EPA.

It should be stressed that all assumptions and generalizations made in the process of SNARL setting are made in such a way as to protect public health. This is the essence of the conservative approach of the government agencies in determining safe levels of tetrachloroethylene and other chemicals.

In light of the widespread contamination of the Massachusetts water supplies which became apparent in 1980, the EPA Office of Drinking Water, responsible for setting the SNARL of 20 ppb for chronic exposure, re-evaluated all the health effects of the compound and recommended a temporary Suggested Action Guide (SAG) of 40 ppb. The choice was justified by the facts that tetrachloroethylene is not an overtly toxic chemical, that the problem was not a long term one and because the SNARL of 20 ppb had a very conservation safety margin of 1000 built into it.

III - Testing Program

The testing program conducted by DEQE has been undertaken in essentially 4 phases. The first was to quickly determine the extent of the problem, the second to further identify areas where the problem might be most serious, the third to support efforts and experiments to find solutions or determine effectiveness of control measures, and the fourth to monitor to verify that control measures continued to be effective and provide direct assistance to communities.

PHASE I:

Original testing was performed in Westford on one section of the AC pipe with vinyl lining in late January 1980. The analysis of samples collected showed levels of tetrachloroethylene exceeding 1,000 parts per billion of water (ppb). These few samples led to further testing in 23 communities.

Testing in these 23 communities was done on:

- unlined AC pipe
- lined AC pipe under normal flow conditions
- lined AC pipe under low flow conditions

Both ground and surface supplies were tested.

The analyses of samples collected showed that:

- unlined AC pipe gave no tetrachloroethylene
- lined AC pipe under normal flow conditions generally gave low or intermediate levels.
- dead end or low flow conditions gave concentrations of tetrachloroethylene in the high hundreds to several thousands of parts per billion.

PHASE II:

Because of the concentrations of tetrachloroethylene discovered in phase one, each water supply system was contacted, and samples were collected where vinyl-lined AC pipe was present in water distribution systems. DEQE requested a distribution map from each water department in the affected communities to determine the location of the pipe, its age, and number of customers served. Communities were ranked by DEQE for priority of assistance based upon mileage of pipe and general response to the questionnaire sent in April. DEQE met with local water suppliers on the basis of this priority list and established a limited sampling program based on analytical resources available to the Department.

Samples were also collected and analyzed to determine the effects of pipe age, detention time, or other conditions affecting tetrachloroethylene concentration. This phase of sampling eliminated many areas from future consideration because of the low level detected. It also showed some areas where the concentrations were above guidelines and indicated the need for looping, flushing, installation of bleeders or some other control measure. During this testing phase 75 water supply systems were sampled and 574 samples analyzed.

PHASE III:

Many samples were collected and analyzed to determine the effects of flushing, bleeding, use of faucet aerators, pH control, chlorination, cement lining, etc., on tetrachloroethylene concentrations. This phase will continue as required. Approximately 248 samples from 13 systems were analyzed during the first eight months of the program. Since then, these special studies have accounted for about 160 additional tests.

PHASE IV:

The original testing procedure used at the Lawrence Experiment Station involved the gas chromatograph. About 50 minutes were required for each sample. In addition, known standards had to be run for quality control and time had to be devoted to machine maintenance.

The Experiment Station developed an acceptable variation in the procedure and reduced the time needed to process a sample for tetrachloroethylene. When down time, quality assurance, machine maintenance and other requirements are factored in, about 50 tetrachloroethylene samples per week can be performed on a sustained basis. Initially, with one laboratory machine and a trained chemist devoted exclusively to the tetrachloroethylene problem, the laboratory ran tests of that rate. Because of the success of control measures, the need to monitor gradually decreased. Very close to 2000 individual tests have been run by the laboratory in the twenty-four months since the problem was discovered.

IV - Studies and Solutions:

During the course of this problem, there have been many suggestions and recommendations about avenues which should be pursued in looking for a solution.

The following summarizes various investigations.

Faucet Aeration

An attempt was made to determine the effect of faucet aerators on the tetrachloroethylene content of affected homes.

From this very limited study, it can be concluded that household aerators have no significant effect on tetrachloroethylene content.

Since the problem lies in the distribution system and not the source, the only reasonable place to consider aeration would be at the point-of-use.

Dilution

Dilution is an effective method of reducing the concentration of material in a water supply by mixing that water supply with another cleaner source of water, but there is no practical way of providing dilution to solve this particular problem.

Cleaning and/or Lining

In 1980 a research program was conducted by Haley and Ward, Inc., to find a cost-effective method of treating asbestos-cement vinyl-lined (A.C. - V.L.) pipe to reduce the leaching rate of tetrachloroethylene thus reducing the concentrations.

That program has been summarized in a report titled: "Tetrachloroethylene (TCE) Concentration Reduction in Vinyl-Lined Asbestos Cement Water Mains Through The Application Of Cement Mortar Linings". The Boston office of the Department has four copies of the report which may be examined on the premises during normal working hours. Individuals desiring their own copy should communicate directly with Haley and Ward Inc., Engineers, Waltham, Mass.

A test site was constructed in Ashland, Mass., consisting of 156 linear feet (L.F.) of A.C. - V.L. pipe installed within an earthen berm, in four separate sections.

- Section "A" consisted of 52 L.F. of pipe, with the vinyl liner removed by wire brushing and a cement liner installed.
- Section "B" consisted of 52 L.F. in which the cement liner was installed directly over the vinyl liner.
- Section "C" and "D",26 L.F. each, were left in the original condition.

All sections were chlorinated, flushed and refilled with clean water, and samples were taken approximately every 7 days for a period of 60 days, with analyses done by the DEQE laboratory at Lawrence. For this particular installation, a consistent 97-99% reduction in TCE concentration was realized for Section 'A" and "B", compared to Sections "C" and "D". It should be understood that this was a short term test (60 days), for pipe 6-months old prior to installation and under static (no flow, no pressure) conditions. Results to date indicate this method of treatment shows promise, and could be utilized at approximately 1/3 the cost of complete pipe replacement,

The method of placing a cement lining over the vinyl lining has been estimated to cost $10 per foot. To remove the vinyl lining from the pipe and then apply the cement lining could be done for approximately $15 per foot.

Additional testing was also attempted by. Haley and Ward, at this site, on similar asbestos-cement vinyl-lined pipe.' The first test consisted of directing a high temperature (200'F), high pressure water jet from a machinery cleaning apparatus on a specific location on the vinyl-liner for 5 minutes. There was no measurable reduction in thickness. An attempt was made to remove the liner with sandblasting equipment. Within one second of operation, the liner was removed but there was so much damage to the pipe itself that this method was judged impracticable and the test suspended.

Flushing and/or Bleeding

Extensive sampling of vinyl--lined pipes by DEQE revealed a definite and direct relationship between residence time (length of time the water is in contact with the pipe) and the tetrachloroethylene level observed. It was logical to assume that reducing residence time by flushing and/or bleeding would result in a reduction of the tetrachloroethylene level.

Almost from the outset, DEQE was aware that flushing would lower tetrachloroethylene levels but the level would recover when flushing was terminated. Recognizing the need to be able to predict the rate, duration, and frequency of flushing required to maintain acceptable levels; DEQE has participated in studies designed to provide such information. Data gathered to date relative to high velocity flushing (1 turnover per hour or greater) indicates that 2 complete turnovers will reduce the tetrachloroethylene level to less than 1% of the original level and the maximum rate at which tetrachloroethylene recovers to the initial level is approximately 10% per day.

Continuous bleeding at the terminus of dead ends at a rate of 1 turnover per day appears to be even more effective than high velocity flushing in that there is less fluctuation in the tetrachloroethylene level. Sampling results from approximately 10 locations show that continuous bleeding has consistently lowered the level to below 40 ppb which in most cases represents less than 10% of the original level.

This information on the effectiveness of installing a bleeder on the system is consistent with work done by Johns-Manville (J-M) in Simsbury, Connecticut. There it was found that maintaining flow rates as low as 2 to 3 gallons per minute was adequate to maintain low TCE levels. The tests were all conducted on 8 inch lines but the J-M report indicates similar results could be expected for 10 and 12 inch lines. Pipes used in the J-M experiment were installed in 1977, 1978 and 1979.

Flushing and/or bleeding is reported to be the method employed in controlling this problem in the other New England States. This solution or control measure is not without its drawbacks. Water conservation is a stated goal and program of the Commonwealth. Continuous wasting of water is inconsistent with the program. Many communities are water short and cannot afford to waste water. The question has also been raised about a bleeder being left running in winter causing a safety hazard by forming ice in the street.

The Department has determined that a bleeder line may be discharged into a catch basin or similar receiving area without constituting a cross-connection if:

(1) The supplier provides the Department with a listing giving the location of each installation.

(2) A pressure type vacuum breaker is installed on the line.

(3) The water supplier periodically (at least biweekly) inspects the vacuum breaker to see that it **is in** operating condition.

(4) The supplier agrees to shut off and physically remove all piping associated with the bleeder when the problem is solved.

Attachment "B" to this report lists the provisionally approved types of vacuum breakers and outlines a simple testing procedure which requires no special equipment.

Question was raised about the effect a flushing or bleeding program might have on other parts of the environment. DEQE does not believe adverse effects will be caused by the discharge of this water to waste because of the low levels and the probable dilution in the ground.

Since vinyl-lined pipe contains a finite amount of tetrachloroethylene, even normal water flow in the distribution system will eventually remove all the chemical originally present. Evaluation of the results of 230 samples collected in Southeastern Massachusetts shows that the tetrachloroethylene level decreases as the age of the pipe increases. The mean (average) level has been found to be less than 40 ppb in pipe which is 5 years or older. (See Attachment "A") Similar information compiled on 82 samples in the State of Maine supports this finding.

Carbon Filtration

Most state and federal agencies maintain that drinking water delivered to the ultimate consumer should be safe and the consumer should not have to install and/or operate any type of device at point-of-use to insure this safety. If treatment of a public water supply is necessary, it should be accomplished at a central plant where it is under the control of a trained operator.

This philosophy is still valid except that in the present situation, the contamination is occurring at diverse locations in the distribution system and not at the source.

The problem will eventually disappear through use and ingestion of the water is the only real concern about its use. By making some assumptions and using laboratory test data supplied by the EPA one way the concerned individual home owner could address the problem is by installing a filter.

EPA's Office of Drinking Water published a (July 1980) Fact Sheet/Update on their testing of Home Water Treatment Units. Under a contract some 30 commercially available activated carbon units were tested to determine their effectiveness in removing certain organics, bacteria and endotoxins. Of particular interest for this report is the fact that the removal efficiency for tetrachloroethylene should be of the same order of magnitude as that for trihalomethanes, one of the organics actually studied.

If a home owner chose to install a unit with a reported efficiency of 95% for example for trihalomethane (THM) removal, that unit should reduce water with a tetrachloroethylene level of 800 ppb down to 40 ppb for the indicated test life of the filter cartridge.

Assuming a family of four, the amount of water used for drinking and cooking purposes amounts to no more than five gallons per day. If a carbon filter were installed just ahead of a faucet used only to obtain water for these purposes and the filter had an indicated test life of 500 gallons, the carbon cartridge would have to be replaced at approximately 3 month intervals. Use of this tap for other purposes such as dishwashing would reduce the useful life of the filter.

A copy of pertinent parts of this report is available from the DEQE or EPA on request.

<u>Boiling</u>

EPA laboratories in Cincinnati and Lexington have experimented to determine the effectiveness of boiling water as a means of removing chemical contamination. The two compounds chosen for the experiment were trichloroethylene and tetrachloroethylene but it is reasonable to assume other chlorinated hydrocarbons would follow the same trend.

Results show that after five minutes of a <u>vigorous boil</u> less than. 1% of the tetrachloroethylene remained.

A number of cautions should be observed in using this solution to the problem:

1. The person should not stand over the pot of boiling water .where the vapors can be breathed.

2. A range hood should be used.

3. A timer is a must. An accurate time of boiling is difficult to judge.

4. The inorganic quality of the water should be considered. If the water is heavy with iron for example, boiling will tend to concentrate the iron.

For maximum effectiveness, the depth of water should be no greater than 2 inches. Either glass or metal pans are suitable.

The Department feels that boiling can be an effective method of reducing the concentration of tetrachloroethylene in drinking water, but because of the variabilities with respect to original concentration and other cautions, it may not be a practical long term solution.

pH Adjustment

At the same time the presence of tetrachloroethylene in vinyl-lined asbestos cement pipe was confirmed, a town in Central Massachusetts was about to add potassium hydroxide to the towns water supply for the purpose of corrosion control. It was recognized that this afforded an excellent opportunity to study the effect of pH on the concentration of tetrachloroethylene.

The town has one vinyl lined asbestos cement pipe in a low flow location. This line,1500 feet long, 10" diameter, serves 5 houses. The calculated residence time is 4.9 days. Several samples were collected from a hydrant at the end of this line before the KOH was added, with results as follows:

March 18	123 ppb
April 24	38 ppb (after flushing)

The addition of potassium hydroxide was begun on May 9, 1980 and the pH raised to 8.2. The line was flushed to waste for a period of two weeks to draw the high pH water through the line. At the end of that time samples were collected weekly, with results as follows:

May 9	150.4 ppb	
May 16	Less than 5 ppb	(while flushing)
June 3	3.3 ppb	
June 10	91.8 ppb	
June 17	144 ppb	
June 25	137 ppb	
July 9	285 ppb	
July 16	180 ppb	
July 23	140 ppb	

At the time of the latest sampling, the pH was 8.2 at the station and 8.9 at the hydrant.

It. can be seen that within a short time, the level of tetrachloroethylene reverted to its original level and increasing the p1-i has no effect on reducing the tetrachloroethylene concentration.

Superchlorination

Dufresne-Henry, consulting engineers for the town in Southeastern Massachusetts, recently designed a water transmission main using vinyl-lined AC pipe. After installation, samples of water taken from the transmission line showed concentration levels of tetrachloroethylene above the recommended level of 40 ppb.

To determine the effectiveness of super chlorination in reducing the tetrachloroethylene concentrations, the pipe line was chlorinated at a level, of 50 ppm and the chlorinated water allowed to flow through the pipe at 20 gallons per minute (gpm) for 16 days then allowed to stand in the pipe for 5 days, Chlorinated water was flushed out of the pipeline and the pipeline periodically re-sampled.

Periodic sampling showed that tetrachloroethylene concentrations returned to their original levels after chlorination and flushing.

The EPA has also done bench studies on the effect of chlorination on vinyl-lined asbestos cement pipe and observed generally similar results.

Replacement

Asbestos cement, vinyl-lined pipe is located in areas across the Commonwealth, from Clarksburg in the Berkshires to Provincetown on Cape Cod, including the offshore islands. Sizes vary from 6 inches up to 16 inches with the majority being 6 inches and 8 inches in size. Several lines are short spur lines that dead end, many less than 2400 feet in length. To dig up and replace this pipe would create a costly problem for the communities. Our best estimate of quantity is 660 miles or 3,484,800 feet of pipe in the ground.

Replacement of the pipe would entail more than just digging it up and relaying. Any house service on the existing line would have to be reconnected;, this would also mean hydrant connections; plans and specifications would have to be prepared for bidding; and engineering inspection for the contract would be another cost.

Currently, contractor bids for laying 6" mains are $35 per foot; 8" mains are $40 per foot; and 10" mains are $45 per foot. Using the 10 inch cost per foot as an average, the raw replacement of the mains would be:

Total Replacement	660 miles	156,816,000
75% Replacement	495 miles	117,612,000
5O% Replacement	330 miles	78,408,000
25% Replacement	165 miles	39,204,000

To these costs must be added the costs of:

1) Plans and specifications
2) Bidding
3) House service connections
4) Hydrant connections
5) Construction inspection
6) Repair of streets, sidewalks and driveways affected.

No specific state or federal programs exist for problems of this type for cost sharing, so the entire cost of replacement must be borne by the water supplier.

Bottled Water - Alternate Water Supply

Bottled water as an alternate supply is usually available in either one gallon plastic jugs at the supermarket or five gallon carboys from a company which will deliver to the home. Testing of bottled water is not as comprehensive a program as the testing of public water supplies.

In many communities there is no-problem with tetrachloroethylene in any part of the water system and even in the affected communities not all parts of the system are affected. This raises the possibility of taps in public buildings (libraries, fire stations, the well or treatment plant) being made available to people who wish to draw water for drinking and culinary purposes.

V - Conclusions and Recommendations

The problems are:

(1) This contaminant is in the distribution pipe and not the source.

(2) It is not amenable to treatment with another waterworks chemical, i.e., chlorination, corrosion control chemicals, etc.

(3) There is no Maximum Contaminant Level yet established by the federal EPA. However, the Department has adopted the EPA guideline of 40 ppb which was established to protect the public health with a margin of safety.

(4) Since the lining was applied by hand rather than an automated process, the amount of vinyl lining can vary. In at least one case it is reported that the local water department was dissatisfied with the amount of material on some pipe they bought and it was sent back to the factory to be lined. This, coupled with the varying age of pipe in the systems tested, lack of knowledge about how old the pipe was before it was laid and the difference in flow patterns that the pipe is subject to in the system, make it impossible to draw more than broad and general conclusions from the data. Significantly more amounts of testing probably will not allow us to be any more precise with general conclusions. The degree of the problem is to a large extent site specific and must now be dealt with on that basis.

Possible solutions to the problem are several and selection of the most advantageous one (or combination of several) must depend on decisions made at the local level.

Possibilities to be considered include:

(a) Providing a program of bleeding and/or flushing.

(b) Providing an alternate water supply.

(c) Providing for carbon filtration.

(d) Looping dead end situations or making other structural changes to provide for a better flow of water.

(e) Boiling water used for consumption.

(f) Scraping and/or relining pipe in place.

(g) Replacing the pipe.

The eventual goal is to provide water in all locations where samples or water in the pipes under normal use conditions is consistently less than 40 ppb. The sampling program could then be discontinued. Further use and aging of the pipe will eventually lower this level to 0 ppb, well within the 70 year time span on which the SNARL is based.

To solve the problem of tetrachloroethylene in water pipes, each supplier must submit a written action plan to the Department indicating how he proposes to address his problem.

The Department will assign one water supply engineer in each region whose prime responsibility will be to work with the water suppliers on this problem, collect such additional samples as necessary to assess the success of the efforts and keep a current record on each affected supplier's efforts and the results of those efforts so that as areas of concern fall below the 40 ppb level, they can be eliminated from further testing. Samples collected by these engineers will be analyzed by the Department. However, neither the Commonwealth nor the EPA have the laboratory capability to do all of the monitoring work that will be required. Suppliers should contract with private laboratories to do the routine analytical work, keeping a record of all expenses incurred.

It is the responsibility of the water supplier to provide the best possible quality of water to the consumers. If, despite best efforts there is still a problem, the ultimate consumer must be made aware of the quality of the supply by the water supplier. The consumer will then be aware of the problem and the factors which have gone into any decision and can make informed judgments about using or not using the water for various purposes.

Strategy for Dealing with the Problem

The following strategy is suggested as a possible plan for action.

1. Water suppliers identify all areas where vinyl-lined AC pipes have been installed.

2. Areas where the pipe is in a constant flow situation and areas where the pipe is five years old or older be tested and eliminated from future testing if the concentration is 40 ppb or less.

3. Areas where previous sampling has shown the concentration to be 40 ppb or less under normal use conditions be eliminated from future testing.

4. Areas where previous sampling or new sampling shows the concentration to be between 40 ppb and 100 ppb under normal flow conditions be immediately flushed and equipped with a bleeder. The bleeder should be protected with a backflow device such as a pressure type vacuum breaker if necessary. One sample should be collected from these locations every six months to confirm that the level is being maintained below 40 ppb..

5. Areas where the concentrations are above 100 ppb under normal use conditions to be identified; and

   a) Flushes and bleeders installed where appropriate.

   b) Sampled monthly by the water supplier. Frequency of this sampling can be reduced to once every 6 months provided that 3 consecutive months' samples show tetrachloroethylene levels below 40 ppb.

If steps (a) and (b) show the concentration is not kept below an average of 40 ppb over a six month average, or if any monthly sample exceeds 175 ppb which is the 10 day SNARL, then the supplier must initiate a program for the affected area whereby:

a) Consumers in the affected area are formally notified of the problem and the water supplier's intended further actions to correct it.

b) Affected consumers are advised of possible alternatives such as:

- Obtaining water from another nearby source which is not affected.

- Installation of an appropriate carbon filtration unit.

- Boiling water used for consumption.

As an indication of their concern and awareness of this problem, it is suggested that the supplier, as a matter of policy, keep consumers affected by this problem informed about its prevalence within the system, efforts being made to solve the problem, outcome of these efforts, results of testing, etc., as this information becomes known.

The essence of the program should be that the average level of tetrachloroethylene is maintained at, or below, 40 ppb even though the short-term (less than a month) levels may be higher than that. The Department believes that despite these short-term variations in excess of 40 ppb, the long-term effects of tetrachloroethylene at these levels present no danger to the health of the exposed population, based on two liters of water ingested per day for 70 years.

VI - Program Status, April 1982

Of the 91 communities using vinyl-lined asbestos cement pipe as water mains, 33 were shown by testing to meet standards without corrective measures, 48 chose to control levels of the contaminant tetrachloroethylene by continuous bleeding of water from the pipes, three replaced the pipe, one lined the pipe, and one controls the contaminant levels by routinely flushing the pipe. Five communities have not fully controlled the problem.

Table I which follows identifies the 91 communities which used the pipe under discussion and gives the lengths of the lined pipe used in those communities.

Table II identifies the 33 communities where levels of tetrachloroethylene were below 40 micrograms per liter so that corrective action was not necessary.

Table III identifies 48 communities which maintain the level of the contaminant at or below 40 micrograms per liter by bleeding water from the vinyl-lined mains.

Table IV identifies the five communities which have controlled the contaminant level at or below 40 micrograms per liter by one of the following procedures.

1) replacement of the pipe; or
2) lining the pipe; or
3) routine flushing of the pipe.

The five communities which have not fully controlled the problem are Clarksburg, East Bridgewater, Ipswich, Sandwich, and Whitman. Testing in these towns has shown the following ranges of contaminant levels.

COMMUNITY	RANGE OF PERC LEVELS FOUND
Clarksburg	62-72 Parts per billion
East Bridgewater	0-179
Ipswich	0-250 " "
Sandwich	1-167
Whitman	0-254 " " "

Clarksburg is a small community which does not have enough water available to control the situation by system bleeding and does not have sufficient funds for other possible control measures. The community provides bottled water at the schools and notified its citizens who must make their own arrangements about obtaining suitable drinking water.

East Bridgewater submitted a plan indicating intent to control the contaminant levels by installing bleeding devices in problem areas. The Department directed Bridgewater to proceed with its plan in November 1981.

Ipswich has three areas with high results and informed DEQE that customers in these areas have been notified of the problem. The town had testing done and advised DEQE that system bleeding devices will be installed.

Sandwich installed devices for system bleeding to control the problem. Test results show the problem is not yet entirely solved and more devices are necessary.

Whitman obtains water from the Brockton water supply system. Because of the extreme water shortage experienced by City of Brockton, bleeding of the distribution system within Whitman has not been possible. Although about 80% of the areas with the vinyl lined pipe meet standards, there are still areas with high test results.

State funds are not available to assist the communities with this problem. However, as some of the communities have been eliminated from the list of towns where monitoring is necessary, DEQE will be able to provide increased assistance to the problem areas in the form of testing service and advice. It may become necessary in some cases to take strong enforcement action.

PART **VI**

TABLE I

WATER SUPPLIES WITH ASBESTOS CEMENT VINYL LINED PIPE

NO	TOWN	WATER SUPPLY	MILES OF PIPE
1	Acushnet	Town Supply	' 2.0
2	Amherst		1.0
3	Arlington		0.1
4	Ashland		4.0
5	Ayer		4.5
6	Barnstable	Barnstable Water Company	16.0
7	Bourne	Bourne Water District	15.0
8	Bourne	Buzzards Bay Water District	0.05
9	Bourne	North Sagamore Water District	5.0
10	Bourne	South Sagamore Water District	2.0
11	Brewster	Town Supply	6..0
12	Bridgewater	"	16.0
13	Brookfield	" "	1.25
14	Burlington	" "	15.50
15	Chatham	"	7.5
16	Chicopee	Municipal Supply	0.75
17	Clarksburg	Red Miles Water Supply	1.10
18	Cohasset	Town Supply	12.0
19	Dartmouth	" "	12.0
20	Deerfield	Deerfield Fire District	0.2
21	Deerfield	South Deerfield Water District	0.45
22	Douglas	Town Supply	2.0
23	Duxbury	" "	15.0
24	East Bridgewater	" "	20.0
25	East Brookfield	" "	0.25
26	Easthampton	" "	0.1
27	Edgartown	Edgartown Water Company	15.0
28	Essex	Town Supply	0.5
29	Fairhaven		10.0
30	Falmouth	"	50.0
31	Franklin		5.0
32	Gosnold	Gosnold Water Company	0.05
33	Halifax	Town Supply	4.0
34	Hamilton	" "	7.75
35	Hanover	" '	12.0
36	Hanson		18.0
37	Harwich	" "	0.2
38	Hatfield	"	0.5
39	Haverhill	Municipal Supply	0.05
40	Holden	Town Supply	8.0
41	Holliston	" "	2.0
42	Ipswich	" "	12.8
43	Kingston		0.2
44	Lincoln	"	1.0
45	Littleton	"	1.0
46	Longmeadow	" "	5.0
47	Lunenburg	"	1.0
48	Marion		4.0
49	Marshfield		15.0

PART V1

TABLE I

WATER SUPPLIES WITH ASBESTOS CFM NF VINYL LINED PIPE

NO	TOWN	WATER SUPPLY	MILES OF PIPE
50	Mashpee	Highwood Water Company	1.0
51	Mattapoisett	Town Supply	4.0
52	Milford	Milford Water Company	42.0
53	Nantucket	Wannacomet Water Company	0.2
54	Norfolk	Town Supply	8.7
55	North Brookfield	" "	3.0
56	Northborough	T' "	7.0
57	Northfield	Northfield Water District	0.75
58	Norwell	Town Supply	2.0
59	Oak Bluffs		10.0
60	Paxton	" "	1.0
61	Pembroke	π π	5.0
62	Plymouth		35.0
63	Provincetown		6.0
64	Raynham	Raynham Center Water District	2.0
65	Raynham	North Raynham Water District	2.0
66	Rowley	Town Supply	3.8
67	Rutland		1.0
68	Salisbury	"	3.3
69	Sandwich	"	50.0
70	Scituate	T'	3.0
71	Sharon	'' ''	1.0
72	Shirley	Mass Correction Institution	1.0
73	Shrewsbury	Town Supply	8.0
74	Southborough	"	7.0
75	Southampton	"	0.05
76	Sterling		15.0
77	Sunderland	" "	0.5
78	Taunton	Municipal Supply	20.0
79	Tisbury	Town Supply	10.0
80	Wareham	Wareham Fire District	20.0
81	Wareham	Onset Fire District	20.0
82	West Boylston	West Boylston Water District	0.5
83	West Bridgewater	Town Supply	5.0
84	West Brookfield	"	0.1
85	Westford	π "	7.0
86	Westminster		3.0
87	West Newbury	" π	0.3
88	Whitman	IF It	8.0
89	Winchester	'T IT	4.5
90	Woburn	Municipal Supply	0.60
91	Wrentham	Town Supply _	4.0

PART VI

TABLE II

COMMUNITIES MEETING STANDARDS WITHOUT CORRECTIVE ACTION

TOWN	SUPPLY	MILES OF PIPE
Acushnet	Town Supply	2.0
Arlington	"	0.1
Ayer		4.5
Barnstable	Barnstable Water Company	16.
Bourne	Buzzards Bay Water District	0.05
Brookfield	Town Supply	1.24
Chatham	"	7.5
Cohasset	"	12.
Deerfield	Deerfield Fire District	0.2
Duxbury	Town Supply	15.
Franklin	" "	5.
Hanover		12.
Harwich	"	0.2
Haverhill	Municipal Supply	0.05
Holden	Town Supply	8.
Holliston	"	2.
Lunenburg	"	1.
Milford	Milford Water Company	42.
Nantucket	Wannacomet Water Company	0.2
North Brookfield.	Town Supply	3.
Paxton	" "	1.
Provincetown	"	6.
Raynham	North Raynham Water District	2.
Rutland	Town Supply	1.
Salisbury	'	3.3
Sharon	"	1.
Shirley	Mass. Correctional Institution	1.
Southborough	Town Supply.	7.
Sunderland	" "	0.5
Wareham	Wareham Fire District	20.
Westminster	Town Supply	3.
West Newbury	" "	.3
Woburn	Municipal Supply	.60

PART .VI
TABLE III

COMMUNITIES MEETING STANDARDS BY SYSTEM BLEEDING

TOWN	SUPPLY	MILES OF PIPE
Amherst	Town Supply	1
Ashland	" "	4.
Bourne	Bourne Water District	15.
Bourne	North Sagamore Water District	5.
Brewster	Town Supply	6.
Bridgewater		16.
Chicopee	Municipal Supply	0.75
Dartmouth	Town Supply	12.
Deerfield	South Deerfield 'Water District	0.45
Douglas	Town Supply	2.
East Brookfield		0.25
Easthampton	"	0.1
Edgartown	Edgartown Water Company	15.
Fairhaven	Town Supply	10.
Falmouth		50.
Gosnold	Gosnold Water Company	0.05
Halifax	Town Supply	4.
Hamilton	,' ''	7.75
Hanson	', "	18.
Kingston	"	0.2
Lincoln		1.
Littleton	" "	1.
Longmeadow	,'	5.
Marion		4.
Marshfield		15.
Mashpee	" "	1.
Mattapoisett	" "	4.
Norfolk		8.7
Northborough		7.
Northfield	,'	0.75
Norwell	''	2.
Oak Bluffs	" "	10.
Pembroke		5.
Plymouth	"	35.
Raynham	"	2.
Rowley	',	3.8
Scituate	" "	3.
Shrewsbury	"	8.
Sterling	" "	15.
Taunton	Municipal Supply	20.
Tisbury	Town Supply	10.
Wareham .	Onset Fire District	20.
West Boylston	West Boylston Water District	0.5
West Bridgewater	Town Supply	5.
Westford		7.
Winchester		4.5
Wrentham	"	4.

PART VI

TABLE IV

COMMUNITIES MEETING STANDARDS BY MISCELLANEOUS METHODS

TOWN	WATER SUPPLY	MILES OF PIPE	CONTROL METHOD
Hatfield	Town Supply	0.5	Replaced Pipe
Southampton	" "	0.05	
West Brookfield	"	0.1	" "
Burlington	"	15.50	Lined Pipe
Essex	"	0.50	Flush System

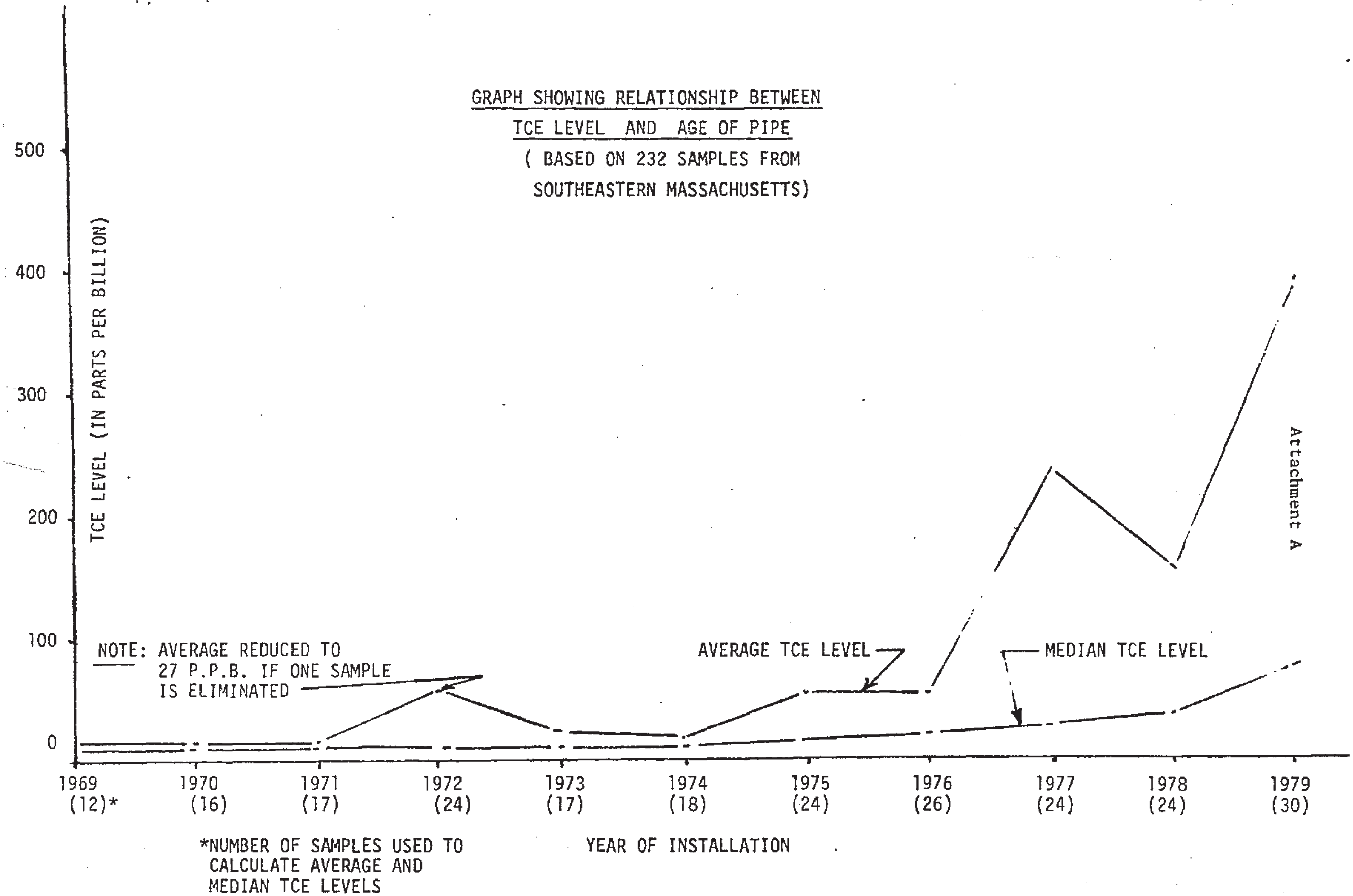
PART VI

TABLE V

COMMUNITIES WHERE PROBLEM IS NOT COMPLETELY UNDER CONTROL

TOWN	WATER SUPPLY	MILLS OF PIPE	LEV].IS FOUND
Clarksburg	Red Mills Supply	1.1	62-72 Parts Per Billion
East Bridgewater	Town Supply	20.	0-179 " "
Ipswich	" "	12.8	0-250 " " "
Sandwich	"	50.	1-167 "
Whitman	"	8.	0-254 "

Attachment A



Attachment B PRESSURE = TYPE . VACUUM BREAKERS

The model and size of pressure type-vacuum breakers listed below are not yet fully approved by the Department. In accordance with our policy of requiring evaluation under field conditions before full approval is given they will be allowed to be used on bleeder lines from public water supply distribution systems to lower the tetrachloroethylene levels. The water supplies must make application to the Department for each installation although no formal permit will be issued or fee charged.

Company	Model	Sizes
FEBCO	765	1/2",3/4",1",1-1/4",1-1/2" and 2"
WATTS	No. 8000 series	3/4",1",1-1/4",1-1/2" and 2"
RAINBIRD	PVB 075	3/4"
	PVB 100	1"
	PVB 125	1-1/4"
	PVB 150	1-1/2"
	PVB 200	**2**"
NEPTUNE	**720**	1/2',3/4",1",1-1/4",1-1/2" and 2"

TEST PROCEDURE FOR PRESSURE VACUUM BRED

1. Remove canopy from top of vacuum to expose air inlet tube.
2. Close shutoff valve No. 2 on discharge side of vacuum breaker.
3. Close shutoff valve No. 1 on inlet side of vacuum breaker.
4. Slowly open test cock No. 2, watching guide in air inlet tube. Valve must be fully open by the time the water stops running from test cock No. 2. If it is not open, then air inlet is sticking and valve must be repaired.
5. Close test cock No. 2.
6. Open inlet shutoff valve No. 1 very slightly and *allow* water to fill to the top of the air chamber. Then close shutoff valve No. 1 tightly.
7. Open test cock No. 1.
8. The water level in the air inlet tube will drop initially due to the seating of the diaphragm. After the initial drop, the level of the water should remain fixed in the air inlet. If it continues to drop, then check valve is leaking and should be replaced.
9. If both 3 and 7 test satisfactorily, restore all shutoff valves and test cocks to initial positions.

NOTES: Open shutoff valve No. 2 on the discharge side of the vacuum breaker before opening the shutoff valve No. 1. This eliminates any shock that might cause the diaphragm to blew due to the compressed air and resultant shock wave.

Table 1
Water Supplies with Asbestos Cement Vinyl Lined Pipe

NO.	Town	Water Supply	Miles of Pipe
1	Acushnet	Town Supply	2.0
2	Amherst	" "	1.0
3	Arlington	" "	0.1
4	Ashland	" "	4.0
5	Ayer	" "	4.5
6	Barnstable	Barnstable Water Company	16.0
7	Bourne	Bourne Water District	15.0
8	Bourne	Buzzards Bay Water District	0.05
9	Bourne	North Sagamore Water District	5.0
10	Bourne	South Sagamore Water District	2.0
11	Brewster	Town Supply	6.0
12	Bridgewater	" "	16.0
13	Brookfield	" "	1.25
14	Burlington	" "	15.50
15	Chatham	" "	7.5
16	Chicopee	Municipal Supply	0.75
17	Clarksburg	Red Miles Water Supply	1.10
18	Cohasset	Town Supply	12.0
19	Dartmouth	" "	12.0
20	Deerfield	Deerfield Fire District	0.2
21	Deerfield	South Deerfield Water District	0.45
22	Douglas	Town Supply	2.0
23	Duxbury	" "	15.0
24	East Bridgewater	" "	20.0
25	East Brookfield	" "	0.25
26	Easthampton	" "	0.1
27	Edgartown	Edgartown Water Company	15.0
28	Essex	Town Supply	0.5
29	Fairhaven	" "	10.0
30	Falmouth	" "	50.0
31	Franklin	" "	5.0
32	Gosnold	Gosnold Water Company	0.05
33	Halifax	Town Supply	4.0
34	Hamilton	" "	7.75
35	Hanover	" "	12
36	Hanson	" "	18.0
37	Harwich	" "	0.2
38			
39	Haverhill	Municipal Supply	0.05
40	Holden	Town Supply	8.0
41	Holliston	" "	2.0
42	Ipswich	" "	12.8
43	Kingston	" "	0.2
44	Lincoln	" "	1.0
45	Littleton	" "	1.0
46	Longmeadow	" "	5.0
47	Lunenburg	" "	1.0
48	Marion	" "	4.0
49	Marshfield	" "	15.0

NO.	Town	Water Supply	Miles of Pipe
50	Mashpee	Highwood Water Company	1.0
51	Mattapoisett	Town Supply	4.0
52	Milford	Milford Water Company	42.0
53	Nantucket	Wannacomet Water Company	0.2
54	Norfolk	Town Supply	8.7
55	North Brookfield	" "	3.0
56	Northborough	" "	7.0
57	Northfield	Northfield Water District	0.75
58	Norwell	Town Supply	2.0
59	Oak Bluffs	" "	10.0
60	Paxton	" "	1.0
61	Pembroke	" "	5.0
62	Plymouth	" "	35.0
63	Provincetown	" "	6.0
64	Raynham	Raynham Center Water District	2.0
65	Raynham	North Raynham Water District	2.0
66	Rowley	Town Supply	3.8
67	Rutland	" "	1.0
68	Salisbury	" "	3.3
69	Sandwich	" "	50.0
70	Scituate	" "	3.0
71	Sharon	" "	1.0
72	Shirley	Mass Correctional Institution	1.0
73	Shrewsbury	Town Supply	8.0
74	Southborough	" "	7.0
75			
76	Sterling	" "	15.0
77	Sunderland	" "	0.5
78	Taunton	Municipal Supply	20.0
79	Tisbury	Town Supply	10.0
80	Wareham	Wareham Fire District	20.0
81	Wareham	Onset Fire District	20.0
82	West Boylston	West Boylston Water District	0.5
83	West Bridgewater	Town Supply	5.0
84			
85	Westford	" "	7.0
86	Westminster	" "	3.0
87	West Newbury	" "	0.3
88	Whitman	" "	8.0
89	Winchester	" "	4.5
90	Woburn	Municipal Supply	0.60
91	Wrentham	Town Supply	4.0

Vinyl-Lined Asbestos Cement (VLAC) Pipe Survey, 2009

Brief History

In January 1980 the Massachusetts Department of Environmental Quality Engineering (now Massachusetts Department of Environmental Protection (MassDEP)) and the other five New England States discovered a problem with the chemical tetrachloroethylene (PCE) leaching into some of their drinking water because of the type of pipe used in some parts of the water distribution system. Tetrachloroethylene is an organic chemical slightly soluble in water used in a variety of ways including the dry cleaning process, as a degreasing solvent, and heat transfer medium. The source of the contamination proved to be vinyl-lined asbestos cement water mains. The PCE had been used by the pipe manufacturer as a solvent for the vinyl resin liner. In the coating process, the solution had been sprayed onto the interior walls of the pipe and allowed to dry. In some cases traces of the solvent remained in the resin lining or in the pores of the pipe walls up to the time the pipes were installed as water mains.

Asbestos cement (AC) pipes have been in use since the 1930's. The lined variety had been in use for approximately twelve years in New England. The vinyl lining reportedly was developed as a response to customer complaints about the taste and odor of water coming into contact with the asphaltic coating used on water supply pipes, especially in dead end situations.

An extensive survey revealed that 660 miles of the pipe were used as water mains in Massachusetts with 91 different communities involved. The area most seriously impacted fell under the jurisdiction of MassDEP southeast region. Cities and towns within that area accounted for approximately 500 miles of the pipe, with 44 different communities contributing to the figure. As a result of this discovery public water systems throughout Massachusetts, having known quantities of VLAC pipe, began monitoring for PCE. Nineteen years later, many miles of VLAC pipe have been removed but PCE is still detected in approximately 30 percent of distribution samples with a few sites requiring mitigation to reduce levels below the 0.005 mg/l maximum contaminant level (MCL).

Current Status

The information provided in this summary is a comparison between historical MassDEP data compiled in 1992 and information received from public water systems (PWS) as a result of the VLAC Pipe Survey that was mailed on December 26, 2008.

PWSs that received the 2009 Vinyl-Lined Asbestos Cement (VLAC) Pipe Survey were those that have tetrachloroethylene listed on their current "Required Water Quality Sampling Schedule". PWSs were asked to provide an estimate of the total length of VLAC pipe (in miles) remaining in their system.

As a result of this survey, MassDEP has determined that since 1992 close to 100 miles of VLAC pipe has been removed from the ground, which is a reduction of 15% of the total amount of VLAC pipe remaining in use today. In addition to the removal of 15% of VLAC pipe, numerous PWSs have looped sections of their system which has increased the volume of water flowing through these pipes, thereby decreasing or totally eliminating the detection of PCE during routine scheduled monitoring.

The MassDEP Drinking Water Program Guide for VLAC pipe monitoring was updated in May 2006 [Vinyl-Lined Asbestos-Cement Pipe (VLAC) Monitoring Program Guide for Tetrachloroethylene, a/k/a Perchloroethylene (PCE). This is an effort to assist MassDEP in determining when sampling for PCE can be reduced or eliminated. MassDEP recognizes that existing sample schedules for PCE may not reflect current pipe conditions. PWSs are encouraged to review the updates to the VLAC Monitoring Program Guide as it may affect your PWS.

PWSID	TOWN_NAME	PWS NAME	WATER SUPPLY	MILES OF PIPE 1992	MILES OF PIPE 2009
1061000	CHICOPEE	CHICOPEE WATER DEPT. (MWRA)	Municipal Supply	0.75	0.75
1063003	CLARKSBURG	BRIGGSVILLE WATER DIST.	Town Supply	1.1	1
2025000	BELLINGHAM	BELLINGHAM DPW WATER DIV.	Town Supply	Unknown	Unknown
2084000	EAST BROOKFIELD	EAST BROOKFIELD WATER DEPT.	Town Supply	0.25	0.28
2134000	HOLDEN	HOLDEN WATER DEPT.	Town Supply	8	8
2136000	HOLLISTON	HOLLISTON WATER DEPT.	Town Supply	2	Unknown
2158000	LITTLETON	LITTLETON WATER DEPT.	Town Supply	1	0.25
2185000	MILFORD	MILFORD WATER CO.	Milford Water Co.	42	42
2208000	NORFOLK	NORFOLK WATER DEPT	Town Supply	9	2.27
2215000	NORTHBOROUGH	NORTHBOROUGH WATER DEPT.	Town Supply	7	6.35
2257000	RUTLAND	RUTLAND WATER DEPT.	Town Supply	1	0.41
2271000	SHREWSBURY	SHREWSBURY WATER DEPT.	Town Supply	8	2.3
2277000	SOUTHBOROUGH	SOUTHBOROUGH DPW WATER DIV.	Town Supply	7	2
2282000	STERLING	STERLING WATER DEPT.	Town Supply	15	5.8
2286001	STOW	ASSABET WATER CO.	Town Supply	Unknown	Unknown
2332000	WESTMINSTER	WESTMINSTER DEPT. OF PUBLIC WORKS	Town Supply	3	0.4
3014000	ASHLAND	ASHLAND WATER & SEWER DEPT.	Town Supply	4	4
3048000	BURLINGTON	BURLINGTON WATER DEPT	Town Supply	15.5	1.4
3079001	DRACUT	KENWOOD WATER DIST.	Town Supply	Unknown	4.5
3092000	ESSEX	ESSEX WATER DEPT.	Town Supply	0.5	0.5
3119000	HAMILTON	HAMILTON WATER DEPT.	Town Supply	7.75	7.7
3144000	IPSWICH	IPSWICH DPU WATER DEPT.	Town Supply	12.8	12.6
3157000	LINCOLN	LINCOLN WATER DEPT.	Town Supply	Unknown	1
3254000	ROWLEY	ROWLEY WATER DEPT.	Town Supply	4	3.8
3259000	SALISBURY	SALISBURY WATER DEPT.	Town Supply	3	3.3
3330000	WESTFORD	WESTFORD WATER DEPT.	Town Supply	7	28.44
3344000	WINCHESTER	WINCHESTER WATER DEPT.	Town Supply	5	2.3
3347000	WOBURN	WOBURN WATER DEPT.	Municipal Supply	0.6	0.95
4003000	ACUSHNET	ACUSHNET WATER DEPT.	Town Supply	2	0.8
4020004	BARNSTABLE	HYANNIS WATER SYSTEM	Barnstable Water Co.	16	21.72
4036000	POCASSET	BOURNE WATER DIST.	Bourne Water Dist.	6	15
4036002	BOURNE	NORTH SAGAMORE WATER DIST.	North Sagamore Water Dist.	5	0.5
4041000	BREWSTER	BREWSTER WATER DEPT.	Town Supply	6	6.39
4042000	BRIDGEWATER	BRIDGEWATER WATER DEPT.	Town Supply	16	10

4055000	CHATHAM	CHATHAM WATER DEPT.	Town Supply	7.5	0
4072000	NORTH DARTMOUTH	DARTMOUTH WATER DIV.	Town Supply	Unknown	6.54
4072000	DARTMOUTH	DARTMOUTH WATER DIV.	Town Supply	12	Unknown
4082000	DUXBURY	DUXBURY WATER DEPT.	Town Supply	15	3.2
4083000	EAST BRIDGEWATER	EAST BRIDGEWATER WATER DEPT.	Town Supply	20	36
4089000	EDGARTOWN	EDGARTOWN WATER DEPT.	Edgartown Water Co.	15	12.82
4094000	FAIRHAVEN	FAIRHAVEN WATER DEPT.	Town Supply	10	7
4096000	FALMOUTH	FALMOUTH WATER DEPT.	Town Supply	50	9.2
4109000	GOSNOLD	GOSNOLD WATER DEPT.	Gosnold Water Co.	0.05	0.37
4118000	HALIFAX	HALIFAX WATER DEPT.	Town Supply	4	2.1
4122000	HANOVER	HANOVER WATER DEPT.	Town Supply	12	12
4123000	HANSON	HANSON WATER DEPT.	Town Supply	18	15.39
4145000	KINGSTON	KINGSTON WATER DEPT.	Town Supply	0.2	3.3
4169000	MARION	MARION WATER DEPT.	Town Supply	4	4
4171000	MARSHFIELD	MARSHFIELD WATER DEPT.	Town Supply	15	3.4
4172039	MASHPEE	MASHPEE WATER DIST.	Highwood Water Co.	1	2.7
4197000	NANTUCKET	WANNACOMET WATER CO.	Wannacomet Water Co.	0.2	0.2
4219000	NORWELL	NORWELL WATER DEPT.	Town Supply	2	2
4221000	OAK BLUFFS	OAK BLUFFS WATER DIST.	Town Supply	10	10
4231000	PEMBROKE	PEMBROKE WATER DIV. DPW	Town Supply	5	0.9
4239000	PLYMOUTH	PLYMOUTH WATER DEPT.	Town Supply	35	35.53
4242000	PROVINCETOWN	PROVINCETOWN WATER DEPT.	Town Supply	6	Unknown
4245000	RAYNHAM	RAYNHAM CENTER WATER DIST.	Raynham Center Water Dist.	2	10.5
4261000	SANDWICH	SANDWICH WATER DIST.	Town Supply	50	54.79
4264000	SCITUATE	SCITUATE WATER DIV.	Town Supply	3	Unknown
4293000	LAKEVILLE	TAUNTON WATER DEPT.	Municipal Supply	Unknown	0.4
4296000	TISBURY	TISBURY WATER WORKS	Town Supply	10	10
4310000	WAREHAM	WAREHAM FIRE DIST.	Wareham Fire Dist.	20	18.9
4310003	WAREHAM	ONSET FIRE DIST.	Onset Fire Dist.	20	20
4322000	WEST BRIDGEWATER	WEST BRIDGEWATER WATER DEPT.	Town Supply	5	18
4338000	WHITMAN	WHITMAN WATER SYSTEM	Town Supply	8	2.15
4350000	WRENTHAM	WRENTHAM WATER DIV.	Town Supply	4	3.85
			TOTAL	**580.2**	**496.15**