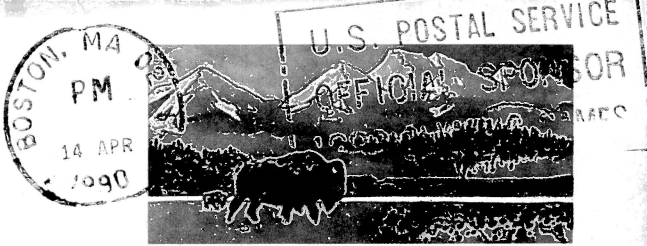
Fresh Pond Reservoir is currently the only designated area in Cambridge for dogs to exercise freely. As a Cambridge citizen who supports the continuation of such rights, I also believe in responsible dog ownership and aggressive enforcement of existing dog waste laws. Please vote to keep the existing Fresh Pond ordinance intact.

NAME: Brian Cooper
ADDRESS: 71 Antrim Street
DATE: 4-12-90



America the Beautiful USA 15

Cambridge City Council
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Cambridge City Hall
795 Massachusetts Avenue
Cambridge, MA 02139

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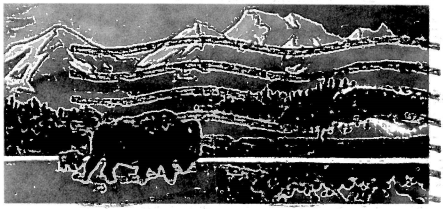
Fresh Pond Reservoir is currently the only designated area in Cambridge for dogs to exercise freely. As a Cambridge citizen who supports the continuation of such rights, I also believe in responsible dog ownership and aggressive enforcement of existing dog waste laws. Please vote to keep the existing Fresh Pond ordinance intact.

NAME: Margueritte Murphy
ADDRESS: 71 Antrim St.
DATE: 4-8-90

BOSTON, MA 021 4
PM
13 APR
1990



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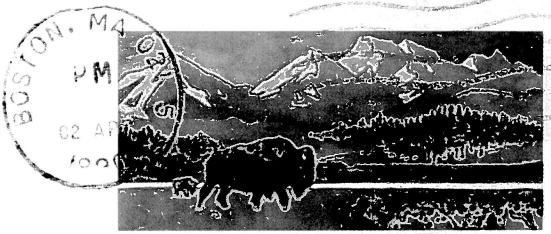
NAME: Ann Marie Lipinski
ADDRESS: 86 Irving St. Camb.
DATE: April 1, 1996

People need dogs.
Dogs need exercise.

We are responsible owners please be responsible in your vote.



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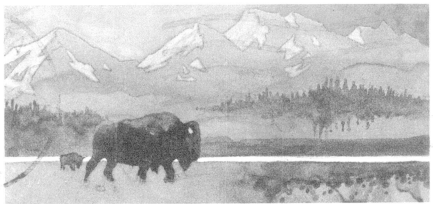
NAME: PATRICIA RANDALL
ADDRESS: 10 FOUNTAIN TER., CAMB.
DATE: 4-1-90



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Cambridge, MA 02139

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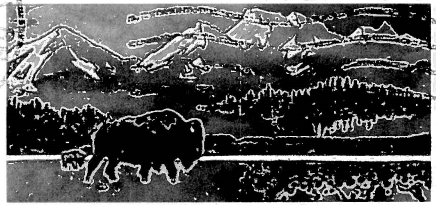
NAME: LOUIS V. PELUSI
ADDRESS: 22 VALENTINE ST
DATE: March 30, 1990



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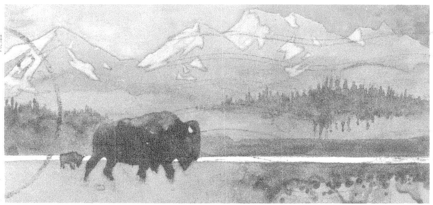
NAME: Arlee Scott

ADDRESS: 1580 Mass Ave

DATE: 3-31-90



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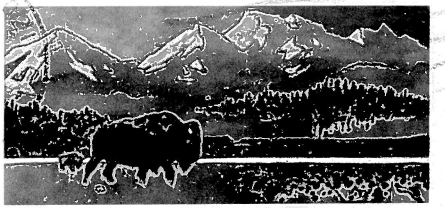
NAME: Andy Baker
ADDRESS: 3 STINSON CT. CAMB. MA 02139
DATE: 3/31/90



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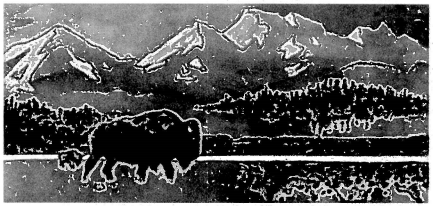
Please don't take away the last place our pets can run free. Thank you.

Fresh Pond Reservoir is currently the only designated area in Cambridge for dogs to exercise freely. As a Cambridge citizen who supports the continuation of such rights, I also believe in responsible dog ownership and aggressive enforcement of existing dog waste laws. Please vote to keep the existing Fresh Pond ordinance intact.

NAME: Steve Kagan

ADDRESS: 86 Irving St. Cambridge

DATE: 4/1/90



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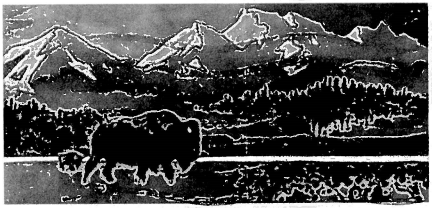
NAME: Ellin Sarot

ADDRESS: 654 Green St Cambridge MA 02139

DATE: 31 March 90





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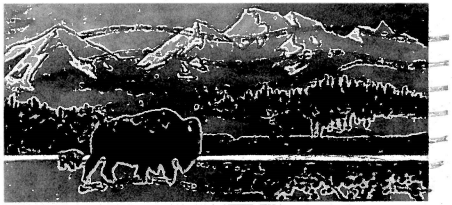
NAME: Patricia L. [illegible]

ADDRESS: 317 Upton St Camb

DATE: 3/30/[illegible]





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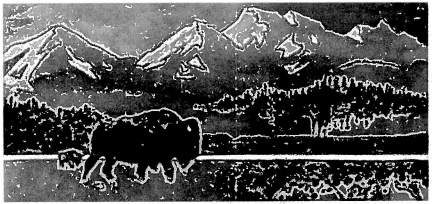
D1

NAME: Phoebe Moore
ADDRESS: 663 Green St, Cambridge
DATE: March 31, 1990



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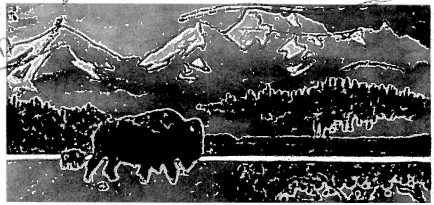
NAME: Linda E Colwell EO
ADDRESS: 47 Henry St #3
DATE: 3-30-9



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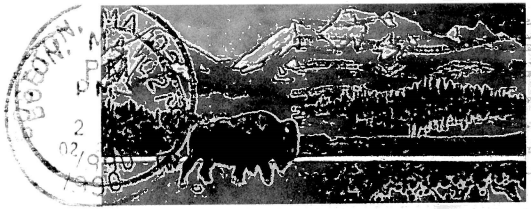
NAME: Barbara Anthony
ADDRESS: 1580 Mass. Ave
DATE: 4-1-90



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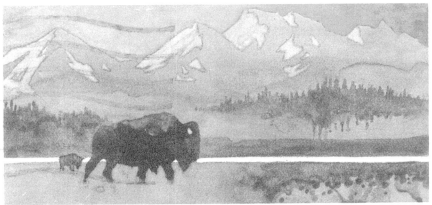
NAME: Leslie Heerman
ADDRESS: 98 Huron Road Camb MA 02138
DATE: 4/1/90



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Cambridge, MA 02139

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NAME: EMarylin Babbaly David golden
ADDRESS: 15 Madison St.
DATE: Cambridge, MASS 02138



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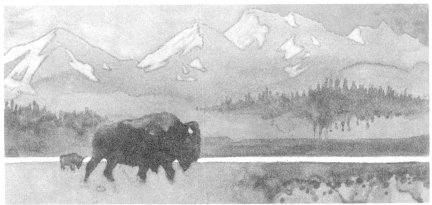
RECEIVED BY
OFFICE OF CITY CLERK
1990 APR 2 3:02
CAMBRIDGE, MA.

NAME: Darthea Goss

ADDRESS: 111 Magazine St

DATE: Camb. 3/29/90



America the Beautiful USA 15

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Cambridge, MA 02139

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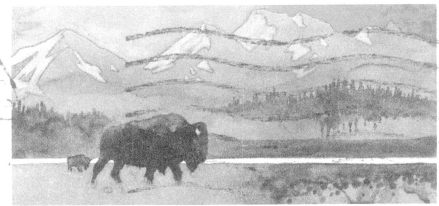
RECEIVED BY
OFFICE OF CITY CLERK
1990 APR 2 PM 3:02
CAMBRIDGE MA.

NAME: Arthur Mazur

ADDRESS: 214 Garden St.

DATE: 3/30/90



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Cambridge, MA 02139

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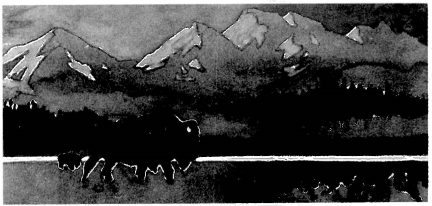
NAME: Mary-Jane Ward

ADDRESS: 134 Garden St Cambridge MA 02138

DATE: 3/27/90

RECEIVED
OFFICE OF CITY CLERK
CAMBRIDGE, MASS.
'90 MAR 27 P2:02



America the Beautiful USA 15

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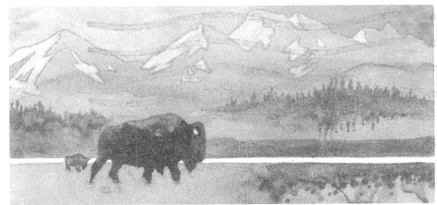
RECEIVED BY
OFFICE OF CITY CLERK
2000 APR 2 P 3:02
CAMBRIDGE, MA.

NAME: Ed Slea

ADDRESS: 299 Walden St Cambridge Ma

DATE: 3-28-00



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Cambridge, MA 02139

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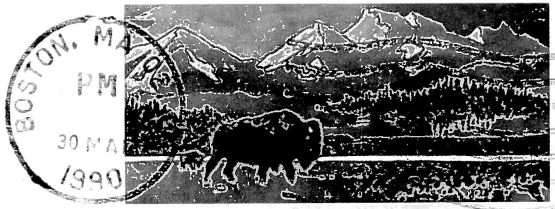
OFFICE OF CITY CLERK
CAMBRIDGE MA.
APR 2 PM 3 00

NAME: EVE STERN

ADDRESS: 29 DONNELL ST.

DATE: ~~CAMBRIDGE, MA~~ 3/29/90



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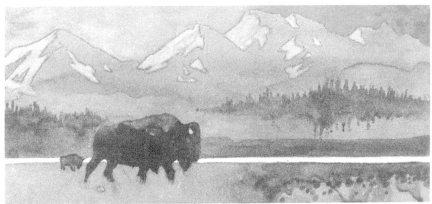
RECEIVED BY
FICOE CITY CLERK
1991 APR 2 PM 3:02
CAMBRIDGE MASS

NAME: Barbara Stone

ADDRESS: 281 Walden Street #302 Cambridge MA 02138

DATE: 3/25/90



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Cambridge, MA 02139

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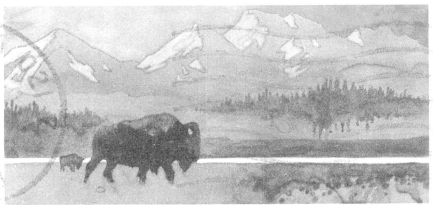
NAME: Nagib Armyo-Hassen

ADDRESS: 8 FOLLEN ST CAMB

DATE: 3/29/90

RECEIVED BY
OFFICE OF CITY CLERK
1990 APR -3 PM 3:0
CAMBRIDGE MASS



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Cambridge, MA 02139

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NAME: Esther Pullman

ADDRESS: 10 Ash Street Place

DATE: 3/29/90 Cambridge

02138

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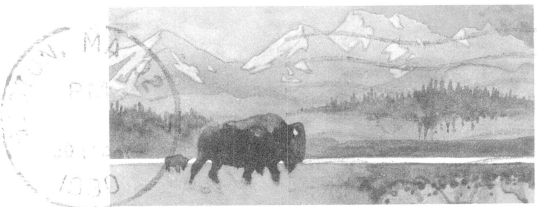
OFFICE OF CITY CLERK
1990 APR -2 PM 3:42
CAMBRIDGE, MA



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Cambridge, MA 02139

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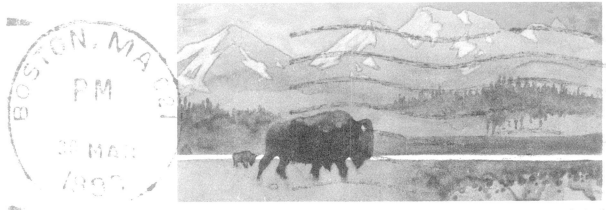
NAME: CLARK M. NEILY JR

ADDRESS: 79 MARTIN ST, #3

DATE: CAMBRIDGE, MA 02138

RECEIVED BY
OFFICE OF CITY CLERK
CAMBRIDGE MA
2010 APR -2 PM 3:



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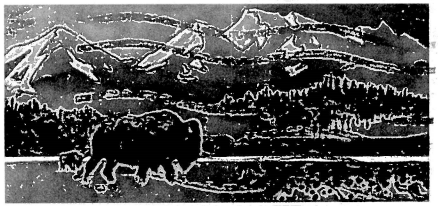
RECEIVED BY OFFICE OF CITY CLERK
1990 APR 3 PM 3:02
CAMBRIDGE, MASS.

NAME: Bridget A. Marrane
Bridget A. Murrane
ADDRESS: 375 Mt. Auburn St, Cambridge
DATE: 3/29/90





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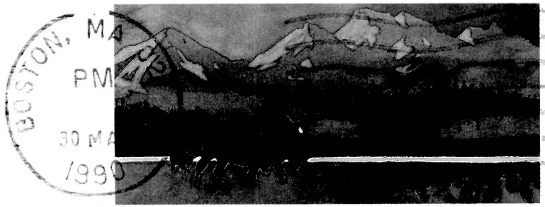
RECEIVED BY
OFFICE OF CITY CLERK
1990 APR 2 PM 3:12
CAMBRIDGE, MA

NAME: Chuck Dresner

ADDRESS: 503 Huron Ave Camb. MA 02138

DATE: 3/29/90



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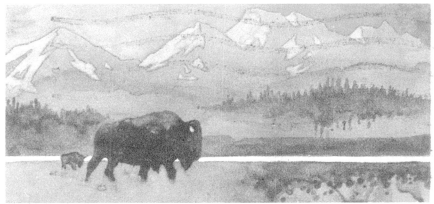
RECEIVED BY
OFFICE OF CITY CLERK
1990 APR 2 PM 3:02
CAMBRIDGE, MA.

NAME: Jacqueline Solmo

ADDRESS: 115 Magazine St.

DATE: Cambridge MA 02137



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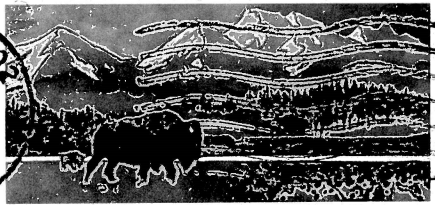
NAME: ANNA DiSALVO

ADDRESS: 16 SPYRIDAKIS TERR

DATE: MARCH 29, 1990

RECEIVED BY
OFFICE OF CITY CLERK
CAMBRIDGE, MA.
'90 MAR 30 PM 1:36



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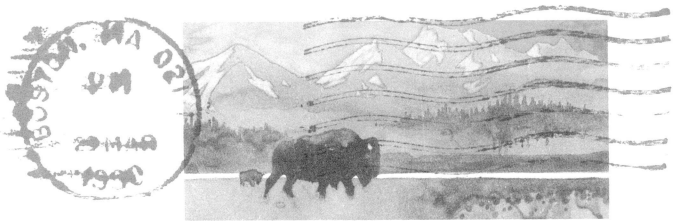
RECEIVED BY
OFFICE OF CITY CLERK
1990 MAR 30 PM 1:36
CAMBRIDGE MA

NAME: Lisa Hirschkop
ADDRESS: 12 Lawrence St Cambridge
DATE: 3/29/90

James Dunn 15 Lawrence St Cambridge 3/29/90



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Cambridge City Hall
795 Massachusetts Avenue
Cambridge, MA 02139

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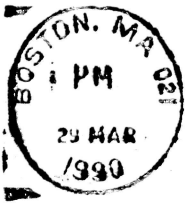
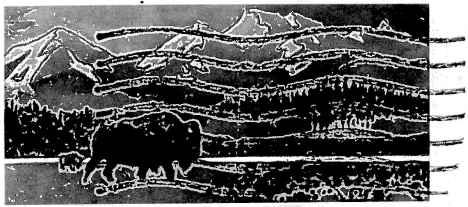
RECEIVED BY
OFFICE OF CITY CLERK
1990 MAR 30 P 1:36
CAMBRIDGE, MA.

NAME: Edith A. RAY
ADDRESS: 135 Peridakis Terrace, Camb.
DATE: March 29, 1990





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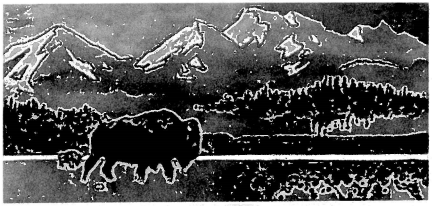
OFFICE OF CITY CLERK
1990 MAR 30 PM 1:36
CAMBRIDGE MASS

NAME: Jeffrey McIlroy

ADDRESS: 25 Cogswell Rd / Cambridge 02140

DATE: 3·28·90



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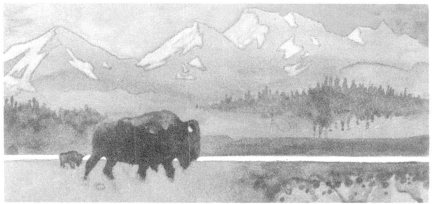
NAME: Christopher Lee

ADDRESS: 49 Lawn St / Cambridge

DATE: 3/28/90

RECEIVED BY
OFFICE OF CITY CLERK
'90 MAR 30 P1:36
CAMBRIDGE, MA.



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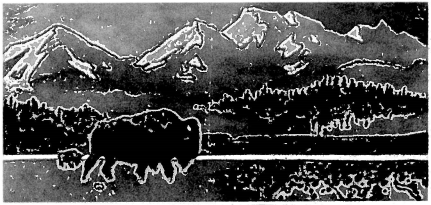
NAME: Gwendolyn Fichtr

ADDRESS: 33 Walker

DATE: Cambridge MA 02138

RECEIVED BY
OFFICE OF CITY CLERK
2010 MAR 30 PM 1:36
CAMBRIDGE MA



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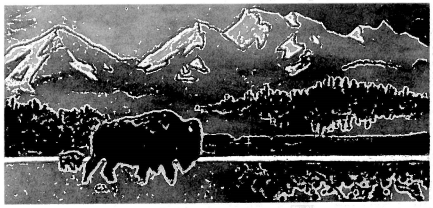
RECEIVED BY
OFFICE OF CITY CLERK
1998 MAR 30 AM 8:38
CAMBRIDGE, MA.

NAME: John Pedersen

ADDRESS: 215 Lexington Ave

DATE: 3/28



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RECEIVED BY
OFFICE OF CITY CLERK
2000 MAR 30 P 3:38
CAMBRIDGE, MA

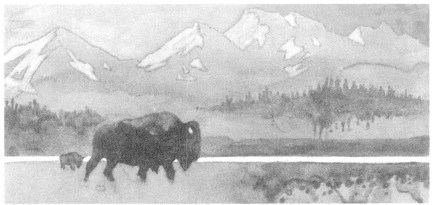
D4

NAME: SANDRA HEWITT

ADDRESS: 7 EXETER PARK

DATE: CAMBRIDGE, MA 3/28

02140



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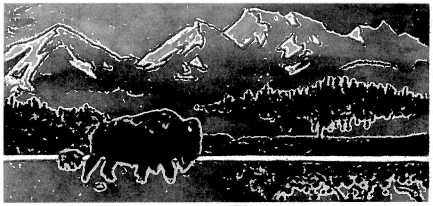
RECEIVED
OFFICE OF CITY CLERK
'90 MAR 30 P1:36
CAMBRIDGE, MASS.

NAME: MIKE MACMANN

ADDRESS: 10 FOUNTAIN TER CAMB 02138

DATE: 28 MAR 90



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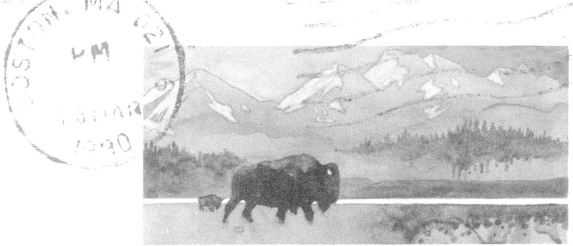
NAME: Stephanie Berk

ADDRESS: 56 Shepard Str.

DATE: 3/20/90

RECEIVED BY
OFFICE OF CITY CLERK
1990 MAR 29 PM 3:00
CAMBRIDGE, MA



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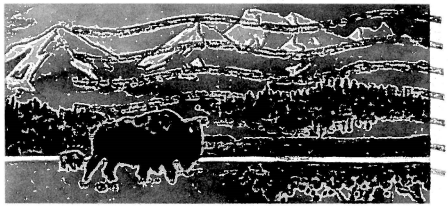
RECEIVED BY OFFICE OF CITY CLERK
1990 MAR 29 3:00
CAMBRIDGE, MA.

NAME: Charles Welch

ADDRESS: 56 Shepard St.

DATE: 3/26/90



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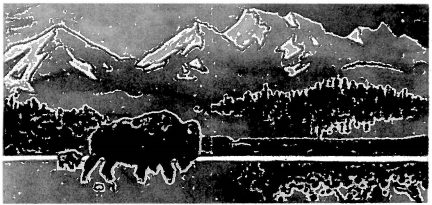
NAME: Jane Reed - Is there
ADDRESS: Something else we can do?
DATE:

Jane



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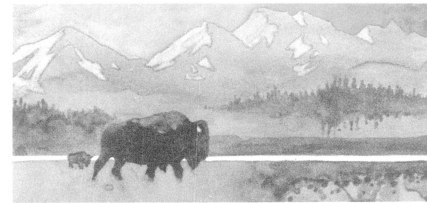
NAME: Celia Hall
ADDRESS: 273 Upland Rd Cambridge 02140
DATE: 3-27-90



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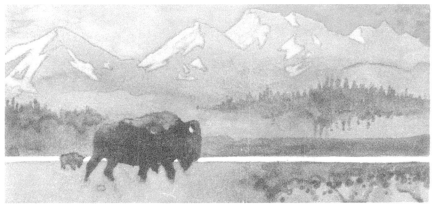
NAME: WENDY ROBERTS

ADDRESS: 53 SHERMAN ST. CAMB. 02140

DATE: 3-26-90



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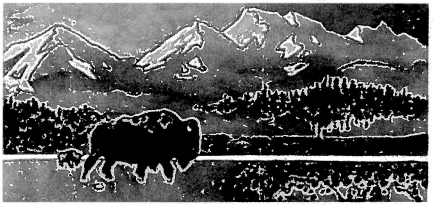
NAME: BRUNO D'AGOSTINI

ADDRESS: 72 LEXINGTON AVE, CAMB. MA. 02138

DATE: 3-27-90



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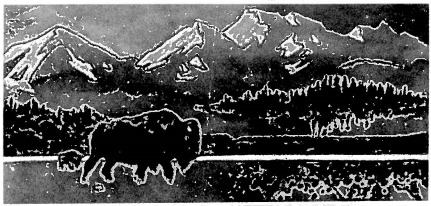
NAME: Kristen Flaherty
ADDRESS: 127 Huron Ave. Camb. Ma. 02138
DATE: 3/26/90



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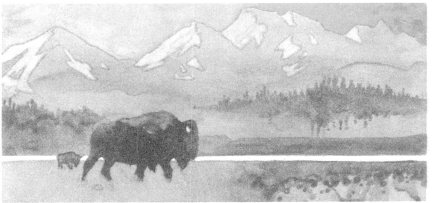
NAME: Janis Pryor
ADDRESS: 12 Cogswell Ave
DATE: March 26, 1990



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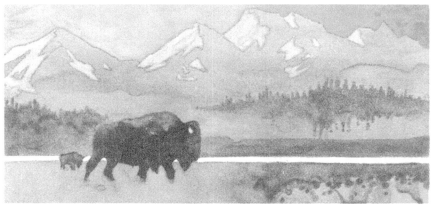
NAME: Eric Houston

ADDRESS: 17 Fresh Pond Pl

DATE: 3/27/90



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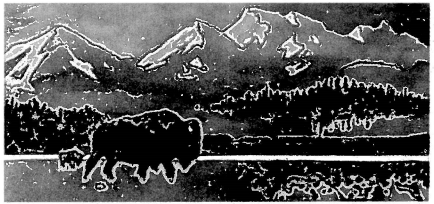
NAME: Catherine O'Neil

ADDRESS: 452 Franklin St 02139

DATE: 3/27/90



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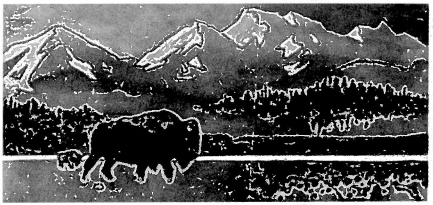
NAME: Adele Pressman
ADDRESS: 58 Highland St.
DATE: 27 March 1990



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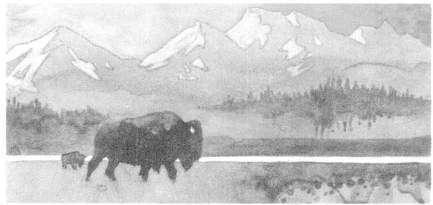
NAME: Mr & Mrs C Barbour Currie

ADDRESS: 23 Cambridge Terrace

DATE: Cambridge Ma 02140



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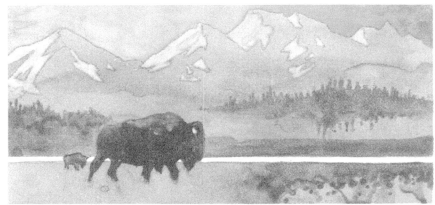
NAME: FRANK JAFFE
ADDRESS: 159 Concord Ave
DATE: 3-24-90



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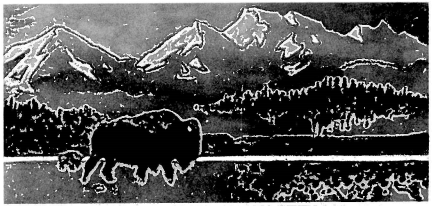
NAME: PAUL Jean-Claude
ADDRESS: 29 Concord Ave #212
DATE: 03/26/90



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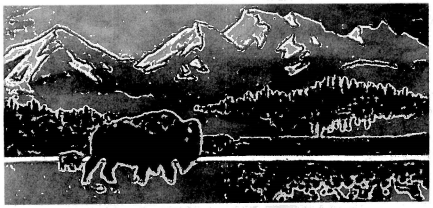
NAME: Lydia S Spitzer
ADDRESS: 52 Shepard St.
DATE: 3-26-90



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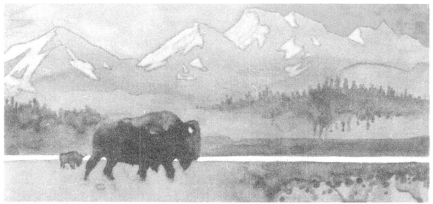
NAME: Melissa L. Weber
ADDRESS: 87 Washington Ave Camb.
DATE: 3-27-90



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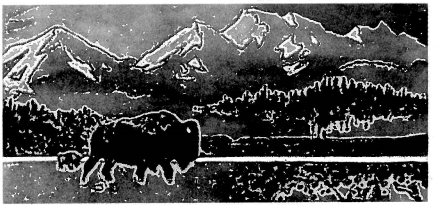
NAME: Cris Paul
ADDRESS: 29 Concord Ave #212 Cambridge. 02138
DATE: 3-26-90



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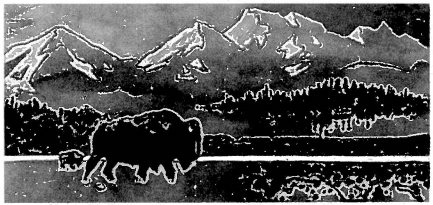
NAME: Karen Rock...
ADDRESS: 345 Harvard St. #3B
DATE: 3/26/90



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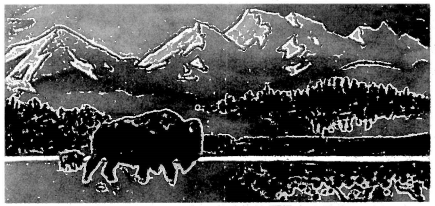
NAME: Susan Cartinhy

ADDRESS: 6 Garden Terrace, Cambridge

DATE: March 26, 1990



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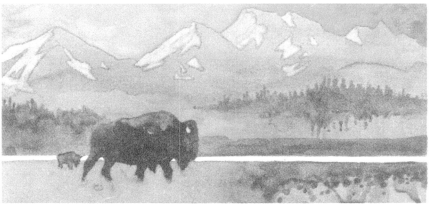
NAME: Sachiko Gordon
ADDRESS: 167 Upland Rd Cambridge
DATE: 3/26/90



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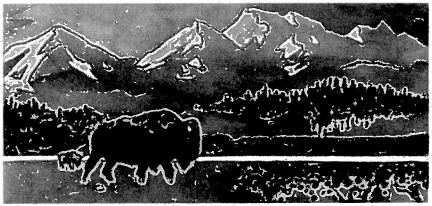
NAME: GENEVIEVE ST. GEORGE

ADDRESS: 5 SHEPARD ST

DATE: 3/26/90



America the Beautiful USA 15

Cambridge City Council
C/O Mr. Francis H. Duehay
Cambridge City Hall
795 Massachusetts Avenue
Cambridge, MA 02139

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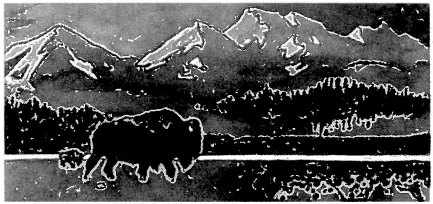
Fresh Pond Reservoir is currently the only designated area in Cambridge for dogs to exercise freely. As a Cambridge citizen who supports the continuation of such rights, I also believe in responsible dog ownership and aggressive enforcement of existing dog waste laws. Please vote to keep the existing Fresh Pond ordinance intact.

NAME: Sara Moslin
ADDRESS: 240 Concord Ave Cambridge
DATE: 3/26/90



America the Beautiful USA 15

Cambridge City Council
C/O Mr. Francis H. Duehay
Cambridge City Hall
795 Massachusetts Avenue
Cambridge, MA 02139

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RECEIVED BY
OFFICE OF CITY CLERK
1990 JUL 26 PM 1:28
CAMBRIDGE MA.

2 Parkway Terrace
Cambridge, MA 02138
July 18, 1990

The Honorable City Council
Cambridge City Hall
795 Massachusetts Ave.
Cambridge, MA 02139

Honorable Members:

As a member of the Fresh Pond Citizens Association, I am writing to ask you to please vote AGAINST the Water Board's proposed extended leash law at Fresh Pond.

It is very important to my health and that of my dogs to be able to run them off leads when I ride my bicycle at Fresh Pond. A bad back precludes my walking or running with the dogs on leads; walking the dogs on leads is not enough exercise for the dogs. Located five minutes from my home, the Pond make this exercise possible in a crowded familial and professional schedule. We have enjoyed this park with our children and our dogs for over 20 years; we would like to go on enjoying it!

The Reservoir can be kept clean and healthy with the existing pick up law. The continued education of dog owners plus good signage and enforcement IS working. In fact, I see more owners with leashed animals neglect to pick up after their animals than owners whose dogs are running free, but they are learning, too!

Thank you for your consideration.

Sincerely,

Victoria M. Blair-Smith

Victoria M. Blair-Smith

Comm. from Victoria M.Blair-Smith, 2 Parkway Terrace, requesting the City Council to vote against the Water Board's proposed extended leash law.

In City Council,

July 30, 1990

Referred to the petition

The Honorable City Council
City Clerk's Office
Cambridge City Hall
795 Massachusetts Avenue
Cambridge, Mass. 02139

39 Parker Street
Cambridge, MA 02138
June 20, 1990

Dear Council Members:

I am writing to ask you to vote against the Water Board's proposal to extend the leash law at Fresh Pond.

I am a responsible dog owner who cleans up after my dog. Fresh Pond is a wonderful place for me and my dog to exercise, without fear of automobiles. The weekend afternoons I spend there, enjoying the view, getting a workout, and watching my dog romp with others is one of my regular pleasures. I do believe that the public can be educated to behave responsibly, and that this lovely site should not be closed to dogs, especially as there is no alternative location in Cambridge.

I urge you to consider some of the suggestions made by the Fresh Pond Citizens Association, which I believe will go far to eliminating the problem caused by a few irresponsible dog owners.

Sincerely,

Nancy Curtis

Comm. from Nancy Curtis, 30 Parker Street, requesting the City Council to vote against the proposal by the Water Board to extend the leash law at Fresh Pond.

In City Council,

July 30, 1990

Referred to the petition

RECEIVED BY
OFFICE OF CITY CLERK
1990 JUN 25 PM 1:28
CAMBRIDGE MA.

RECEIVED BY
OFFICE OF CITY CLERK
1990 JUN 21 AM 8:43
CAMBRIDGE MA.

June 15, 1990

Honorable Sheila D. Russell, Councilor
Cambridge City Hall
795 Massachusetts Avenue
Cambridge, Mass. 02139

Dear Councilor Russell:

My name is Lois Jenness and I have been a lifelong resident of the City of Cambridge in the Fresh Pond area. From childhood I have continually used the Pond for recreational purposes, as has my husband. In younger years, skating on "Little Fresh" and coasting "Double Hills" in the winter, catching pollywogs in spring with the expectation that some would become frogs, and simply playing throughout the reservation in the summer. Remaining in the area after marriage I continued my visits to the Pond and walked and bicycled the same paths with my husband and children in warmer months, also skating "the Nook" and coasting "Double Hills" in the winter. Jogging came into vogue during my child-rearing years, and I ran the Pond for many years either with neighbors or with my son. I still remember jogging the Pond the very first time and also when I accomplished it twice around. My immediate family, and most of my extended family, still live in the area. My son is marrying soon and will reside here also. His bride-to-be is already fond of Fresh Pond and together they jog or walk around it often. You can see that I think fondly of Fresh Pond and have many long-ago memories of time spent there. Each year as the seasons change certain sounds or sights recall memories, as do the wonderful aromas from the wild flowers when spring breaks and the warm air mixes and carries their fragrances. My joy of jogging has been replaced by walking. I walk the Pond each morning before I leave for work. I often see birds that are rare to me, and yesterday morning met up with a very large snapping turtle travelling along the path. I looked for the turtle again this morning, not actually expecting to find it, but there it remained, delivering its eggs into the nest it had made beneath it.

Regrettably the Pond for all its beauty is not a safe place for women to be alone, especially during the more solitary hours, so I take along a wonderful walking companion named Golda and, as her name suggests, she is a Golden Retriever. Dog walking at the Pond is not something new to me. Long before the leash law, long before the "Pooper Scooper" law, as far back as the 1930s, I cannot recall not owning a dog. All have been walked around Fresh Pond. This now brings me to what is at issue here -- dogs at Fresh Pond. It is said that dogs are creating a water problem for the City in that <u>animal excrement</u> has the potential of causing an outbreak of Giardia, a parasite that when water borne causes intestinal problems upon human consumption of drinking water so infected.

Considering all the dog walking that has taken place at the Pond over the years -- some 50 years within my recollection -- I cannot help but wonder why an outbreak of Giardia is being vocalized so loudly at this time when there is clearly no suggestion, nor has there ever been, of an invasion of Giardia into the Cambridge water supply. Also, as Giardia may be transmitted through the excrement of all warm blooded animals, and knowing the many wooded creatures living at Fresh Pond, why then are dogs being held solely responsible for the possible transmission of this parasite when they are clearly not the only potential carriers to come within these boundaries. It seems more likely that an outbreak of Giardia, or the like, would have more realistically occurred in days past when testing equipment and filtration plants were far less able to detect and screen out problems arising in water supplies. Today's technological advances should afford us with a means of control over the prevention and/or elimination of any water purification problems, real or contrived. Why I ask you would it occur now if our filtration plant is up to standard? I cannot believe that technology cannot keep up with nature. Also, I cannot see how our water supply can become tainted by dog excrement, even by leaching, because the fence and the barrier bordering this entire body of water are of such significant size that encroachment is absoluted prevented.

Personally, I think the "water problem" gives validity to an undercurrent that dogs present a nuisance to joggers or bicyclists or picnickers or the workers at Fresh Pond who mount complaints. I feel that the attitude is one that suggests "Let's just stop these complaints and get rid of the problem once and for all." Perhaps we as dog walkers should call City Hall and/or the City Council complaining about our annoyances, say, the times when groups of joggers squeeze us off a path, or when a jogger, looking possessed, won't jog around you but up your back, expecting you to move aside, because you are evidently walking on ground divined to be "THEIRS ALONE" -- remember now, I was a long-time jogger and am not just looking at jogging with a jaundiced view -- or perhaps we should complain each time a racing bike or bikes spread across an entire path, travelling at excessive speed, only to meet you head on around some blind corner, or when they zip up behind you soundlessly, wildly flying past nearly taking you with them. I feel very strongly that some control needs to be exerted over bicyclists, and enforced, as they pose a real danger at the Pond both to themselves and others. A terrible accident will no doubt happen as they have little or no control when travelling at such excessive speed.

Prior to and since our last meeting I have been observing the cars in the parking lot and it is clear that great numbers of visitors to the Pond do not even live within our City. In fact, sometimes it is the exception to find a car in the lot exhibiting a Cambridge sticker. Most dog walkers I meet walk their dogs to the Pond, exercise them, and leave, obviously nearby residents living within the City. Based on these observations, it stands to reason then that the majority of complaints, as I see it, would come from either transitory residents or from visitors not from Cambridge at all. I am happy to note, however, that dog owners have become increasingly responsible about cleaning up after their pets, and this is as it should be. It is a rare occasion when I come across fesces left behind.

Exercising my dog means exercise for me. I would not walk the Pond alone without my dog for protection. And where else within the City can a dog romp without a leash. I pay taxes, part of which go toward the care, maintenance and preservation of Fresh Pond. Now I know lots of people pay taxes and do not use all of the various services provided through their tax dollars, but there is a vast difference between "DO NOT USE" AND "BEING DEPRIVED OF USE." I do comply with all the restrictions thus far placed on dog owners, and my dog responds to my verbal commands when off leash in the unrestricted areas. I cannot see how walking my dog unleashed, and cleaning up after her, can in any way adversely affect the environment at the Pond, which has remained unaffected thus far. I want the freedom to come and go about the Pond, which I consider an extension of my own back yard and treat it so. I respect the rights and privileges of others and want mine respected and preserved also. It is unthinkable that the Council would even consider banning dogs from the Pond altogether. Therefore, I will only speak to the leash law and ask that dogs be allowed to remain off leash in those areas not now restricted. I ask that you act favorably in this regard.

I will in any way cooperate with the Council to promote responsible dog ownership within the confines of the Fresh Pond Reservation. Therefore, I would be pleased to become a member of a Task Force whose purpose it would be to meet with the City Council and/or the Water Board in order to arrive at and implement and enforce some practical solutions for use and care of the reservoir. My hope is that by preserving my rights I will therefore preserve the rights of future generations and thus ensure that the reservoir remain open to them for their personal use. I find it unthinkable that the Cambridge City Council would use its power without just cause to prevent a certain segment of the population from using the reservoir. The residual effects of such an action would be felt for years to come. If this, what next!

Sincerely yours,

L M. Jenness

Lois M. Jenness
Home: 547-5838
Work: 223-9145

Dear Sheila:

Thanks, as usual, for listening and for the tips about the upcoming wedding.

Lois J.

12.

Comm. from Lois M. Jenness relative to dogs at the Fresh Pond area.

In City Council,

June 25,1990

Referred to Petition

RECEIVED BY
OFFICE OF CITY CLERK
1990 JUN -5 PM 3:
CAMBRIDGE MA.

FRESH POND CITIZENS ASSOCIATION
CAMBRIDGE MASSACHUSETTS

4 June 1990

The Honorable City Council
City Clerks Office
Cambridge City Hall
795 Massachusetts Avenue
Cambridge, MA 02139

Dear City Council:

Recognizing that the safety of the Cambridge water supply is of enormous concern and in a continuing effort to address the issue of dog waste at Fresh Pond Reservoir, a new citizens committee, The Fresh Pond Citizens Association (FPCA), has been created to work on ongoing issues concerning the Reservoir. The FPCA is comprised of approximately 50 Cambridge residents. Recently, with the help of City Councilor Johnathan Myers, a core group of us have been meeting with members of the Water Department, the Water Board, and the City Animal Control Department to devise effective methods of enforcement of existing Pick-Up laws and citizen education at the Reservoir.

Enclosed is a memo presented by the Fresh Pond Citizens Association to the Water Board on May 7, outlining several ideas we would like to see the Water Board and the City of Cambridge implement at the Reservoir. The general reception of these suggestions has been positive and at present the following actions are being taken.

1. The Water Department is considering the use of a new sign (in addition to existing signs) proposed by the FPCA (see attached sample).

2. The Water Department is working on increasing the police detail at the Reservoir to help enforce the existing pick-up and parking restriction laws.

3. The Animal Control Department is very interested in pursuing the idea of supplying complimentary plastic bags for dog waste pick-up.

The FPCA will be presenting our suggestions to the entire Water Board at their Board Meeting on June 21st, along with a mock-up of the proposed additional sign, educational fliers, and a budget for materials needed at the Reservoir (fliers and plastic bags, etc.)

It is our hope that with the help of the Water Board and the Water Department and the support of the City Council we will be able to devise ways to educate and encourage dog owners to keep the Reservoir as clean and as pleasant as possible.

The Fresh Pond Citizens Association would welcome any suggestions or ideas from City Council members concerning the above mentioned issues, and we appreciate the ongoing support of the City Council in helping us to keep Fresh Pond an area of Cambridge where dogs are allowed to exercise Off-Leash.

Sincerely,

Melissa Weber
87 Washington Ave
Cambridge, Ma
02140
(617)876-0864

Tom Ehrenfeld
324 Windsor St
Cambridge, Ma
02141
(617)491-8432

Darthea Cross
111 Magazine St
Cambridge, Ma
02139
(617)354-5259

MEMO

Date: Monday May 7, 1990

To: The Cambridge Water Board

From: The Fresh Pond Citizens Association

Re: Ideas to help keep Fresh Pond Reservoir clean.

We would like to thank the Water Department for so speedily supplying additional plastic barrels and signage around the perimeter of the reservoir. The extra barrels are making it easier and more pleasant to pick up after our dogs.

Recognizing that the safety of the Cambridge water supply is of enormous concern and in a continuing effort to address the issue of dog waste at Fresh Pond we would like to work with the Water Board to devise ways to educate and encourage dog owners to keep the reservoir as clean as possible. After some thought we have come up with a few suggestions:

1. The existing signs provided by the Water Department are helpful in outlining the restrictions and laws concerning dogs in the reservoir area. Some people do not take the time to read them. We feel an additional bold and graphic sign (see sample) placed at each entrance to the park and at each barrel will help to get the message across even more clearly.

2. One excuse sometimes used by dog owners reticent about picking up after their dogs is that they "forgot" a bag or other means by which to clean up. Would it make sense to provide several receptacles containing plastic or paper bags in strategic places around the reservoir to further encourage citizens to "pick up"? A Cambridge citizen who owns The Barking Lot, a pet grooming service, has offered to supply the receptacles for free if he may use the name of his company on the boxes.

3. It is clear that a sustained effort to remind and educate the public is necessary if the reservoir is to be kept clean over time. We would like to recommend that the Water Department and the F.P. Citizens Association come up with a yearly schedule to disseminate

informative fliers outlining the important facts about keeping the reservoir clean, not only from dog waste, but general trash as well. We have come up with a tentative schedule we feel we could adhere to with the help of the Water Department:

> Four months out of the year, lets say October, January, April and July, the Citizens Association and the Water Department could alternate weekends to hand out an educational flier to those people using the park. Rather than focus all our efforts intensely once a year in the Spring, perhaps the continued presence of Cambridge citizens and the Water Department staff working together on the issue will make a more lasting impression.

4. The efforts of the Water Department and Cambridge citizens to keep the Park free of dog waste will be more successful if those who use the Park are aware that the City of Cambridge is seriously enforcing the Pick-Up law. We believe that a dog officer, consistently stationed at the reservoir once or twice a week, for a few hours, at different times of the day would help to spread the word that the City, the Water Department and the F.P. Citizens Association <u>mean business.</u>

5. Finally the continued effort by the Cambridge Police Department to ticket non Cambridge vehicles, not only in the main parking lot, but also in the Employees lot and around the Golf Course area will help to discourage non-Cambridge residents from adding to the already over-used Fresh Pond Reservoir facility.

The reservoir is a much valued and cherished resource for all Cambridge residents and we appreciate the Water Board's willingness to work with us to help keep the Park a clean and pleasant place for all Cambridge citizens to enjoy. We welcome your suggestions and look forward to working with you in the future.



PLEASE CLEAN UP AFTER YOUR DOG

Comm. from Fresh Pond Citizens Association transmitting a memo sent to the Water Board outlining several ideas which could be implemented at the Fresh Pond Reservoir.

In City Council,

June 11, 1990

Referred to the petitioner

CITY OF CAMBRIDGE

MASSACHUSETTS

WATER DEPARTMENT
250 FRESH POND PARKWAY
CAMBRIDGE, MASS. 02138

Watershed Protection Issues, April 4, 1990

Giardia lamblia - a regulated contaminant under the Surface Water Treatment Rule (U.S. Environmental Protection Agency June 29, 1989)

Regulations for filtration, disinfection, turbidity, Giardia lamblia, viruses, Legionella, and heterotrophic bacteria were proposed Nov. 3, 1987, and promulgated June 29, 1989. Known as the Surface water Treatment Rule (SWTR), the regulations apply to all public community and noncommunity water systems that use surface water sources or groundwater sources under the direct influence of surface water. The basis for this rule is the assumption that all surface waters and groundwaters under the direct influence of surface water are at risk, at least to some degree, from contamination by Giardia lamblia and other protozoa, viruses, and pathogenic bacteria. Public water systems using these source waters must provide minimum levels of treatment to ensure protection from illnesses caused by these contaminants.

The difficulty in obtaining reliable results when testing for parasites is the primary reason that the Environmental Protection Agency (EPA) chose to propose minimum treatment techniques instead of a maximum contaminant level (MCL) for Giardia in the SWTR. In the implementation of the SWTR, the Massachusetts Department of Environmental Protection (DEP) has chosen to expand the minimum levels of treatment required to include a multi-barrier approach to pollution prevention.

The DEP has clearly articulated in a document entitled "Surface Water and Long Term Water Quality Assurance Strategy" that in order to adequately protect the quality of all public drinking water sources, pollution prevention must be the corner stone of any water supply protection strategy. Multiple barriers need to be erected between the sources of pollution and the customer on the distribution system. The DEP goes on to list "all the barriers that provide effected insurance against surface water quality problems...":

Watershed land use protection
Disinfection
Adequately maintained and protected distribution system
Sufficient and adequately trained staff
Treatment
Public Education

It is in recognition of the Water Department's responsibility to pursue all avenues of pollution prevention,

that the Department supports the recommendation of the Water Board to change the dog ordinance as it references Fresh Pond Reservation. The Department views the current situation at Fresh Pond to be indefensible under the Massachusetts Drinking Water Regulations.

Water supply liturature, documents from the Massachusetts Department of Public Health, and from other State and Federal agencies have clearly linked Giardia and Cryptosporidium with animals including rodents, dogs, cats, and wild birds. Much of the same literature also documents the link between source water contamination and out breaks of Giardia and Cryptosporidiosis in human populations in spite of convention water treatment practices. A partial bibliography follows:

Craun, Gunther F. Surface Water Supplies and Health, J AWWA Feb. 1988.

Rose, Joan B. Occurrence and Significance of Cryptosporidium in Water, J AWWA Feb. 1988.

Massachusetts Department of Public Health Division of Communicable Disease Control "Giardiasis Fact Sheet"

Ongerth, Jerry E. Giardia Cyst Concentrations in River Water, J AWWA Sept. 1989.

US Forest Service Is the Water Safe? Think Before You Drink, GPO 1981.

Braidech, Thomas and Richard J. Karlin Causes of a Waterborne Giardiasis Outbreak, J AWWA Feb. 1985.

Lin, Shun Dar Giardia Lamblia and Water Supply, J AWWA Feb. 1985.

Pontius, Frederick W. Complying With the New Drinking Water Quality Regulations, J AWWA Feb. 1990.

6

CITY OF CAMBRIDGE

CAMBRIDGE, MASSACHUSETTS 02139
TEL. 498-9011

EXECUTIVE DEPARTMENT
ROBERT W. HEALY
City Manager

RICHARD C. ROSSI
Deputy City Manager

February 2, 1990

To The Honorable, The City Council:

Attached is a recommendation from the Cambridge Water Board to request that City Ordinance No. 998, Ch. 4, Article 1, Section 4-8 be eliminated so that dog management at the Fresh Pond Reservation would conform with dog control requirements throughout the City.

Very truly yours,

Robert W. Healy
City Manager

Attachment

CITY OF CAMBRIDGE

250 FRESH POND PKY., CAMBRIDGE, MASSACHUSETTS 02138• TEL. 498-9070

OFFICE OF THE WATER BOARD

Donald F. Hornig
President
Thomas J. Begley
Ruth C. Birkhoff
Walter N. Conlon
A. Paul Flynn

February 1, 1990

Mr. Robert W. Healy
City Manager
City of Cambridge
Cambridge, MA 02138

Dear Mr. Healy:

Attached is a statement by the Cambridge Water Board concerning dogs at Fresh Pond Reservation which was voted unanimously at its meeting of January 4, 1990.

Dogs have been a concern of the Board for several years and from time to time we have discussed the problem with Mr. Rossi and others. The Water Department has tried to control the situation in various ways. Until now we have had little success in bringing the problem under control. The City Council, for the most part, has opposed restrictions on dogs in the past.

We need help from all of the City Departments which are involved -- police, dog officer, etc.

Sincerely,

Donald F. Hornig

Donald F. Hornig
President

cc: Mr. Richard Rossi

RECEIVED
90 JAN 22 PM 4:37
OFFICE OF THE CITY MANAGER

CITY OF CAMBRIDGE

250 FRESH POND PKY., CAMBRIDGE, MASSACHUSETTS 02138• TEL. 498-9070

OFFICE OF THE WATER BOARD

Donald F. Hornig
President
Thomas J. Begley
Ruth C. Birkhoff
Walter N. Conlon
A. Paul Flynn

The Water Board has felt strongly for some time that allowing dogs to roam freely on the Fresh Pond Reservation is incompatible with its primary purpose, which is the provision of a potable water supply to the City of Cambridge. Until now we have had little support for this position and have been limited to putting up more signs and passing out leaflets to dog owners. There has been some support from animal control but it has been inadequate.

Violations of the dog regulations continue on a large scale. There are deposits of animal waste along the paths, in the grass and even inside the fence, as a result of dogs passing through cuts in the fence. Since a number of parasitic diseases such as Giardia or Cryptospiridium can be introduced into the water supply by contact with feces, these deposits pose a constant health hazard. Outbreaks of these diseases have occurred in other communities. Furthermore, dogs run loose in Kingsley Park and other grassy areas throughout the day and pose a potential hazard to children and other users of the Reservation. Many of the dogs are not there to accompany citizens using the park but are brought to the reservoir in groups for exercise, often by people who are not residents of Cambridge. Lastly, the feces left around the pond by the dogs provide food for a large number of rats.

The large numbers of dogs who run free in the Reservation constitute both a hazard and a public nuisance. However, the Water Board recognizes that dogs contribute to the security of people walking or running around the pond so that their presence is justified if they are kept under control. To protect the water supply (and other citizens) dogs should be leashed at all times and owners should be required to carry means for removing solid waste. The waste must be deposited in the barrels which are provided at intervals along the pond road.

Bearing all of these things in mind the Water Board has voted unanimously to request that Ordinance No. 998, Ch. 4, Article 1, Section 4-8, be eliminated so that dog management at Fresh Pond Reservation would conform with dog control requirements throughout the City.

Committee on Ordinances

Present Councillor Francis H. Duehay - Presiding 4/4/90
5:45 P.M.

1. C. Cyr
2. C. Russell
3. C. Myers
4. C. Reeves
5. Mayor
6. C. Toomey

C. Duehay — Outlined procedure of committee re: testimony, questions of c/c's
action of committee

Dr. Donald Horning
~~Chair~~ Pres / Water Board
16 Longfellow Park

Outlined responsibility of Water Board,
This proposal is an attempt to preserve water system.
Dogs / feases cause disease

Pennsylvania - 300 people affected (giardia). Other states w/ problems.

- Prof. - Harvard School of Public Health
- Presidential advisor

C. Russell — Ques. feases of other types, effecting water supply as well

Dr. Horning — Yes

C. Toomey — Cty shld enforce regulations in effect and we shld help dog owners by adding more barrels to dispose of waste.

C. Walsh — Ques. if chlorination would clear up waste issue

If everything is working correctly it would help.

C. Myers — Ques - primary reason for this request.

Dr. Horning — would like to have dogs leashed ~~prevented~~ prevent them from running loose.

* C. Durkay — Req. report from Dr. Chaffee on his position.

Mayor — Not really hearing that a health hazard exists.

C. Walsh — Ques. re bathroom facilities @ water Reservoir

at the plant facility only

I know

Richard Rossi — declined what Water Dept / city have done to deal w/ dog problem

Primary purpose of this ordinance

C. Reeves — Raised some concern over proposal i.e. certain expectation that area should be available. Has concern about water quality. (Brown and yellow water).

Que. identifying dog owners, enforcement etc.

Leashing not a solution, I don't believe.

" — Que. other locations

R. Ross. — Clarke Quay.

C. Walsh — How do you know feces are dog / raccoon.

C. Cyr — Que. cost of 2 additional people (dog officers)

R. Ross. — $40,000

C. Myers — If proposal is adopted, would the dog droppings across the river.

R. Rossi — Don't believe so.

C. Durham — Water quality primary issue and that is what Water Board is supposed to do.

Very important to join down. Would like to hear from other officials in this area.

Requested R. Rossi to contact these people for their opinion, plus budget for 2 additional positions.

John Cesarb
Supt.
45 Hickory Rd.
Brainbridge

New water treatment rules require close attention.
EPA suggests multiple barrier concept to protect water supply.

Fall 88 - ~~Spring~~ winter 89, worked w/ Dog officers sending out questionnaires etc. (Public Info. Campaign) This had positive impact.

Kennel trucks come and exercise their dogs. Some days, we have more dogs than people.

C. Duchay — C/C attempting to obtain as much info as possible.

C. Reeves — Shld C/C not support proposal what wld plan of water Bd be.

J. Cusack — More Public Info and more enforcement

C. Cyr — Do other cities have this problem

J. Cusack — I think we are somewhat unique

My concern for health issues grow because of my concern for Water Dept. to clean the water.

Although many people here tonight I believe are responsible, there are as many that are not!

I haven't heard any realistic solutions

C. Myers. We want to see that area cleaned up. I think a more responsible approach by dog owners is required.

Timothy McDonald
Manager / Water Resources
151 Grove St
Reading

Supports proposal. DEP will codify multiple barrier.

Winter time, dog waste is greater

Mark McCabe
Animal Director
4 Dorothy Rd
Arlington

Leash law is easier to enforce.
We have been working w/ dog owners to resolve problem. We are dealing with them in a "peer pressure" philosophy

C. Russell

What about signs, barrels
licensing dogs vs. non-

M. McCabe

Some have been torn down
did use more barrels

"
Response to T.G.

1st	offense	$10.00	K-9 waste
2	"	25.00	
3	"	50.00	
4	"	50.00	

I wld like to see dogs remain @ Fresh Pond.

C. Reeves

Some people are simply afraid of dogs and they feel they are at certain risk.

Jack Mastrilli
Auburn St.
Ph.d in Organic Chemistry

Technical issues. Understands concept of Fresh Pond.

Supports proposal of Water Board. - Health and water quality.

Garbage is a real possibility in Cambridge people.
It will soon be regulated by DEP

Compared visits have not been discussed

C/C needs to pay serious attention to this.
Supports city having additional officers.

C. Dwelley

Is Water Board on forefront of change in bringing reform to Reservoir

J. Martenell — They have been sensitive to political concern, but things are changing

Norma Weinberg
Mt. Auburn St. — Quality of water is my concern.

Elizabeth Homans — Opposed to ordinance
Concern w/ out of town people coming to Pond

* Check possible prohibition of out of town use w/ B. Albright

Barbara Norfleet
79 Raymond St. — Opposed to ordinance
Fresh Pond a "happy place":
People speak to others w/ dogs.
Done some research in this area, and her informants said dogs shouldn't be problem.

Ellen Gully

~~#~~ Opposed to ordinance
Supports "peer pressure"

- Some owners talk
- " " log

Kings watershed area did be used as a running area

Ester Bull
Ash SG-Place

Struck by enforcement issue vs. cleaning up the Pond. Fences in water Bd. concerns as well as owners.

Posting rules and explain them.

Sharon Ward, Esq.
9 Potter Park

Opposed
People do relieve themselves
Droppings @ Kingsley Park

Rebecca
100 Lovely Rd.

Bring extra bags for droppings

Opposed.

Tom Ereifeld
324 Windsor St

" "

Big dog community
No instance of garden.

Phebe ~~Morris~~ Morse
263 Green St.

Opposed
Enforcement in very lacks
No leaflets
More barrels.
Unfiltered water systems cause disease, not something like Cambridge system.

Reasonable relationship needs to exist in developing any regulation.

Anita McLellan
5 Gearns St.

Opposed
Homeowners shld clean their side walks of droppings.

Elizabeth Dungan Fenno Street	opposed My dog went to obedience school.
Jane Myers 165 Charles St.	opposed Leashes won't solve problem.
Druetha Cross 111 Magazine St.	opposed
Abigail Winsor 30 Kelley Rd	"
Melvia Webb 87 Washington Ave	" Pick up law can make difference
Lois Lawson 180 Lexington Ave	"
Mary Ahern 25 Upham St. Lowell	"

C. Duchay — Can city bar non-resident.

Birge Albright — Rather ~~to~~ do some research on this question

* C. Walsh — Ref to C/C w/ unfam. recommendation
V/V

C. Russell — Signage be checked throughout Park
V/V

Adj. 8:34 P.M.

8:40 Hearing / Traffic Mitigation

C. Walsh — Recess until 4/11/90 @ 7 P.M.

8:42 P.M.

Boston Sunday Globe 12-22-85 page 36

Beavers bringing illness to hundreds in Pittsfield

By Jerry Ackerman
Globe Staff

"The first six reports of the acute diarrhea sweeping through Pittsfield showed up on Dec. 6, a Friday.

"By the next Wednesday the tally was up to 70, and each succeeding day brought more.

By the end of last week, health officials counted 445 out of Pittsfield's 50,000 residents as victims of a debilitating intestinal disorder, giardiasis, caused by an amoeba-like parasite in the city's drinking water – apparently put there by a colony of beavers which carried it in their feces.

Officials with the state Department of Public Health and the US Centers for Disease Control predicted several hundred more cases. "This may be the largest recorded outbreak in the country," said Dr. Lynne Mofenson of the Massachusetts Department of Public Health. The epidemic is expected to turn this weekend, however, as the water source, the city's Ashley Reservoir, located alongside a state forest in the nearby town of Washington, is cut off and the beavers are removed.

Through this weekend, Pittsfield's residents – who for more than a week have been drinking bottled water or tapwater that had been boiled – were advised to avoid all use of municipal water.

The voluntary ban was necessary, according to city health commissioner Louis Bolduc, while the Ashley Reservoir is disconnected from the city mains – an action likely to stir up dormant giardia parasites in the pipes. At the same time, large doses of chlorine are being added to the water.

"We anticipate the water will be very dirty and will smell bad and taste bad until the changeover is completed," Bolduc said during a telephone interview Friday.

Identified in 1960s

"We are telling people that if they absolutely need the water, to boil it... and not to do their laundry in it, because their clothes will come out dirty."

Identified as an intestinal disorder in the United States since the 1960s, giardiasis has erupted at least 85 times in communities from New Hampshire to Washington. Its source, the giardia parasite, is carried not only by beavers but muskrats, dogs, cats, rats and mice – and humans.

Indeed, 25 to 40 percent of the population apparently is immune.

Continued on next page

Epidemic traced by detective work

Continued from preceding page

to its debilitating symptoms, according to Mofenson, while still being capable of passing the parasite on to others.

Outbreaks are common in child-care centers, she said, where workers may forget to wash after handling soiled diapers. But dozens of community outbreaks also are known of, including Aspen, Colo., Rome, N.Y., and Berlin, N.H.

The condition is easily treated with prescription drugs, Mofensen said. Its major symptoms are "a watery, smelly diarrhea occurring one to 10 times a day." Without treatment they can continue for up to six weeks. The Pittsfield outbreak apparently was detected only as large numbers of people visited their doctors seeking cures for uncontrollable diarrhea.

Outbreak is ironic

Communities most susceptible to these episodes, according to Gerald McCall of the Massachusetts Department of Environmental Quality Engineering, are cities and towns that depend on streams or reservoirs for water but don't filter their supply.

Ironically, officials said, the Pittsfield outbreak occurred because the city is installing water treatment equipment which is expected to avoid a similar episode in the future.

Unused for several years, the Ashley Reservoir was put into use on Nov. 14 while the city's larger

Cleveland reservoir was disconnected so the treatment equipment could be installed.

But the Ashley Reservoir wasn't pinpointed as the source of the epidemic until last week, after 10 days of detective work by local, state and federal officials.

Dr. George P. Kent, of the Centers for Disease Control's epidemiologic intelligence service, said the breakthrough came "when we interviewed the victims and we found that the infections hit a peak along about the 28th and 29th of November, right on Thanksgiving weekend."

The average incubation time for giardia in the human intestine is two weeks, he said – a timespan that matched precisely the day the Ashley Reservoir was hooked up to start feeding water into the municipal system.

Furthermore, he said, the reservoir's location, southeast of Pittsfield, matched up with the way that the diarrhea was sweeping through Pittsfield from southeast to northwest.

Although part of Pittsfield's water continued to come from a third source, the uncontaminated Farnham reservoir, Kent said, "We found the progression [of the giardiasis] was quite clear . . . as the water moved through the mains across the city."

While beavers are not the sole carrier of giardiasis, they were suspected almost immediately as a possible source of the scourge in Pittsfield because their population has been on the rise in Berkshire County for several years.

Wendell Dodge, a professor of wildlife management at the University of Massachusetts in Amherst, traces this to the Depression, when farms were abandoned in western Massachusetts and the land reverted to forest habitat conducive to beavers.

Globe 12-27-85; p. 23.

Epidemic from bad water seen easing in Pittsfield

Health officials said yesterday that a diarrhea epidemic in Pittsfield caused by contaminated drinking water has begun to ease, but additional cases are expected through next week.

Dr. George P. Kent, a field epidemiologist with the US Centers for Disease Control, said the number of confirmed cases of giardiasis rose to 520 yesterday, not including any cases reported on Christmas.

In addition, he said, a telephone survey conducted by city health department employees and volunteers may uncover many more cases that went unreported.

Residents of the western Massachusetts city of 50,000 remained under orders to boil their drinking water as mains were flushed and extra chlorine added.

The epidemic, which began to show up Thanksgiving weekend, has been traced to the city's Ashley Reservoir, located in the adjoining town of Washington.

NEW ENGLAND NEWS BRIEFS

Disease outbreak said to be subsiding

PITTSFIELD – Residents can be cautiously optimistic the largest reported outbreak of the intestinal disease giardiasis in state history is on the wane, officials said yesterday. The number of laboratory-confirmed cases of the disease rose to 603 over the weekend, up from 546 as of last Friday, said Louis A. Bolduc, commissioner of the city's Health Department. But Bolduc said the most recent date on which residents report being hit by giardiasis symptoms – which include diarrhea, cramps, gas and loss of appetite – is consistent with the day the city issued a recommendation that residents boil their water. The most recent symptoms were noted Dec. 26. Given the disease's 14-day bodily incubation period, there is reason to believe residents complied with the Dec. 12 recommendation and that the outbreak is subsiding, he said. (UPI)

Scho
goe

10.

Comm. from Jack Martinelli, 171 Auburn St., transmitting communication regarding an outbreak of human giardiasis in Pittsfield, MA.

In City Council,

April 23, 1990

Referred to the Proposed amendment on dogs petition

Pittsfield counts 560 cases of illness linked to beavers

By Trudy Tynan
Associated Press

SPRINGFIELD – Cartoons of beavers and signs reading, "All I want for Christmas is a beaver coat," have appeared on drinking fountains in Pittsfield since health officials linked an outbreak of intestinal disease to beaver droppings in the water supply.

But city officials and medical investigators, who face weeks of waiting before they can be sure the danger is past, say the disease that has stricken hundreds in the Berkshire Hills city is no laughing matter.

"It is a little early to say whether this is the largest outbreak of giardiasis we've ever had in the country, but it is certainly measuring up to be one of the largest," said Dr. George P. Kent, a field epidemiologist with the US Centers for Disease Control.

Through Friday, 560 cases of the parasitic disease had been confirmed in the city of 50,000 people. "And we suspect that's just the tip of the iceberg," Kent said.

Health officials issued a boil-water order Dec. 13 and closed a backup reservoir used for drinking water Dec. 21 after tracing the main infestation to it.

This weekend, they hoped to complete the laborious process of flushing all the city's water mains with high amounts of chlorine in hopes of eradicating organisms lingering in the pipes.

"One of our biggest concerns now is that the boil-water order has been in effect for some time and people will begin to pay less attention to it," said Pittsfield Mayor Charles Smith. "It's nice that we can still laugh and smile and make beaver jokes, but it's not funny for the people, who are suffering with the disease."

The first cases were reported around Thanksgiving, about two weeks after the city began taking drinking water from Ashley Reservoir in the nearby town of Washington, Kent said.

The city reactivated the reservoir, unused for two years, in order to begin installing piping for a $9 million filtration system at its main reservoirs. Ironically, filtration is the best defense against the parasitic microorganisms, which are resistant to normal levels of chlorination, he said.

for Berkshire Medical Center, the city's largest hospital, said three giardiasis victims had been admitted since the outbreak began. The hospital has tested 1,400 people suspected of having the disease and confirmed 540 cases, she said.

But Kent said the actual number of people stricken is probably higher.

"There are always people who didn't bother to seek help or physicians who didn't report cases," he said. "An informal survey of pharmacies showed twice as many prescriptions for antibiotics had been written as we had reported cases and we are now conducting a random telephone survey of homes from which we hope to be able to extrapolate the full extent of the epidemic."

> 'It is a little early to say whether this is the largest outbreak of giardiasis we've ever had in the country, but it is certainly measuring up to be one of the largest.'
>
> – Dr. George P. Kent

Beavers were also implicated in major outbreaks of the disease several years ago in Rome, N.Y., and Berlin, N.H. But Thomas Eng, a veterinarian with the Massachusetts Department of Public Health, said the rodents could also have been "co-victims" of the parasites, which in some cases has been traced to contamination of the beavers' water supply by human feces.

Pittsfield Health Commissioner Louis A. Bolduc said the incubation period for the disease ranges from 5 to 30 days, with 14 days the average.

"If what we suspect is the cause, we should begin to see some decrease in the number of cases shortly, as a result of the boil water order, and further decreases about two weeks from the closing of the reservoir and then the

April 5, 1990

RECEIVED BY
OFFICE OF CITY CLERK
1990 APR 10 PM 3:33
CAMBRIDGE MA.

Councilor Francis Duehay
Committee on Ordinances
Cambridge City Council
795 Massachusetts Avenue
Cambridge, MA 02139

Dear Councilor Duehay,

I am enclosing several newsclippings and a prospective "Letter to the Editor" regarding an outbreak of human giardiasis in Pittsfield, MA. in December, 1985. I am not aware that either of our two local papers carried my proposed letter so I don't have a clipping of it.

Please include this material in the packet for the Council consideration regarding the proposed dog-leash regulation at Fresh Pond.

Sincerely,

Jack Martinelli

Jack Martinelli
171 Auburn St.
Cambridge, MA 02139-3949

Letter to the Editor:

Cambridge citizens should heed the recent outbreak of giardiasis in Pittsfield, Ma. Between Thanksgiving and Christmas day, 560 cases of this disease were confirmed. City officials have evidence that an equal number may have been unreported. "This may be the largest recorded outbreak in the country," said Dr. Lynne Mofenson of the Mass. Dept. of Public Health.

The protozoan intestinal parasite causes severe diarrhea and abdominal pain and can be fatal to infants and the debilitated-elderly through dehydration. The protozoal cyst is resistant to normal concentrations of chlorine, but is removed by adequate filtration. Ironically, the Pittsfield cases developed two weeks after the city disconnected one water reservoir and connected a second in preparation for construction of a modern filtration plant.

The source of the disease is believed to be beaver feces. The giardia protozoa is carried by many mammels including beavers, muskrats, rats, mice, dogs, cats - and humans. Therein lies the warning for Cambridge. Recently the incidence of giardiasis in newly-born dogs has increased to 4 of 5 dogs - clearly epidemic proportions. Within five years nearly every dog may be an unsymptomatic carrier.

Last summer, the Cambridge Water Dept. was publicly criticized for adopting new restrictions on pets at Fresh Pond intended to prevent contamination of the reservoir by dog feces. Perhaps dog owners can better understand the seriousness of the problem. Perhaps all Cambridge citizens can better appreciate the need for improvements to the water treatment plant which can better avoid such an outbreak here.

Jan 7, 1986

Jack E. Martinelli
171 Auburn St.
Cambridge, MA 02139

Globe 12-20-85

Pittsfield reservoir to be shut down

PITTSFIELD – Officials plan to shut down a reservoir the state has found to be a source of an outbreak of intestinal disease that has left up to 400 persons sick. Test results show the protozoa which causes the disease, giardiasis, is coming from the Ashley Reservoir, one of Pittsfield's three main drinking water supplies, Health Commissioner Louis A. Bolduc said. The disease commonly causes diarrhea among its victims and, in extreme cases, can be life-threatening to infants or debilitated elderly. It is believed the reservoir was contaminated through beaver stools. Tests are still being done on Pittsfield's other reservoirs to determine whether they might contain the disease. (UPI)

Globe 12-15-85

Pittsfield residents told to boil water

Associated Press

PITTSFIELD – The city has ordered residents to boil their drinking water because of the outbreak of an intestinal infection in this western Massachusetts community, the health commissioner, Louis Bolduc, said yesterday.

Bolduc said more than 100 cases of giardiasis, an infection of the small intestine, have been reported since Dec. 6. Symptoms include severe diarrhea, abdominal pain and weight loss, he said.

Bolduc said a 17-member task force of physicians and state officials has been formed to find the cause of the problem. The order to boil water was issued Thursday, he said.

"We don't have it nailed down," he said, "but we have strong epidemiological evidence that it's the city's water supply."

Bolduc said he did not know how long the order would remain in effect. He said residents were complying with the order, buying bottled water or seeking spring water.

There are three drugs available in the United States for treatment of the parasitic infection, he said.

Pittsfield has about 52,000 residents.

Fresh Pond
Dog Walking Permit

173

Fresh Pond
Dog Walking Permit

173

Protection of Cambridge Water Quality is the responsibility of all who use Fresh Pond Reservation.

Keep Fresh Pond clean.

Deposit trash in recepticles provided.

Dog owners are required to clean-up dog waste.

Keep dogs on leash until this is accomplished.

FRANK DUEHAY

Please continue to allow dogs to run off leash in the Fresh Pond Reservation. Our dogs are important to us and this place where they can be free to get the exercise and socialization they need is essential to our well-being as well as theirs. We are more than willing to work with you and the Water Board to try to solve the problem of dog waste in the Reservation and to resolve the conflicts between dog walkers and other users; and we feel sure that these problems can be solved without resorting to a ban on unleashed dogs.

DATE	NAME	ADDRESS
3/3/90	Abigail J. Tim	109 Grozier Rd
	Stephen [illegible]	" " "
3/3/90	Robert [illegible]	48 BRASTOW AVE SOMERVILLE
3/3/90	Gary Swift	Topanga, California
3/3 90	Maureen Hanlon	121 Appleton St Cambridge
3/3/90	Barbara Minges	103 Raymond Ave Somerville
3/4/90	[illegible]	324 Windsor Street Cambridge
3/4/90	Abigail Winston	20 Kelly Camb. 02139
3/4/90	[illegible] B. Golden	3½ Madison St. Camb. 02138
3.4.90	Melissa Weber	87 Washington Ave 02140.
3/4/90	Rebecca Folliman	100 Larch Rd Camb.
3/4/90	Leslie Heerman	98 Larch Rd Camb
3/4/90	Jeffrey Freyman	98 LARCH RD., CAMB.
3/4/90	Jonathan Aaron	100 Larch Road, Camb.
3/4/90	David MAZIERES	100 Larch Road, Camb
3/4/90	Estelle Disch	528 Franklin St. Camb

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DATE	NAME	ADDRESS
3/3/90	Ellen P. Duehay	130 Mt. Auburn St., Cambr.

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DATE	NAME	ADDRESS
3/5/90	MR & Mrs Peter Stanoish	107A Lake View Cambridge
3/6/90	Mr. Mrs. Henry Sigourney	102 Lakeview ave Cambridge
3/14/90	Ellen + Gordon Tully	112 Lake View Ave
3/14/90	Ellen D. B. Tully	112 Lakeview Ave.

SIGN UP SHEET
IN
OPPOSITION (to Water Board)

NAME	ADDRESS
Elyabeth Homans	3 Burns Court Cam 02138
BARBARA NORFLEET	79 RAYMOND ST. Cam 02140
Ellen Tully	112 Lake View
Esther Pullman	10 Ash St Place
Sharon Ward	2 Potter Park
Rebecca Folkman	100 Larch Rd
ERIK AND SUSANNE JARNRYD	14 1/2 FAYETTE
Tom Ehrenfeld	324 Windsor St.
Phoebe Moese	663 Green
BARBARA HARRIS	52 LEXINGTON AVE
ARTHUR PEARSON	52 LEXINGTON AVE
Anita McClellan	50 Stearns St
Elizabeth Dunker	37 Fenno St
Jane Myers	165 Charles St
Darthea Cross	111 Magazine St
MICHAEL D. MACMANN	10 FOUNTAIN TER CAMB

SIGN UP SHEET
IN
FAVOR of WATER BOARD

NAME	ADDRESS
John Clifford	57 Huron Avenue
William Jones	
Jack Martinelli	
Chris Hall	
Norma Weinberg	130 Mt. Auburn

water quality

SIGN UP SHEET
IN
OPPOSITION of Weaker Boom

NAME	ADDRESS
Abigail Chuntz -	30 Kelly Comb -
Melissa Weber	87 Washington Avenue.

21 pages (200)
58 Cards

21 pages (200
58 Cards

FRANK DUEHAY

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3/3 90	Maureen Hanlon	121 Appleton St Cambridge
3/3/90	Barbara Minges	103 Raymond Ave Somerville
3/4/90	[illegible]	324 Windsor Street Cambridge
3/4/90	Abigail Winston	20 Kelly Camb. 02139
3/4/90	[illegible] B. [illegible]	3½ Madison St. Camb. 02138
3.4.90	Melissa Weber	87 Washington Ave 02140.
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3/4/90	Leslie Heerman	98 Larch Rd Camb
3/4/90	Jeffrey Freyman	98 LARCH RD, CAMB.
3/4/90	Jonathan Aaron	100 Larch Road, Camb.
3/4/90	David MAZIERES	100 Larch Road, Camb
3/4/90	Estelle Disch	528 Franklin St. Camb

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DATE	NAME	ADDRESS
3/3/90	Ellen P. Fisher	130 Mt. Auburn St., Cambr.

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3/6/90	MR & MRS. Henry Ligourney	108 Lakeview Ave Cambridge
3/14/90	Ellen + Gordon Tully	112 Lake View Ave
3/14/90	Ellen D.B. Tully	112 Lake View Ave.

RECEIVED BY
OFFICE OF CITY CLERK
1990 APR -4 PM 12: 47
CAMBRIDGE MA.

Fresh Pond Reservoir is currently the only designated area in Cambridge for dogs to exercise freely. We are Cambridge citizens who support the continuation of such rights. We believe in responsible dog ownership and aggressive enforcement of existing dog waste laws. We oppose the water board's effort to take away these rights.

NAME	ADDRESS	PHONE
Cosmo CREMALDI	13 William ST. Camb 5-1	354 7969
Catherine Cremaldi	13 William Street Cambridge	354-7969
Genevieve Cremaldi	13 William St. Cambridge	354-7969
David Mucci	658 GREEN ST CAMB	491-2179
Lucy McCauley	8 Lancaster #1 Cambridge 02140	868-9766
Catherine Olofson	20 Cogswell Ave #1 Camb. 02140	661-6732
Melissa Weber	87 Washington Ave., Cambridge	876-086
Karen Rockow	345 Harvard St #3B Camb 02138	354-0124
Michael [illegible]	23 SARGENT ST [illegible]	
Catherine O'Neil	452 Franklin St Cambridge	
C Bertram Currier	23 Cambridge Terrace Cambridge	
Catharine B. Currier	23 Cambridge Ter. Cambridge	
Kate O'Neil	452 Franklin St. Cambridge	
Eric Houston	17 Fresh Pond Pl. Camb	
James Harrell	61 Granville Rd. Camb.	566-090
Donna Harrell	61 Granville Rd Camb	
Joan Shaughnessy	94 Aberdeen Ave Camb	
Leslie Stebbins	86 Aberdeen Ave Camb	868-6823
JAN FORTE	250 HURON AVE., CAMBRIDGE 02138	492-2543
Amy [illegible]	71 Fulkerson St #203 Cambridge 02141	57[illegible]-8318
[illegible]	64 Reed St Camb. 02140	868-3448
Allison Dystel Hausman	" " " " "	"

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NAME	ADDRESS	PHONE
Phoebe Moss	663 Green ST Camb.	547-8025
Rob E Johnes	658 Green ST CAMBRidge	491-4121
Barbara A Richard	652 Green St Cambridge	491-8405
Francis L. Richard	652 Green St. Cambridge	491-8405
Elizabeth E Esler	22 Lawn St Cambridge, MA	492-6151
Dan A Holin	22 Lawn St Cambridge MA	492-6151
Sandra Hewitt	7 Exeter Park 02140	354-0425
H James Brown	57 Reservoir St 02139	497-6669
M. P. Prada	64 Grozier Rd 02138	354-6644
Lynne O Chang	12 Ellery St 02138	492-3275
Jonathan Simon	30 Carver St 02138	354-2775
Sonia Dettmann	106 Berkshire 02141	492-6497
Robert Pollak	21 St Marys Rd 02139	492-1434
Cyprian Doolittle	2353 Mass Ave #86 02140	868-4534
Susan Ware	16 Hilliard St 02138	492-5315
Donald R. Ware	16 Hilliard ST 02138	492-5315
Ellen Sarot	654 Green St 02139	868-7726
Philip A. Willms	651 Green St. 02139	354-3858
Marilyn Weller Willms	651 Green St. 02139	354-3858
Benjamin Bolte	10 Poplar Rd 02138	576-1220
Lori Barsalou	244 Lexington Ave 02138	868-0743

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NAME	ADDRESS	PHONE
Annette Donnelly	467 Huron Ter	661-2533
Maureen Hunter	12 Appleton St Cmbr	876-1843
Joan Sullivan	12 Appleton St Cmbr	876-1843
Patricia Hunter	11 Holly Ave Cmbr	876-1843
Robert C Hooper	48 Brewster St Camb	864-0664

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NAME	ADDRESS	PHONE
Esther Pullman	10 Ash Street Place Camb.	4926258
Nagib Armyo-Hussein	8 Kellen St CAMB	
Chuck Dresner	503 Huron Ave. Cambridge MA 02138	
Bridget Murnane	375 Mt. Auburn St Camb MA 02138	
Frank Mallahan	31 Blakeslee St. Camb.	
Elizabeth G Homans	3 Burns Ct, Camb-02138	
Paul Fitzgerald	94 Aberdeen Ave Cambridge	
Leslie Heerman	98 Larch Road Cambridge Ma 02138	
Cassie Swenbeck	107 Columbia St Camb 02139	
Jacqueline Schiec	115 Magazine St. Camb. 02139	
ANDY BAER	3 STINSON CT. CAMB 02139	

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NAME	ADDRESS	PHONE
CRIS PAUL	29 CONCORD AVE. #212 CAMB.	495-3769
Jean-Claude PAUL	29 Concord #212 CAMB.	876-1043
Kristen Flaherty	127 Huron Ave. Cambridge, Ma. 02138	868-2053
Lydia Spitzer	52 Shepard St. Cambridge, MA 02138	864-9650
Wendy Roberts	53 Sherman St. Cambridge MA 02140	491-0348
[illegible]	42 Cogswell Cambridge 02140	
[illegible] ST. GEORGE	5 SHEPARD ST. CAMB. 02138	492-1345
Jane Reed	36 Follen Street, Cambridge 02138	491-0773
Frank Jaffe	159 Concord Ave, Cambridge Ma 02138	
Susan [illegible]	6 Garden Terrace, Cambridge MA 02138	
Sachiko Garden	167 Upland Rd Cambridge Ma 02140	
Adele Pressman	58 Highland St. Cambridge Ma 02138	
BRUNO D'Agostino	72 LEXINGTON ~~AVE~~ CAMBRIDGE, MA. 02138	
Alice Hall	273 Upland Rd Cambridge 02140	491-0779
[illegible]	10 Fountain [illegible] Camb. 02138	547-5119
Jeffrey McIntyre	25 Cogswell Avenue Cambridge Ma	354-1555
Christopher E. Lee	49 Lawn St Camb. Ma.	868-1165

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NAME	ADDRESS	PHONE
[illegible]		
Tom Blumenthal	33 C[illegible]	-2-1639
[illegible]		
Dorthea Cross		
Dorthea Cross	111 Magazine St Camb.	354-5259
Susan Miller	Susan Miller 2301 Mass. Ave Cambridge 02140	547-7431
[illegible]		
JANE ZIMMERMAN	120 ABERDEEN AVE	661-7969
Patricia Michaels	66 Otis St.	492-4371
[illegible]	230 Chestnut	547-2905
[illegible]	70 Langdon St.	868-5722
Sally Ackerman	7 Camden Pl	864 5918
[illegible]	11 Fayerweather St.	547-8243
JoAnne VARNADOE	48 JFK CAMB	864-4430
[illegible]	17 Lincoln Camb	864-4178
[illegible]	852 Mass Ave Camb MA	876-4814
NELLE JENKENS	585 FRANKLIN AVE CAMB MA	661-7269
Margaret Chevedden	30 Holly Rd Camb	661-3036
[illegible]	14 Magnolia Ave Camb	868 1737
A M UPINSKY	86 Irving St. Cambridge	576-6420
Steve Kagan	86 Irving St. Cambridge	576-6420
Brian Cooper	71 Antrim St Cambridge	354-2486

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NAME	ADDRESS	PHONE
EVE SPERN	28 DONNELL ST.	876-4561
Rich Schultz	140 Garden St	864-4280
FED MEELCARZ	140 GARDEN ST	661-8855
Barbara Stone	2[illegible] Walden St. #3	876-1862
Mary Eva Ward	134 Garden St. #1	354-0064
Ed Shea	299 Walden St	868-5118
Woodley Chapman	304 Walden St	661-0319
Arthur Magoun	218 Garden St.	354-6140
CLARK M. NEELY JR	79 MARTIN ST #43	492-7475
[illegible]	[illegible]	[illegible]
Hyla Shapiro	225 Walden St	876-3095
Guy Spinzi	205 Walden	547-5545
Marcia Ring	252 Garden St. Camb.	491-4239
Peter Kaplan	174 Garden St	661-7583
Janet C Macaluso	30 Donnell St	354-7609

March 7, 1990

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NAME	ADDRESS
J S Cappy (Judy Appel)	49 Garfield St. Cambridge, Ma
G. Joyce (Gayle Joyce)	8 Hurlbut Cambridge, Ma
Simmi [illegible]	7 Potter Park Cambridge Ma
Steven Ott (Steven Ott)	11 Linnaean Cambridge, MA
Jane A. Fisher (Jane A. Fisher)	11 Linnaean Cambridge
Rachel Brooks (RACHEL BROOKS)	6 Linnaean St CAMBRIDGE MA 02138
J Robert Shoemaker	2 Potter Park #2 Cambridge, MA 02138
Sharon M. Ward	2 Potter Park #2, Cambridge 02138
Sarah Fahey (SARAH FAHEY)	64 PRENTISS ST. #2 CAMB, MA 02140
Karen Kreiger (KAREN KREIGER)	17 Humboldt Cambridge MA 02138
Lynette Ward-Rohing	31 GRAY STREET CAMBRIDGE MA 02138
Connie Dyer	10 Appleton Rd Cambridge MA 02138
Camilla England	335 Concord Ave. Cambridge MA 02138
Karen Jones	64 Prentiss St. Cambridge MA 02138
Nanette Redmond	6 Linnaean St Cambridge MA 02138
Sara Griggs	31 Gray St. "
Susan Q Cobb	62 Dover St., Somerville, MA 02143
Lena Washington	31 Gray St, Cam MA 02138
Ruth Knight	11 Linnaean St, Camb MA 02138
Bill Lemieux	11 Linnaean St. Camb. MA 02138

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NAME	ADDRESS	PHONE
Laura Dinwiddie	10 Rollins Ct. Camb. 02139	661-5868
Blair Bergstrom	29 Concord Ave Camb 02138	492-4570
Tom Ehrenfeld	324 Windsor St Camb 02141	491-8432
Willie "Lassie" Tyler	48 Maple Ave Camb 02139	491-0190
Nan Stone	69 Fayerweather St Camb 02138	661-7427
[illegible]	18 AMORY ST 02139	492.7725
AE RANCATORE		
Kim Makseyn	61 Sixth ST. Camb. 02141	864-9530
Nyla Hendrick	282 Mass Ave. Camb 02139	225-9132
Hetchen Ehrenfeld	324 Windsor St Camb 02141	491-8432

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NAME	ADDRESS
Melanie Rubin (Rubin)	31 Gray St. Cambridge 02138
Barry Shulak Shulak	11 Linnaean St Cambridge 02138
Akam [illegible]	31 gray st Cambridge 02138
Morrison Neal	31 Gray St Cambridge 02138
Molly Meredith	11 Linnaean St. " "
[illegible]	17 Humboldt Cambridge 02140
[illegible] Burns	6 Linnaean Cambridge 02138
Eugene A. Bernardin III	11 LINNAEAN ST. CAMBRIDGE MA. 02138
Douglas Marshall	49 Garfield St. Cambridge MA 02138
Leilani S. Baker	11 Linnaean St. Cambridge Ma 02138
[illegible] (PER JOHANSEN)	64 Prentiss, Cambridge, MA 02140
[illegible] A Santi (LAURA SANTI)	11 Linnaean St Cambridge MA 02138
Jan LaRue	11 Linnaean Camb 02138
[illegible] Esq.	17 Humboldt Camb. 02140
Robin Johansen	64 Prentiss St #3 Camb 02140
Jennifer L. Cross	11 Linnaean St Cambridge 02138
James A. Hassan	31 Gray St. Cambridge 02138
[illegible] (HOWARD BOSTER)	6 Linnaean St Cambridge
[illegible]	11 Linnaean St Cambridge 02138
James Rolvig	31 Gray St. Camb 02138

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NAME	ADDRESS	
Linda L. Barnes	24 Lancaster St	Cambridge, MA 02140
Sunthar Viswalingam	126, Montgomery St	Cambridge, MA 02140
[illegible]	32 Linnaean St	Cambridge, MA 02138
Deborah Thrall	335 Concord Ave.	Cambridge MA 02138
T. Lankie Willauer	10 APPLETON RD. #1	CAMBRIDGE, MA 02138
Thrall (Thomas Thrall, M.D.)	335 Concord Ave	Cambridge Ma 02138
Dan E. Dencer	20 Roseland	Camb MA
[illegible]	3 Frost St	Camb. MA 02140
Jerry Sutherland	3 Frost St	Cambridge 02140
Sandy Goodnough	4 Chauncy Terr	Cambridge, 02138
Joel Marver	17 Humboldt St.	Camb. 02140
Hugo Marver	17 Humboldt St.	Camb. 02140
Linda Pope	24 Peabody #601	Camb 02138
Rebecca Riese	31 Gray St.	Camb 02138
Cecilia Bonner	17 Humboldt	Camb 02140
Virrie Yee	24 Lancaster St.	Camb 02140
Duncan Coule	5 Potter Park	Camb 02138
Andrew Davidson	17 Humboldt St	Camb. 02140
Lisa Hoberg	31 Gray St	Camb 02138
Andrea Bonn	17 Humboldt St	Camb 02140

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NAME	ADDRESS
Joan Ames	19 Lancaster St. Cambridge, Ma 02140
Carla Cimorella	64 Princess St Cambridge Ma 02138
[illegible]	49 Garfield St Cambridge Ma 02138
[illegible]	49 Garfield St Camb. MA 02138
[illegible]	335 Concord St. Camb MA. 02138
Jane Coyle	8 Newport Rd Camb. MA 02140
Thomas A Palmer	31 Gray St Camb MA 02138
Rick Dyer	10 APPLETON ROAD CAMB. MA. 02138
Dan Eyink	3 Frost St Cambridge MA 02140
Rachel Gaffney	16 Linnaean St Camb. MA 02138
Steve Coyle	8 Newport Rd Camb MA 02140
[illegible] Diane Asay	17 Humboldt Cambridge MA 02140
Carol Locke	3 Frost Cambridge 02140
Bonnie Kreser	18 Chauncy St. Apt 3 Cambridge MA 02140
Kerry Smith	17 Humboldt ST Cambridge MA 02140
Susan Marshall	49 Garfield St #5 Cambridge Ma 02138
Susan Lennerts	11 Linnaean St. Cambridge MA 02138
Claudia J. Lewis	73 Martin St. Cambridge, MA 02138
Jeanne Perrin	73 Martin St. #5 Cambridge, MA 02138
Arwen Spina	11 Linnaean Cambridge, MA 02138

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NAME	ADDRESS
Ellen L. Ober	43 Lennaean St Cambridge 02138
Naran Koller	79 Martin St., Cambridge 02138
[illegible]	3 Lancaster St Cambridge 02140
Mary Hilsmin	18 Dudley St. CAMBRIDGE Mass 02140
Sandy Beehler	172 Lexington Ave. Cambridge
Kiana Williams	33 Follen St. Cambridge 02138
Bill Belanger	33 Follen St Cambridge 02138
Dora Eddy	24 Harris St. Cambridge 02140
Gordon M. Jones III	24 Harris St. Camb. 02140
Christie P. Dennis	92 Washington Av. Camb. 02140
[illegible] Maier	60 Larchwood Dr. Cambridge 02138
[illegible] Hoffman	#1 Ridge Ter Cambridge 02140
C. Morse	95 Inman Str. Camb 02139
[illegible] Ummerman	120 Aberdeen Ave CAMBRIDGE
Lynne Meyer-Gray	10 Bowdoin St #5 Cambridge 02138
[illegible]	8 Follen St, Cambridge
Kristen Flaherty	127 Huron Avenue Cambridge Ma.
Lisa Fuentes	12 Bond Cambridge
[illegible]	33 Walker Cambridge
Nate Engerd	335 Concord Ave Cambridge

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NAME	ADDRESS
Leslie Goldstein	22 Roseland St. Cambridge 02140
[illegible]	11 Linnaean St. Cambridge 02138
Ellen Hynson	35 Walden #1B Camb 02140
[illegible]	5 Frost ST #3 Cambridge 02140
Liz Bayzam	6 Hurlbut St. Cambridge 02138
William L. [illegible]	31 Gray St. Cambridge MA 02138
Cris Pant	29 Concord Ave #212 Camb. 02138
Mary Joan Keith	131 HURON AVE CAMB. 02138
Barbara J. Flaherty	127 Huron Ave Camb. 02138
[illegible]	22 Concord Ave, #212 Camb. 02138
STEF DIMEO	47 GARDEN ST. CAMB. 02138
Perian Flaherty	1 Chauncey Street #19 Camb. 02138
J. Pryor	42 Cogswell Ave, Camb 02140
Ten Chevequel	324 Windsor St. Cambridge
Mara Brenner	24 Concord Ave. #213 Camb. 02138
Timothy Hickey	24 Washburn Ave Cambridge 02140
Lucinda Hickey	24 WASHBURN " "
Ruki Navarro	6 Linnaean St Camb 02138
Sarah Moran	6 Linnaean St Camb 02138

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Ellen W. Ober	43 Lennaean St Cambridge 02138
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Mary Hilsmin	18 Dudley St. CAMBRIDGE Mass 02140
Sandy Beehler	172 Lexington Ave. Cambridge
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[illegible]	8 Follen St, Cambridge
Kristin Flaherty	127 Huron Avenue Cambridge Ma.
[illegible]	12 Bond Cambridge
[illegible]	33 Walker Cambridge
Nate England	335 Concord Ave Cambridge

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NAME	ADDRESS
Timothy Welsh	1661 Commonwealth Ave. #1
Willa Axelrod	94 Concord Ave #203
Dorothy Gann	30 Madison St.
Genevieve St. George	5 Shepard Street
Jennifer Miller	29 Concord Ave #810
Ricardo Harris-Fuentes	12 Bond St.
Juson Quinn	127 Lexington Ave.
Lydia Spitzer	52 Shepard St.
Nancy Curtis	39 Parker St
Susan Contrill	6 Garden Terrace

Fresh Pond Reservoir is currently the only designated area in Cambridge for dogs to exercise freely. We are Cambridge citizens who support the continuation of such rights. We believe in responsible dog ownership and aggressive enforcement of existing dog waste laws. We oppose the water board's effort to take away these rights.

NAME	ADDRESS	PHONE
[illegible]	165 Charles Street #3	492-3582
Elizabeth D. Dunker	31 Fenno St.	661-8236
Jayne D. Miller	39 Fenno St.	868-7376
Billie Miller	39 Fenno St	868-7376
JOE VENDETTI	155 CHARLES ST. CAMB.	868-9084
George M Vendetti	155 Charles St	868-9084
Ruth G. Gamble	159 Charles St. Camb.	unlisted
[illegible]	159 CHARLES ST CAMB	unlisted
Josephine Vendetti	155 Charles St. Camb.	868-9084
Melodie Mitchell	163 Charles St. Cmbs.	547-4485
Andrea Holliday	163 Charles St #2 Camb	547-9635
Melanie Kellogg	163 Charles St #2 Camb.	547-9635
Andrea COUSINS	40 Fenno St Camb 02138	492-4979

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NAME	ADDRESS	PHONE
Julian Wilson	16 Dover st.	491-2613
Tom Shannon	70 Richdale Ave	661-1227
Elica Thomas	30 Union St	354-1362
Dan Kenel	18 [illegible] st	354-5445
Beth Zalsinger	18 Dover St.	492-7324

April 3,1990

Dear Councillor Duehay

This letter is in response to a request by the Water Board to eliminate the section in Ordinance 998 which allows dogs to be unleashed at Fresh Pond Reservation. As a Cambridge resident, a dog owner, a dog trainer by profession and a user and lover of Fresh Pond, I oppose this change. The valid concerns of the Water Board can be addressed by other measures; the rest should be dismissed.

The major parasite mentioned by the Water Board, Giardia, is removed from the water supply by a combination of chlorination and filtration - both of which Cambridge uses. Dogs, while they can carry Giardia, are neither the only nor even a major source of Giardia contamination. Wildlife is more frequently implicated. It is important to consider how significant a source of pollution dog waste is when compared to the other types of pollution which affect our water supply: road salt, salt stored at Fresh Pond, the Exxon oil depot, other organic loading. Furthermore, leashing dogs does nothing to diminish the amount of dog waste left in the park. Owners need to be educated to pick up after their dogs; and educated owners will pick up regardless of whether their dogs are leashed or unleashed. Past programs designed to change dog owners' behavior relative to cleaning up after their dogs have been practically and psychologically ill-conceived, and when combined with the infrequent placement of trash barrels, make it surprising that there is as much cooperation as one finds. I am sure that a better conceived program, involving the dog-owning community and combining information and enforcement, could eliminate the problem of dog waste at Fresh Pond.

The other issue of concern to the Water Board is the perception that free-running dogs are a hazard and a nuisance to other users of the park. So they are, to an extent; but anyone who has had to jump to avoid fast bikers or the pack of Saturday morning racers knows that dogs are not the only hazards and nuisances around the Pond. My point is that Fresh Pond Reservation is not a private yard, nor a race track nor a tot lot, but a city amenity; and we who use it must adjust our expectations to that reality. We cannot expect the privacy of a yard nor the safety of a track, but must accomodate ourselves to other users. Joggers can't sprint as fast as they would like; bikers have to moderate their speed to avoid joggers and walkers; and walkers can't meander dreamily along, but must be alert for fast moving traffic. In this context it is not unreasonable to ask people to accomodate to dogs, to adjust speed and

concentration for them just as for other interferences. However, in other parks the City does designate special areas for special constituencies - small children, basketball players, golfers, etc. - without limiting their access to the rest of the park. The City Council could consider setting aside a part of the Fresh Pond Reservation as a dog park such as they have in both Berkeley, Calif. and New York City.

Cambridge has been a pioneer in showing compassion for animals in laboratories and providing for their needs. Can we not extend a little of this compassion to our most faithful companion animal as well? Dogs delight in running free. They are genetically programmed to be energetic animals, hunting, tracking, following a flock or pulling a sled; and they need an opportunity to express that part of their makeup that can be expressed in no other way. Where else in Cambridge can they run, except at Fresh Pond? Let us not be guilty of unnecessarily limiting another creatures freedom because we do not have the compassion or the vision to find a better way. Please allow dogs to remain unleashed at Fresh Pond.

Yours truly,

Ellen Tully

Ellen D.B.F.Tully

6

CITY OF CAMBRIDGE

CAMBRIDGE, MASSACHUSETTS 02139
TEL. 498-9011

EXECUTIVE DEPARTMENT
ROBERT W. HEALY
City Manager

RICHARD C. ROSSI
Deputy City Manager

February 2, 1990

To The Honorable, The City Council:

Attached is a recommendation from the Cambridge Water Board to request that City Ordinance No. 998, Ch. 4, Article 1, Section 4-8 be eliminated so that dog management at the Fresh Pond Reservation would conform with dog control requirements throughout the City.

Very truly yours,

Robert W. Healy
City Manager

Attachment

CITY OF CAMBRIDGE

250 FRESH POND PKY., CAMBRIDGE, MASSACHUSETTS 02138• TEL. 498-9070

OFFICE OF THE WATER BOARD

Donald F. Hornig
President
Thomas J. Begley
Ruth C. Birkhoff
Walter N. Conlon
A. Paul Flynn

February 1, 1990

Mr. Robert W. Healy
City Manager
City of Cambridge
Cambridge, MA 02138

Dear Mr. Healy:

Attached is a statement by the Cambridge Water Board concerning dogs at Fresh Pond Reservation which was voted unanimously at its meeting of January 4, 1990.

Dogs have been a concern of the Board for several years and from time to time we have discussed the problem with Mr. Rossi and others. The Water Department has tried to control the situation in various ways. Until now we have had little success in bringing the problem under control. The City Council, for the most part, has opposed restrictions on dogs in the past.

We need help from all of the City Departments which are involved -- police, dog officer, etc.

Sincerely,

Donald F. Hornig

Donald F. Hornig
President

cc: Mr. Richard Rossi

RECEIVED
90 JAN 32 PM 4:37
OFFICE OF THE CITY MANAGER

CITY OF CAMBRIDGE

250 FRESH POND PKY., CAMBRIDGE, MASSACHUSETTS 02138• TEL. 498-9070

OFFICE OF THE WATER BOARD

Donald F. Hornig
President

Thomas J. Begley

Ruth C. Birkhoff

Walter N. Conlon

A. Paul Flynn

The Water Board has felt strongly for some time that allowing dogs to roam freely on the Fresh Pond Reservation is incompatible with its primary purpose, which is the provision of a potable water supply to the City of Cambridge. Until now we have had little support for this position and have been limited to putting up more signs and passing out leaflets to dog owners. There has been some support from animal control but it has been inadequate.

Violations of the dog regulations continue on a large scale. There are deposits of animal waste along the paths, in the grass and even inside the fence, as a result of dogs passing through cuts in the fence. Since a number of parasitic diseases such as Giardia or Cryptospiridium can be introduced into the water supply by contact with feces, these deposits pose a constant health hazard. Outbreaks of these diseases have occurred in other communities. Furthermore, dogs run loose in Kingsley Park and other grassy areas throughout the day and pose a potential hazard to children and other users of the Reservation. Many of the dogs are not there to accompany citizens using the park but are brought to the reservoir in groups for exercise, often by people who are not residents of Cambridge. Lastly, the feces left around the pond by the dogs provide food for a large number of rats.

The large numbers of dogs who run free in the Reservation constitute both a hazard and a public nuisance. However, the Water Board recognizes that dogs contribute to the security of people walking or running around the pond so that their presence is justified if they are kept under control. To protect the water supply (and other citizens) dogs should be leashed at all times and owners should be required to carry means for removing solid waste. The waste must be deposited in the barrels which are provided at intervals along the pond road.

Bearing all of these things in mind the Water Board has voted unanimously to request that Ordinance No. 998, Ch. 4, Article 1, Section 4-8, be eliminated so that dog management at Fresh Pond Reservation would conform with dog control requirements throughout the City.

Surface Water Supplies and Health

Gunther F. Craun

Rivers, streams, lakes, and reservoirs have long been important sources of drinking water. In the past, these sources were often heavily contaminated by sewage discharges and, unfortunately, were also important in the transmission of communicable diseases such as typhoid and cholera. With improvements in sewage disposal practices, development and protection of water sources, and water treatment, outbreaks of waterborne disease are less frequently reported, and drinking water becomes a less important route of transmission of communicable disease. In the United States, the incidence of waterborne disease is low but waterborne outbreaks continue to occur. Outbreak statistics are reported in this article, and information is presented on the causes of these outbreaks, especially in surface water systems.

Surface water sources are currently used by an estimated 155 million people in 6,000 community water systems, some 23 percent of which provide unfiltered drinking water to an estimated 21 million people.[1] The majority of these communities are small, but 15 cities with populations of more than 100,000 people continue to provide unfiltered surface water to some 16 million consumers.[1] Although many of these cities use water sources protected to some extent from contamination by discharges of human sewage, reliance is placed solely on disinfection to prevent the waterborne transmission of infectious agents. With increasing evidence of disease transmission and water contamination from wild and domestic animals,[1] it is important to determine whether disinfection as the only treatment of surface water can be expected to provide sufficient protection against waterborne disease transmission. The potential health risks associated with unfiltered surface water sources are discussed in the context of waterborne disease outbreak statistics, current and proposed drinking water regulations, and the multiple barrier concept of water treatment.

Although the emphasis of this article is waterborne infectious disease, a related issue for surface water systems is also considered, i.e., the potential adverse health effects that may be associated with long-term exposure to chlorine or chlorinated by-products. Even though reducing the amount of chlorine added to surface water may result in decreased levels of chlorinated by-products, the effects of this action must be carefully evaluated. Abel Wolman[2] reminds us that water chlorination has saved many lives, and the potential risks of water chlorination must be tempered with considerations of the benefits. This is particularly important for communities that continue to provide unfiltered surface water. Increased dosages of chlorine may be required in these systems to ensure inactivation of the more resistant protozoan cysts;[1] reducing the risk of infectious waterborne disease in unfiltered surface waters could result in increased levels of chlorinated by-products. Reviewed are the available epidemiologic data reporting increased risks of cancer and cardiovascular disease in populations using chlorinated water supplies. This article should assist readers in gaining a better understanding of the potential risks and benefits of chlorine disinfection.

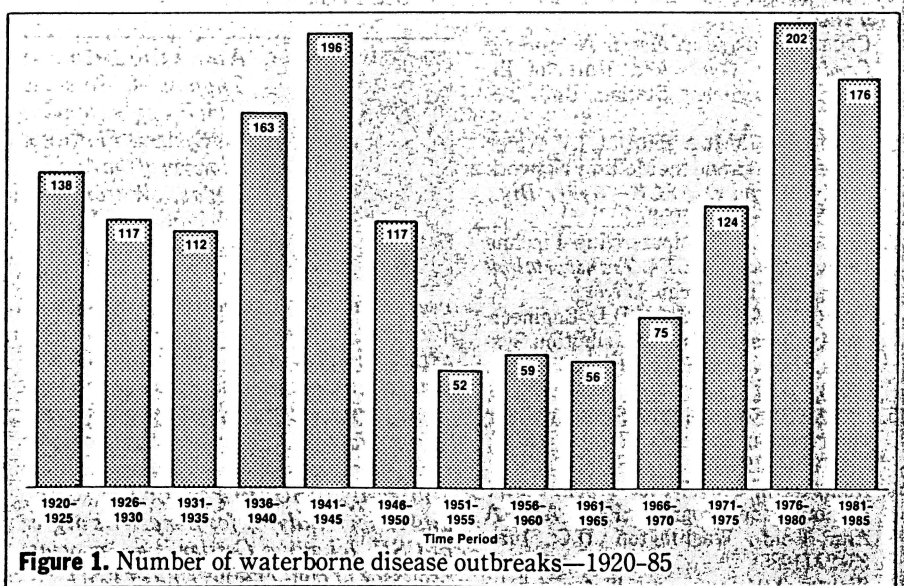


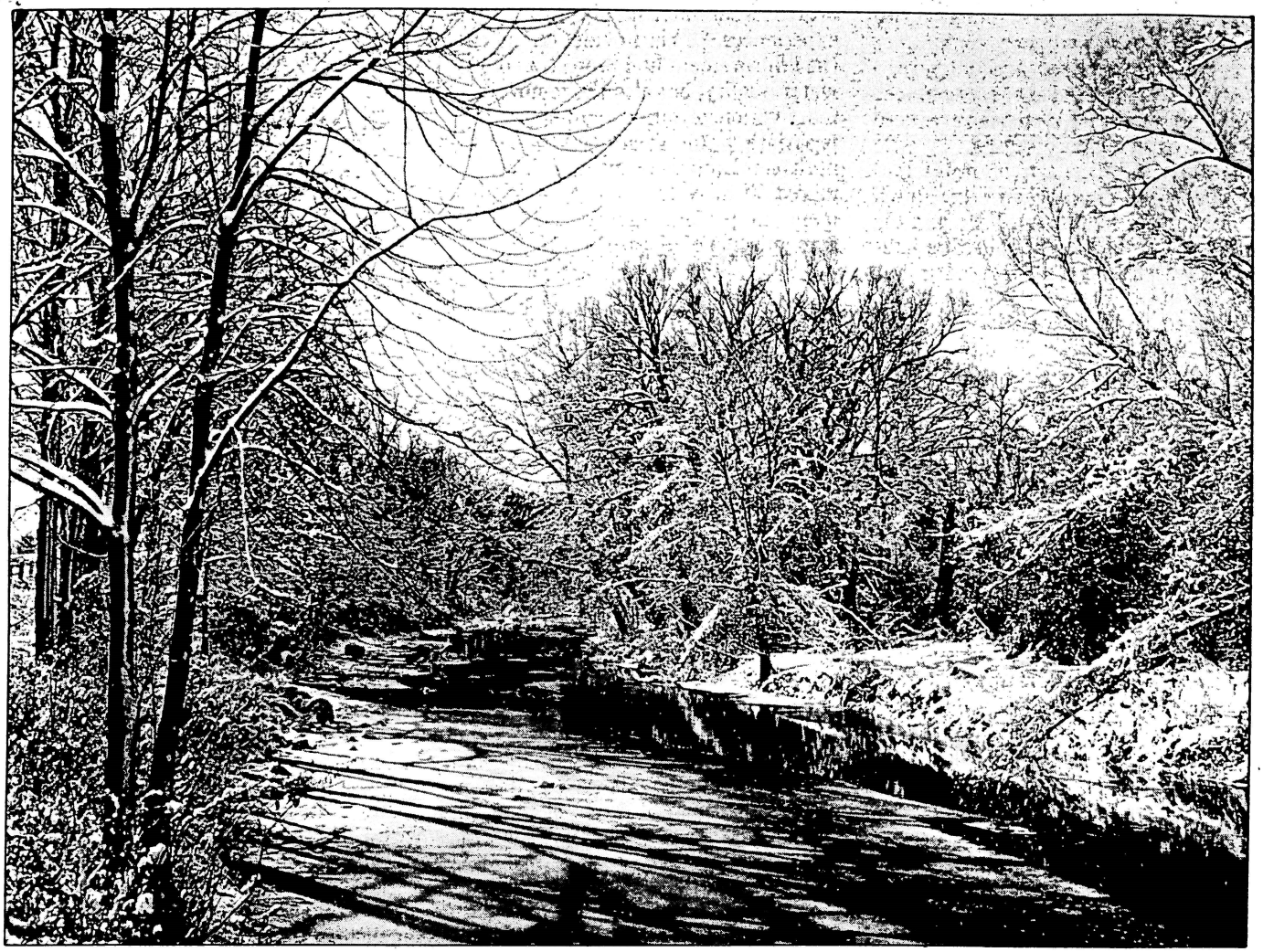
Figure 1. Number of waterborne disease outbreaks—1920–85

Regulations

The Safe Drinking Water Act (SDWA) requires the US Environmental Protection Agency (USEPA) to establish drinking water regulations for public water supplies to prevent adverse effects on human health. National Interim Primary Drinking Water Regulations (NIPDWRs)[3] for bacteria, turbidity, 10 inorganic constituents, 6 pesticides, and radionuclides became effective June 24, 1977. Amendments[4,5] to the interim regulations include maximum contaminant levels (MCLs), monitoring, and reporting requirements for total trihalomethanes (THMs) in community water systems of more than 10,000 people, and monitoring and reporting requirements for sodium and corrosivity characteristics. National Secondary Drinking Water Regulations[6] were established for contaminants that may adversely affect the aesthetic quality of drinking water through taste, odor, color, and appearance.

The SDWA was amended in 1986 to require the USEPA to regulate 83 contaminants by June 1989, and the agency has undertaken a comprehensive reassessment of the interim regulations to identify additional drinking water contaminants that should be regulated and to establish national primary drinking water regulations (NPDWRs).[7,8] In promulgating NPDWRs, the USEPA must specify recommended maximum contaminant level goals (MCLGs), which are nonenforceable health goals, in addition to MCLs—the enforceable standards. The USEPA has published MCLGs and promulgated NPDWRs for eight volatile organic chemicals[9] and fluoride[10] and has proposed MCLGs for a group of 43 inorganic chemicals, synthetic organic chemicals, pesticides, and microbiological contaminants.[11]

A treatment technique rather than an MCL can be specified if it is not economically or technologically feasible to ascertain the level of a contaminant in



Data from outbreaks of waterborne disease in water systems served by surface water supplies show that disinfection must be accompanied by pretreatment and filtration to effectively remove and inactivate pathogens, especially protozoa such as Giardia *and* Cryptosporidium.

drinking water. The NPDWRs are to be reviewed periodically and amended whenever changes in technology, treatment techniques, or other factors permit greater health protection. Enforcement of these regulations has been delegated, in all but a few instances, to the states. Monitoring and reporting requirements vary according to the constituent and type of water supply.

The current MCLs for all constituents except total coliform bacteria, turbidity, and nitrate are based on possible adverse health effects associated with chronic exposures. The MCL for nitrate was established to prevent acute infantile methemoglobinemia. The MCLs for total coliform bacteria and turbidity were established to prevent acute infectious disease, but waterborne disease outbreaks have occurred in public water systems in which these MCLs have not been exceeded.[12-14] The AWWA Committee on the Status of Waterborne Diseases in the United States and Canada[15] commented on the limitations of routine coliform surveillance in preventing disease outbreaks, and noted that it was more important to know the microbiological quality and potential for contamination of the water source so that appropriate source protection and water treatment could be provided:

> A water supply surveillance program should emphasize frequent engineering evaluation and sanitary surveys to identify and correct potential deficiencies. Microbiological resources [funds and personnel] are better applied to assessing raw water quality, identifying sources of contamination, and evaluating the efficiency of treatment. Routine coliform surveillance of treated water is mandated by the Safe Drinking Water Act; however, the committee feels that its importance is to provide a historical record of operation rather than to prevent waterborne outbreaks.

The primary public health concern for drinking water supplies must be the prevention of waterborne infectious disease transmission. But despite existing regulations, waterborne outbreaks have continued to occur. Examination of the causes of these outbreaks can provide information that should be used to remedy this situation. Additional regulations and surveillance are required, and public water systems should do more in this regard than just provide drinking water that meets currently prescribed MCLs. Preventing the transmission of waterborne disease is a shared responsibility of federal, state, and local health and regulatory agencies and drinking water purveyors—all have an important role in protecting public health. Currently under consideration by the USEPA to reduce waterborne infectious disease risks are: (1) criteria by which state regulatory agencies will determine when filtration will be required for public water systems using surface water sources,[1] (2) disinfection requirements for all public surface water systems,[1] and (3) amendments for MCLs and monitoring of total coliform bacteria.[16]

Historical considerations

In the early part of this century, protection of water sources from discharges of human sewage, filtration of surface water, and disinfection with chlorine were major factors in the dramatic reduction of waterborne diseases such as typhoid fever and cholera. As early as 1893, Mills and Reinke[17] reported improvement in the general overall health of a community after a polluted water supply had been replaced by an unpolluted supply. In 1903 Hazen[17] associated

improvements in health status with water treatment; when a community water supply received adequate treatment, Hazen observed not only a reduced mortality from typhoid but also a reduced mortality from other diseases.

Slow sand filtration of municipal supplies was first applied in the United States in 1889 at Albany, N.Y., and the first mechanical or rapid sand filter built along modern lines was installed in 1893 at Lawrence, Mass.[18] After filtration, the typhoid fever mortality rate was reduced in both cities to 26 cases/100,000 people from an average of 104/100,000 in Albany and 121/100,000 in Lawrence.[19] By 1904, about 10 percent of the US urban population received filtered water; by 1914, 30 percent received filtered water.[18] Similar reductions in typhoid mortality were also observed in other cities after the installation of sand filters. Whipple noted as early as 1908 that "filtration affords the safest protection of surface waters against waterborne diseases. This has been proved . . . abroad, and data illustrating this truth are being accumulated in this country."[19]

The first continuous application of chlorine for disinfection of a municipal water supply in the United States was in 1908. Sodium hypochlorite was used to disinfect the Boonton Reservoir of Jersey City, N.J.[18] George Johnson, one of the proponents of chlorination for disinfection, reported in 1911 that filtration was inadequate as the sole means of treatment for polluted water; over the years disinfection has been established in conjunction with filtration or as a treatment process by itself.[17] The early acceptance of chlorine as a public health safeguard and the development in 1912 of commercial equipment to apply gaseous chlorine to water supplies provided for the rapid expansion of chlorine disinfection.[17] By 1940, some 31 percent of community water systems provided disinfected water, and approximately 67 percent of the US population was served by disinfected or filtered water.[18] Efforts of the Kansas State Health Department provide an example of the use of water chlorination as a public health safeguard.[17] Between 1908 and 1917 at least 30 Kansas communities began using hypochlorite solutions for disinfection, and by 1919 many larger cities had disinfection. By 1942 all 60 surface supplies in Kansas were chlorinated, and by 1960 all public supplies were chlorinated except one.

Multiple barrier concept

In conjunction with sewage treatment and natural barriers that protect water sources from discharges of human sewage, filtration of surface water and disinfection continue to be important in preventing waterborne disease outbreaks. They are considered an essential part of the multiple barrier concept that has evolved from water supply practices and experiences.[20] This provides for not only the improvement and protection of raw water quality, but also the removal and inactivation of microorganisms by appropriate water treatment. Under the multiple barrier concept, reliance is placed on more than one type of treatment to protect against waterborne transmission of disease.

Public health officials are committed to the theory of multiple barriers of treatment and multiple points of control between sewage discharges and water supply intakes. Any type of treatment is fallible, so natural barriers should be maintained wherever possible and multiple water treatment processes should be considered. Disinfection with chlorine or an alternative is the last line of defense or final barrier.[17] For disinfection to be an effective final barrier, the preceding barriers must reduce the microbiological population and remove possible interfering substances so that disinfection will be more efficient.

Properly designed and operated water clarification processes can be effective barriers that reduce the number of microorganisms passing through into finished drinking water.[20-22] At conventional rapid sand filtration plants, sedimentation is the first treatment barrier for the removal of microorganisms; the second is provided by filtration. Disinfection, the final barrier, inactivates the remaining microorganisms. Sedimentation is not part of the treatment process at rapid-rate direct sand, slow sand, and diatomaceous earth filtration plants, and because the only barrier against microorganisms is filtration, it is important to verify that the raw water quality is appropriate for this treatment process.

Some surface water systems rely primarily on natural barriers such as source protection to prevent contamination (e.g., by restricting human activity on the watershed) and provide disinfection as the only barrier. No treatment is provided to remove microorganisms and make the inactivation of waterborne pathogens more effective. For cases in which disinfection has been inadequate, overwhelmed by unanticipated contamination, or interrupted, such treatment has in numerous instances failed to prevent transmissions of waterborne disease.[18] The committee report[15] also addresses the limitations of simple disinfection as the only treatment of surface water and of reliance on the turbidity MCL as protection against the waterborne transmission of pathogens:

> Simple disinfection as the only treatment for surface water sources is ineffective in preventing waterborne transmission of giardiasis. All surface water should receive pretreatment and filtration in addition to disinfection. Both pressure and gravity sand filters have proven ineffective in removing *Giardia* cysts under conditions of poor, or simply casual, operation. This has occurred primarily in systems in which the raw water turbidity was low. Under these conditions, turbidity removal has been achieved without coagulants, but . . . *Giardia* cysts [have not been effectively removed]. Outbreak data, engineering experience, and filtration theory indicate that *Giardia* cysts can be reduced dramatically by properly functioning conventional sand filters, but the water must be effectively pretreated before filtration.* Effective pretreatment includes coagulation, flocculation, and settling prior to filtration or, if the settling process is not used, the addition of appropriate chemicals for conditioning the water or filter media. . . . Waterborne disease outbreaks, primarily giardiasis, have occurred in systems [in which] the health-related turbidity limit has not been exceeded. It cannot be assumed that meeting the turbidity limit will prevent waterborne [giardiasis or other infectious diseases]. . . . [S]afe drinking water can be assured only by properly designed and operated . . . plants that utilize coagulants or filter aids in addition to disinfection.

Natural barriers can contribute to the protection of source water quality but can never substitute for appropriate water treatment to remove and inactivate waterborne pathogens, especially protozoa. The life cycle of protozoa includes a cyst phase that generally has been found to be resistant to the low chlorine concentrations and contact times normally applied in water treatment practices. It is important to remove protozoa such as *Giardia* and *Cryptosporidium* from the water to decrease sole reliance on disinfection for cyst inactivation, because high chlorine concentrations or long contact times are required. For example, at 41°F (5°C) and pH 6.0, 2.0 mg HOCl/L for 40 minutes or 1.0 mg HOCl/L for 80 minutes contact time is required for 99 percent inactivation of *G. lamblia* cysts.[20] Waters with higher pH values require greater concentrations or longer contact times of HOCl. Use of chloramines for disinfection requires long contact times for 99 percent inactivation; at 37°F (3°C) and pH 7.5, 2.4 mg $NH_2Cl/NHCl_2$/L for 220 minutes or 1.2 mg/L for 440 minutes[20] (see reference 1 for values for 99.9 percent inactivation). The effectiveness of chloramine as a disinfectant is also affected by pH and the mode of application.

Numerous wild and domestic animals have been identified as important primary or intermediary sources of infection for giardiasis and other waterborne diseases.[1,18,23-25] The potential exists for contamination of all watersheds and surface waters by infected animals.

*Committee recommendations stress the need for chemical pretreatment or conditioning for rapid sand filtration. Slow sand or diatomaceous earth filtration can, in some situations, be successfully employed for the removal of *Giardia* cysts and other microorganisms; proper maintenance and operation are necessary to achieve 99.9 percent removal.[20]

TABLE 1
Waterborne outbreaks reported in groundwater and surface water systems—1971-85

Year	Number of Outbreaks	Cases of Illness	Cases per Outbreak
1971-75	124	27,831	224
1976-80	202	50,590	251
1981-85	176	32,807	186

TABLE 2
Waterborne outbreaks in groundwater and surface water systems by type of system—1971-85

Type of System	Number of Outbreaks	Cases of Illness
Community	211	75,754
Noncommunity	216	33,958
Individual	59	719
Total	502	111,228

because their complete exclusion from the watershed cannot be maintained. Systems using major river sources have relied more heavily on treatment to improve the aesthetic quality of water and to remove microorganisms; treatment techniques include both filtration and disinfection. Properly operated filtration plants can clarify water, making disinfection more effective, and can remove microorganisms, leaving fewer for the disinfection barrier to inactivate.[20-22]

Waterborne outbreaks

Statistics. The reporting of waterborne disease outbreaks has been and continues to be voluntary. Information on these outbreaks is obtained from scientific and medical literature and through the cooperation and assistance of state and local health officials, epidemiologists, and engineers. The USEPA and the Centers for Disease Control (CDC) have cooperated in the investigation and reporting of waterborne outbreaks since 1971, and publish outbreak data annually. Statistical data are available on waterborne outbreaks reported in the United States since 1920.

The incidence of waterborne disease in the US population has declined from about 8 cases of illness per 100,000 person-years during 1920-40 to 4 cases per 100,000 person-years during 1971-80.[18] A similar decline has not occurred in the number of waterborne outbreaks. More waterborne outbreaks were reported during 1971-85 than in any previous 15-year period since 1920 (Figure 1). During 1971-85, 502 waterborne outbreaks and 111,228 cases of illness were reported to CDC and USEPA (Table 1). The number of cases reported during this time period is exceeded only by the number reported during the time periods 1936-50 and 1920-35. However, the average number of cases per waterborne outbreak has decreased from 572 during 1926-30 and 681 during 1961-65 to 185 cases per outbreak during 1981-85 (Table 1).[18] With a few notable exceptions, reported waterborne outbreaks now tend to occur in small community* and noncommunity water systems, affecting fewer people. During 1920-36, waterborne outbreaks were more frequently reported in community systems, whereas in most succeeding years, outbreaks were more frequently reported in noncommunity systems.[18] During 1971-85, 42 percent of all reported waterborne outbreaks and 68 percent of the cases of illness occurred in community water systems; 43 percent of the outbreaks and 31 percent of the cases occurred in noncommunity systems (Table 2).

The use of contaminated, untreated groundwater or inadequately disinfected groundwater was responsible for 49 percent of the waterborne outbreaks (Figure 2) and 47 percent of the cases of illness reported during 1971-85 (Figure 3). The use of contaminated, untreated surface water or inadequately treated surface water was responsible for 24 percent of the waterborne outbreaks and 32 percent of the cases. The remaining outbreaks were caused by contamination of the distribution system and miscellaneous deficiencies, including use of water not intended for consumption, contaminated ice, and ingestion of contaminated water while swimming; data were insufficient to determine the source of contamination for 15 outbreaks.

Causes of outbreaks in surface water systems. In the 1971-85 period, 123 outbreaks of waterborne disease were attributed to contaminated, untreated surface water or inadequately treated surface water. A seasonal distribution of outbreaks is apparent; 60 percent occurred during May through September (Figure 4). It is not possible to determine the reason for this distribution, but it may be a result of increased contamination of surface water during the summer. Another explanation could be the increased use during the summer of seasonal or noncommunity water systems that may have inadequate treatment.

The number of outbreaks in untreated, disinfected-only, and filtered surface water systems were examined separately to determine the relative importance of each of these deficiencies. The increased use of disinfection and filtration for surface waters since 1920 is the likely reason for the decreased importance of contaminated, untreated surface water in the transmission of waterborne disease (Figure 5). For example, 19 percent of waterborne outbreaks during 1920-30 were attributed to this deficiency, compared with 8 percent during 1971-80 and 3 percent during 1981-85.

Until 1971, more outbreaks were attributed to the use of contaminated, untreated surface water than to deficiencies in treatment. Now outbreaks in surface water systems occur primarily because of inadequate or interrupted disinfection, especially in systems that provide disinfection as the only treatment (Figures 5 and 6). Thirteen percent and 14 percent of waterborne outbreaks during 1971-80 and 1981-85 were attributed to inadequate or interrupted disinfection of disinfected-only surface water, respectively. Previously only 3-7 percent of waterborne outbreaks had been attributed to this deficiency since 1931. In recent years an increased number of outbreaks of waterborne giardiasis has occurred in unfiltered surface water sources in which disinfection was inadequate or interrupted. It is important to remember that disinfection with chlorine can inactivate pathogens, including *Giardia* cysts, only if several conditions are maintained: (1) the water consistently has low concentrations of substances that can create a chlorine demand or interfere with the disinfection process; (2) a sufficient concentration of disinfectant and contact time, as determined from laboratory or field studies, can be provided according to various operating parameters, especially water temperature and pH; (3) the chlorine residual is not depleted for any reason; and (4) heavy or overwhelming contamination does not occur either briefly or intermittently. In the outbreaks occurring in unfiltered systems with inadequate disinfection, one or more of these conditions were not met. In most outbreaks, the chlorine concentration or contact time was insufficent. In all outbreaks, disinfection was ineffective for the number of pathogens in the raw water. During the period of suspected contamination in several outbreaks, chlorine residual levels were reduced to nothing. In outbreaks in which disinfection was interrupted, the chlorine equipment failed or the chlorine supply was exhausted.

*For this article, water systems are classified as community and noncommunity according to the definitions contained in the Safe Drinking Water Act. Individual water systems are used by residents in areas without community systems or by people traveling outside populated areas (e.g., backpackers, campers). Outbreaks associated with the ingestion of contaminated water while swimming, traveling, and so forth are classified as recreational.

In filtered surface water systems, the number of outbreaks attributed to inadequate or interrupted disinfection has remained relatively stable over the years, comprising 1 to 2 percent of waterborne outbreaks (Figure 6). During 1981–85, a dramatic increase in outbreaks was noted for filtered surface water supplies; 8 percent of waterborne outbreaks during this period were attributed to inadequate control of filtration or pretreatment, compared with 0–3 percent since 1931 and 6 percent during 1920–30. The increased outbreaks associated with inadequate or interrupted disinfection and inadequate filtration or pretreatment underscore that treatment not only must be designed to deal with varying source water quality, but also must be properly operated and maintained to provide continuous and effective removal and inactivation of pathogens.

Data have recently been made available on the population and the number of communities served by filtered and unfiltered surface water sources.[1] These data can be combined with the data on waterborne outbreaks to obtain outbreak and disease rates for various water sources and treatments. Comparison of these rates can provide an indication of the types of water systems most susceptible to outbreaks of waterborne disease. The waterborne outbreaks in community water systems attributed to contamination and inadequate treatment of surface water sources during 1971–85 were used to calculate outbreak and disease rates (Table 3). Outbreaks caused by contamination of the distribution system and miscellaneous deficiencies were excluded because their occurrence is unrelated to source water contamination and treatment; the reported chemical poisonings caused by deficiencies in chemical feed were also excluded. Because the reporting of waterborne outbreaks is voluntary, the rates should be used primarily for purposes of comparison. For identifying water systems with the greatest potential for failure, the outbreak rate (column 2, Table 3) is less variable and represents a more stable rate for comparison. The disease rate (column 3, Table 3), however, may have more public health significance because the severity of previous outbreaks is considered, and the prevention of large outbreaks can result in a dramatically lower disease rate.

Approximately 4,611 community water systems serve filtered and disinfected surface water to a population of some 133,560,000 people.[1] These systems experienced 23 outbreaks and 9,450 cases of illness for a rate of 5.0 waterborne outbreaks per 1,000 systems during 1971–85 and 4.7 cases of waterborne illness per million person-years (Table 3). Community water systems that provide disinfection as the only treatment for surface water experienced an out-

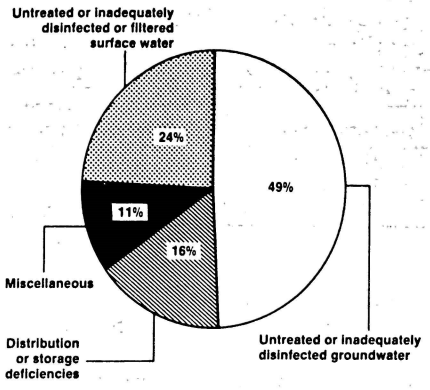


Figure 2. Causes of 502 waterborne disease outbreaks—1971–85

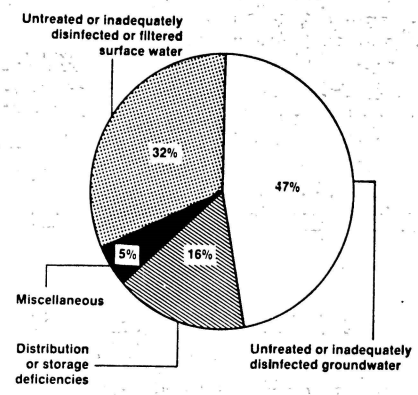


Figure 3. Causes of 111,228 cases of waterborne illness—1971–85

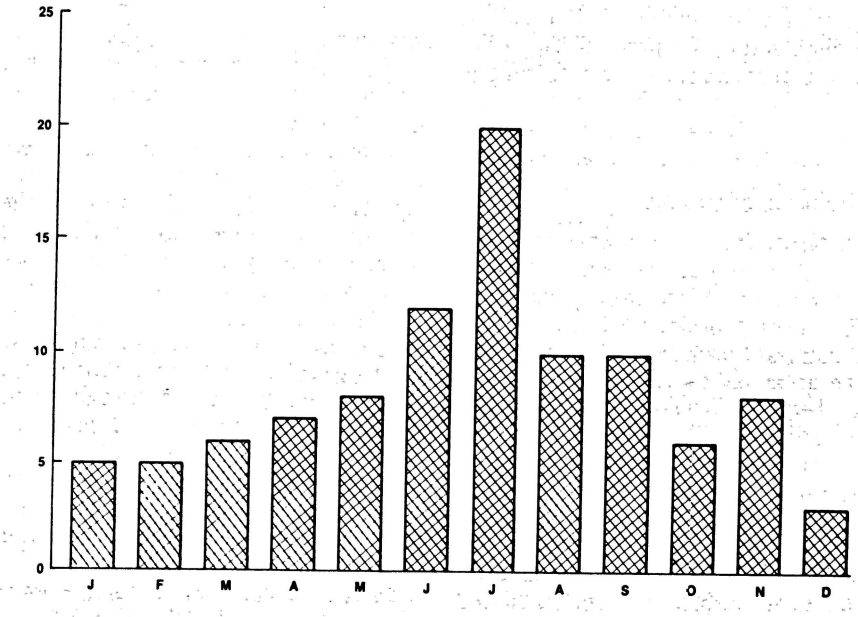


Figure 4. Seasonal distribution of waterborne disease outbreaks in surface water systems—1971–85

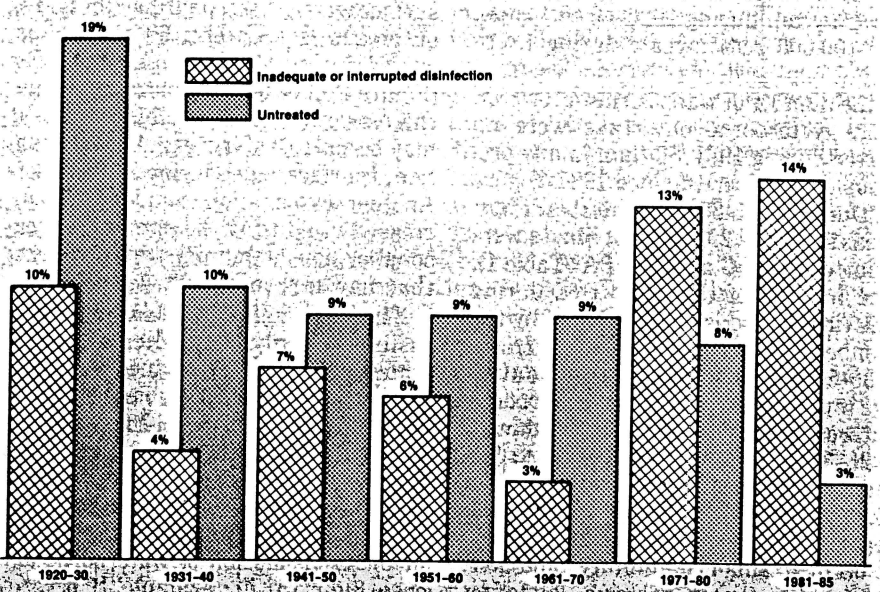


Figure 5. Waterborne disease outbreaks in untreated and disinfected-only surface water systems—1920–85 (*percent of all waterborne outbreaks in each time period as reported in Figure 1*)

break rate of 40.5/1,000 facilities (eight times the rate for filtered and disinfected surface water) and a disease rate of 66.3/1,000,000 person-years (fourteen times the rate for filtered and disinfected surface water). The rates for community water systems using untreated surface water are also much higher than the rates for communities with filtered surface water; however, these rates are highly variable because they are based on only five outbreaks and 612 cases of illness in 154 water systems serving 110,000 people. A high risk of illness would be expected among populations using untreated surface water, and this situation should not be allowed. Lower outbreak and disease rates should result from filtration of community surface water systems. To achieve rates lower than currently observed for filtered surface water sources requires more emphasis on installation, design, operation, and maintenance of filtration facilities.

Etiologic agents. Further investigation of the adequacy of treatment and operation of surface water systems requires identification of the etiologic agents responsible for waterborne outbreaks in these systems. An etiologic agent was determined in only 50 percent of waterborne outbreaks in both groundwater and surface water systems reported for all causes during 1971–85; the remaining outbreaks were categorized as acute gastrointestinal illness of unidentified etiology (Table 4). Although each of the etiologic agents responsible for waterborne diseases shown in Table 4 could potentially be transmitted through contaminated surface water systems, *Giardia lamblia* was the most commonly identified pathogen responsible for waterborne outbreaks in surface water systems (Figure 7). Chemical poisonings have occurred primarily in groundwater systems but have also occurred in surface water systems through cross connections and inadequate control of chemical feed; these are not included in Figure 7. Only one outbreak of cryptosporidiosis (in a groundwater system) was reported during 1971–85, but this could be an important contaminant of surface water systems. The occurrence of *Cryptosporidium* is widespread, and animals as well as humans are important in the waterborne transmission of this organism.[24,25] Little is known about the inactivation of *Cryptosporidium* oocysts by chemical disinfectants, but the available data suggest the organisms may be more resistant to chlorination than *Giardia*.[26] Thus, it may be necessary to remove the oocysts from water by filtration rather than depend on inactivation by disinfection. A large waterborne outbreak of several thousand cases of cryptosporidiosis occurred in a filtered surface water system in Carrollton, Ga., during January and February 1987. Water treatment included coagulant feed, mechanical rapid mix, flocculation, sedimentation, and filtration through anthracite sand filters (2 gpm/sq ft [1.4 mm/s]). During the investigation of the outbreak, analysis of filtered water turbidity at each filter effluent suggested that the practice of stopping and later restarting the flow of water through some filters without backwashing could result in passage of alum floc and contaminants through the filters into the finished water. Earlier USEPA research indicated that turbidity breakthrough, or passage of floc through the filter, could be accompanied by contaminants such as *Giardia* cysts,[27] and it is believed that *Cryptosporidium* oocysts entered the system because the filters were not backwashed prior to placing them in service. Recommendations also included the routine monitoring of turbidity at each filter effluent to prevent turbidity breakthrough of individual filters.

The etiology of waterborne outbreaks in surface water systems was examined for each specific water supply deficiency (Table 5). Giardiasis was the disease most often transmitted because of ineffective filtration or pretreatment of surface water and inadequate or interrupted disinfection of surface water for systems in which disinfection was the only treatment. These deficiencies were responsible for 54 outbreaks and 20,197 cases of giardiasis, 44 percent of all outbreaks, and 58 percent of all cases of illness reported in surface water systems. Although a significant number of giardiasis outbreaks occurred in untreated surface water systems, only 322 cases of giardiasis were reported in these systems, compared with 1,078 cases of gastroenteritis of undefined etiology. The use of untreated surface water is an important cause of outbreaks primarily in noncommunity and individual systems, because only 154 community water supplies[1] provide no treatment of surface water. Interrupted disinfection of surface water caused more gastroenteritis outbreaks of undefined than defined etiology. Approximately 38 percent of all outbreaks in surface water systems were categorized as gastroenteritis of undefined etiology (Figure 7). In many of these outbreaks, the search for an etiologic agent included only stool cultures for *Salmonella* or *Shigella*; in others the collection and investigation of clinical specimens were delayed. Thus, these outbreaks may have been caused by (1) less common bacterial agents, parasites, or viruses that could not be identified because appropriate testing was not done, or (2) etiologic agents that could not be identified because samples were not collected in a timely manner. It is suspected that the gastroenteritis outbreaks represent a combination of viral, bacterial, and parasitic etiologies. In recent years, viral gastroenteritis caused by Norwalk agent or rotavirus, bacterial gastroenteritis caused by *Campylobacter* and *Yersinia*, and cryptosporidiosis have been reported in waterborne outbreaks in surface water and groundwater systems. Each of these agents should be considered during a waterborne outbreak, depending on the symptomatology, and appropriate clinical testing should be performed to identify the etiologic agent. Only by identifying the etiologic agents of waterborne outbreaks can it be ascertained that current sanitary survey activities and water treatment techniques are adequate to prevent transmission of specific infectious diseases.

The most important etiologic agent for surface water systems is *Giardia* (Figure 7). When waterborne outbreaks caused by *Giardia* are analyzed separately, it becomes clear that water supply deficiences responsible for giardiasis are different from the deficiencies responsible for other diseases (Figure 8). Some 71 percent of the waterborne outbreaks of giardiasis during 1971–85 were attributed to the inadequate or interrupted disinfection of surface water, the inadequate filtration or pretreatment of surface water, and the use of contaminated, untreated surface water. Some 20 percent of the giardiasis outbreaks were attributed to use of contaminated, untreated groundwater; inadequate or interrupted disinfection of groundwater; cross-connections; and other distribution system deficiencies. For the other waterborne diseases reported during 1971–85, only 14 percent of the outbreaks were attributed to inadequate or interrupted disinfection, inadequate filtration, and contaminated, untreated surface water. The majority (74 percent) of waterborne outbreaks of other diseases was attributed to contaminated, untreated, and inadequately disinfected groundwater; cross connections; and other distribution deficiencies.

Summary. Outbreaks of waterborne disease continue to occur—the largest number in any 15-year period since 1920 was reported during 1971–85. Because such outbreaks now occur primarily in small community and noncommunity water systems, the incidence of waterborne disease has declined since 1920. Almost three fourths of the outbreaks in the past 15 years were caused by contaminated, untreated groundwater and surface water, or inadequately treated groundwater and surface water. Adequate, continuous disinfection is a necessary final barrier to prevent the transmission of waterborne disease. Disinfection has, however, been inadequate as the only treatment for surface water, and, in all but exceptional situations, effective filtration must also be provided

(including any required pretreatment). Outbreak data also indicate that more emphasis should be placed on the design and operation of filtration facilities if they are to be effective as part of the multiple barrier concept to prevent the transmission of waterborne disease.

Epidemiologic studies of disinfection and chronic disease

The use of chlorine as a disinfectant has been shown to generate a variety of chlorinated organic compounds in drinking water.[28-31] Under certain conditions, free chlorine reacts with selected precursors in drinking water to produce a group of halogen-substituted single-carbon compounds referred to as total trihalomethanes (TTHMs). The THMs include suspected human carcinogens, and their control is required by the NIPDWRs.[4] The concentration of THMs is dependent on the presence and concentration of the precursors, chlorine dosage and contact time, water temperature, and pH.[32] In most instances, more THMs are produced in chlorinated surface waters, but groundwaters in some areas are capable of producing high levels.[32] Because the important precursors that react with free chlorine to produce THMs are naturally occurring aquatic humic substances, THMs have undoubtedly been present in water supplies as long as chlorine has been used as a disinfectant.

Descriptive epidemiologic studies. Since 1974, a number of statistical and epidemiologic studies have been conducted in the United States to assess the relationship between cancer and drinking water quality. These studies differ markedly in their design and in what they can reveal about this possible association. Because of the widespread exposure to chlorination by-products, most of these studies have focused on the chlorination of drinking water. Historical information on water sources and chlorination practices have primarily been used as surrogate measures of exposure to THMs, but in some instances current levels of THMs have been used in conjunction with various operational parameters to estimate historical exposure levels.

To better interpret the results of epidemiologic studies, it is necessary to have a basic understanding of the various types of epidemiologic studies. These are briefly reviewed according to a classification scheme proposed by Monson[33] (Table 6). In an experimental study, the investigator randomly assigns exposure to a study participant (e.g., clinical drug trials), whereas in a nonexperimental study, the investigator has no control over exposure. Environmental epidemiologic studies are nonexperimental. In a descriptive study, information is available on exposure and disease for groups of people only, or information is available only on exposure or disease. Most of the early drinking water epidemiologic studies were descriptive in design, and information on cancer and use of chlorinated water is available only for population groups. The epidemiology subcommittee of the National Academy of Sciences Safe Drinking Water Committee reviewed the descriptive studies conducted through 1978.[33] Nine of 10 descriptive studies found associations between chlorinated surface water and either cancer incidence or mortality, and three additional studies found associations between current levels of THMs and cancer mortality. But these studies have limited value because it is not possible to interpret whether the observed associations are a result of exposure to chlorinated water or a result of potential confounding characteristics that could not be assessed. Although some demographic variables were considered for population groups, no data are available on exposures or confounding characteristics for individuals in these epidemiologic studies. Thus, it is impossible to adequately control or assess these characteristics. The review by the National Academy of Sciences[34] concluded that "the bladder, stomach, large intestine and rectum, which were cancer sites identified in a number of geographic areas, warrant further study" and recommended that analytic epidemiologic studies be conducted. In an analytic epidemiologic study, information on exposures, disease, and potential confounding characteristics is available for each study participant; confounding bias can be assessed and controlled, and a quantative estimate of risk can be obtained.

Analytic epidemiologic studies. Analytic studies can be either longitudinal or cross-sectional.[30,31,33] In a longitudinal study, the time sequence between exposure and disease can be inferred, but in a cross-sectional study, the data on exposure and disease relate to the same point in time. Longitudinal epidemiologic studies include case-comparison and cohort designs. In a case-comparison study, individuals enter the study on the basis of disease status, and various exposures are determined. In a cohort study, individuals enter the study on the basis of exposure status, and each individual is followed to determine morbidity or mortality. In a prospective cohort study, the disease has not occurred at the time the exposed and nonexposed groups are defined. In a retrospective cohort study, the disease has occurred at the time the exposed and nonexposed groups are defined. Both case-comparison and cohort studies of associations between water chlorination and cancer require an assessment of previous or historical exposures because of the long latency period for development of cancer. Analytic studies allow the epidemiologist to make a quantitative statement about an observed association between water chlorination and cancer by comparing rates of similar types. The basic measures of this association are the rate ratio or relative risk and rate difference or absolute risk. In a cohort study, relative and absolute risk are determined from disease rates. In a case-comparison study, the proportion of cases and comparison subjects is arbitrarily determined by the investigator, and, because disease rates are meaningless, the exposure-odds ratio must be determined. The exposure-odds ratio is equivalent to the rate ratio or relative risk for rare diseases.[32] An attributable risk similar to the absolute risk obtained in a cohort study must be estimated.

A rate ratio of unity (1.0) indicates no association; that is, the disease rate is the same for the exposed and unexposed groups, or exposure is similar in cases and comparison subjects. Any other value indicates some association. A rate ratio below 1.2, however, indicates essentially no association, as one or more unknown confounding factors could lead to a weak association, and an epidemiologist's ability to identify and measure such weak confounding factors is limited. It is generally accepted that if some confounding factor that accounts for a larger rate ratio exists, its detection should be relatively simple.[33] Ranges of the rate ratio may be used to judge the strength of the observed association (Table 7). The size of a rate ratio, however, has little to do with the possibility that an association could be the result of systematic bias or random variability (Table 8). This must be assessed separately, and more information is given in references 30, 31, and 33.

Results have been reported for a cohort study and several case-comparison studies of the relationship between water chlorination or current levels of THMs and cancer in the United States. Wilkins and Comstock[35] studied three historical cohorts, each distinguished by a different degree of exposure to chloroform and other chlorination by-products. Incidence rates for bladder cancer among men and liver cancer among women were nearly twofold higher in the drinking water cohort supplied with chlorinated surface water at home versus the cohort supplied with unchlorinated groundwater. The results of this study, however, cannot be interpreted as a true association; the reported rates are unstable and subject to random variation, as few cancer deaths occurred in the cohort.

A variation of the traditional case-comparison study using data available from death certificates for decedent cases and comparison subjects has been used to obtain information on associations of cancer and water quality. Because no interviews with study participants are conducted, the advantages of this approach include considerable cost savings.

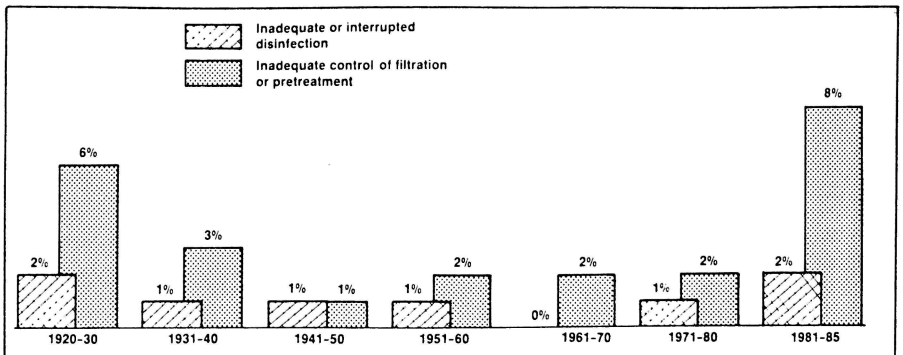


Figure 6. Waterborne disease outbreaks in filtered surface water sytems—1920-85 (*percent of all waterborne outbreaks in each time period as reported in Figure 1*)

The disadvantages of this approach, however, include the loss of important information on residence history, exposures, and confounding characteristics. A review[36] of five case-comparison mortality studies completed through 1981 concluded that information provided by the studies strengthened the evidence for an association between rectal, colon, and bladder cancers and water chlorination but was not sufficient to establish a causal relationship between chlorinated by-products in drinking water and cancer. Because of methodological limitations and the small increased risks observed in these studies, it was not possible to interpret whether the observed associations are a result of exposure to chlorinated water or potential confounding characteristics that could not be assessed or controlled.

Colon and bladder cancer risks. Two recently reported studies[37,38] have employed traditional case-comparison study designs in which individuals were interviewed. Cragle et al[37] investigated the relationship between water chlorination and colon cancer using 200 incident cases of colon cancer from seven hospitals in North Carolina and 407 hospital-based comparison subjects without evidence of cancer and no history of familial polyposis, ulcerative colitis, adenomatous polyposis, or any other major chronic intestinal disorder. Both cases and comparison subjects were required to be residents of the state for at least 10 years to be included in the study. Comparison subjects were matched on age, race, gender, vital status, and hospital to prevent potential confounding by these characteristics. Additional information on potential confounders, including alcohol consumption, genetic risk (number of first-degree relatives with cancer), diet, geographic region, urbanicity, education, and number of pregnancies, was obtained either by mailed questionnaire or telephone interview. These characteristics were assessed and controlled in the analysis. Approximately 71 percent of the eligible population was included in the study. Water exposures were verified for each address and categorized as chlorinated or unchlorinated for the analysis. Logistic regression analysis showed genetic risk, a product term between alcohol consumption and a high-fat diet, and an interaction term between age and chlorination to be positively associated with colon cancer. The association between chlorinated water and colon cancer was found to be highly dependent on age. Rate ratios (*RR*) for people who drank chlorinated water at their residences for 16 or more years were consistently higher than those exposed to chlorinated water less than 16 years, but a statistically significant association between water chlorination and colon cancer, controlling for possible confounders, was found only for those above age 60 (Table 9). For example, 70-79-year-olds who drank chlorinated water for 16 or more years had twice ($RR = 2.15$) the risk of colon cancer compared with 70-79-year-olds who drank unchlorinated water. In the same age group, the risk of colon cancer was about 50 percent ($RR = 1.47$) higher in those who drank chlorinated water for less than 16 years compared with those who drank unchlorinated water.

Cantor et al[38] reported results from a collaborative USEPA-National Cancer Institute (NCI) study of the association between water chlorination and bladder cancer. The study included 2,982 people (73 percent of those eligible to participate) between the ages of 21 and 84 diagnosed with cancer of the urinary bladder in 1978 and residing in 10 areas of the United States (Connecticut, Iowa, New Jersey, New Mexico, Utah, and the metropolitan areas of Atlanta, Ga.; Detroit, Mich.; New Orleans, La.; San Francisco, Calif.; and Seattle, Wash.) and 5,782 population-based comparison subjects, randomly selected and frequency matched on gender, age, and study area. Subjects were interviewed at home by a trained interviewer, and data were collected for a number of possible confounders including smoking, occupation, artificial sweetener use, coffee and tea consumption, and use of hair dyes. A complete residence history was obtained to categorize individuals according to water sources and chlorination status on a year-by-year basis, and information was obtained on use of bottled water and fluid consumption. Of the 587,568 person-years lived by all residents since 1940, 76 percent were at a known water source. Logistic regression analysis was used to control for potential confounders. Among people in all study areas combined, relative risk was not elevated in those respondents living in areas with chlorinated water supplies for 20, 20-39, 40-59, and 60 or more years. This study was originally designed to determine whether saccharin was a human carcinogen rather than to determine cancer risks associated with water chlorination. The study areas were not selected to provide the optimal variability of water sources and treatment, and the statistical power of the study is less than suggested by the large number of individuals studied, as the five metropolitan areas are served primarily by chlorinated water supplies. Among the 10 study areas, participants from the three states with agricultural land use did show an elevated risk for bladder cancer with the number of years at a surface source, but the number of participants in these areas was small compared with the other areas. Among nonsmokers who were never employed in a high-risk occupation (a group otherwise at low risk for bladder cancer), the risk was elevated among those served by chlorinated surface sources with evidence of a duration of exposure-response relationship (Table 10). Only in nonsmokers who resided 60 or more years at a residence served by chlorinated water was the relative risk statistically significant; in this instance the risk of bladder cancer was more than double ($RR = 2.3$) the risk among nonsmokers who resided in areas served by unchlorinated water.

Further analysis of the USEPA-NCI national bladder cancer study has recently been reported by Cantor.[39,40] Among study participants who drank chlorinated surface water for at least 40 years, a small increase in bladder cancer risk was associated with higher tap water consumption. After correcting for age, smoking, and other potential confounding characteristics, it was observed that people who drank the most chlorinated tap water (in the highest quintile) had a bladder cancer risk about twice that of people who drank the least (in the lowest quintile). No increased bladder cancer risk with increased consumption of tap water was observed among consumers of chlorinated surface water for less than 40 years or among long-term consumers of unchlorinated water (primarily groundwater).

To confirm the observed associations between chlorinated water and bladder and colon cancer, a collaborative case-comparison study with NCI and the University of Iowa was initiated in 1986.

TABLE 3

*Waterborne outbreak and disease rates attributed to source contamination and treatment inadequacies in community systems using surface water sources—1971-85**

Type of Community Water System	Waterborne Outbreaks per 1,000 Water Systems	Waterborne Illness per Million-Person Years
Untreated surface water	32.5	370.9
Disinfected-only surface water	40.5	66.3
Filtered and disinfected surface water	5.0	4.7

*Number of community water systems and population served by untreated, disinfected-only, and filtered-disinfected surface water sources from reference 1

TABLE 4

Etiology of waterborne outbreaks in groundwater and surface water systems—1971-85

Illness	Number of Outbreaks	Cases of Illness
Gastroenteritis, undefined	251	61,478
Giardiasis	92	24,365
Chemical poisoning	50	3,774
Shigellosis	33	5,783
Hepatitis A	23	737
Gastroenteritis, viral	20	6,254
Campylobacterosis	11	4,983
Salmonellosis	10	2,300
Typhoid	5	282
Yersiniosis	2	103
Gastroenteritis, toxigenic *E. coli*	1	1,000
Cryptosporidiosis	1	117
Cholera	1	17
Dermatitis	1	31
Amebiasis	1	4
Total	502	111,228

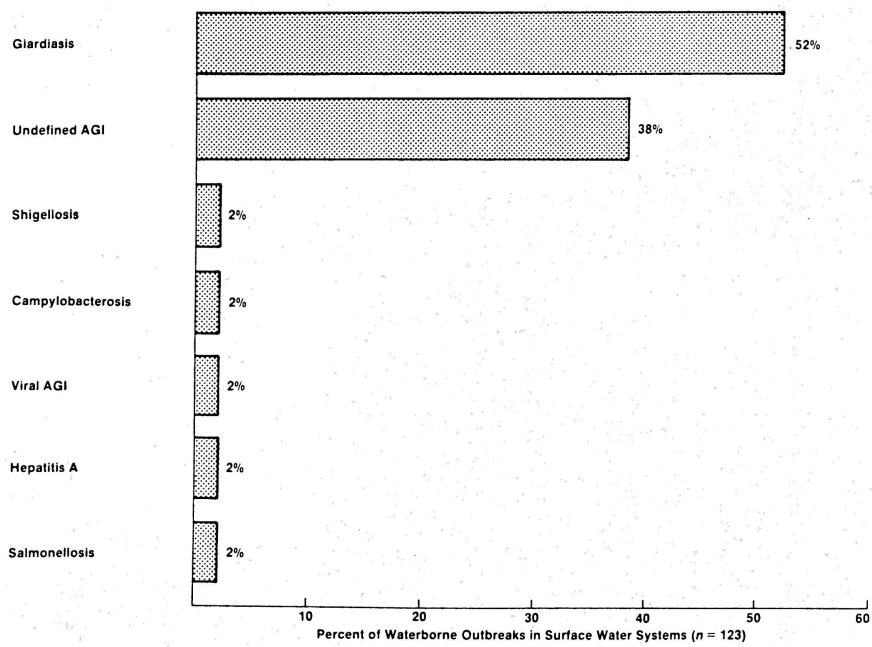


Figure 7. Etiology of waterborne disease outbreaks in untreated, disinfected-only, and filtered surface water systems—1971-85

Approximately 3,200 incident cases of cancer of the colon, rectum, bladder, brain, pancreas, lung, and kidney and approximately 1,500 population-based comparison subjects matched for race, gender, and age will be interviewed in Iowa for information on lifetime residential history, smoking, occupation, medical history, diet, and socioeconomic status to determine cancer risks associated with chlorinated drinking water and water contaminants from agricultural runoff.[41] An exposure history will be developed from the lifetime residential history and water quality data on chlorine use, THMs, six volatile organic compounds, total organic carbon, total organic halide, pesticides, pH, water temperature, total dissolved solids (TDS), and nitrates.

Lynch et al[41] also conducted a separate analysis of the Iowa portion of the USEPA-NCI national bladder cancer study. Included were 300 primary, histologically confirmed cases of bladder cancer in whites and 708 comparison subjects, all of whom had spent more than 50 percent of their lifetimes on primary water sources with known chlorination exposure. In general, those study participants exposed to chlorinated water sources for more than 30 years had twice the risk of bladder cancer observed in participants exposed to unchlorinated water sources. Relative risks were found to be higher when only those participants exposed to surface water or shallow groundwater that was chlorinated prior to filtration (at which point THMs tend to be higher) were compared with participants exposed to unchlorinated water.

Young et al[42] reported an association between colon cancer mortality in Wisconsin and a surrogate THM exposure in drinking water estimated by the average daily chlorine dosage of water over a 20-year period. The study included 8,029 cancer deaths and 8,029 noncancer deaths in white females matched on county of residence, year of death, and age. Death certificates provided information on urbanicity, marital status, and occupation, and these were considered as potential confounders. This association was further pursued in an interview study of 347 incident cases of colon cancer, 611 population-based comparison subjects, and 639 comparison subjects with cancer of other sites.[43,44] Lifetime residential and water source histories and information on water-drinking habits, diet, sociodemographics, medical and occupational histories, lifestyle, and other factors were obtained by questionnaire. No data were available on past THM levels, and these were estimated using a predictive statistical model based on current, quantitative THM levels and routinely recorded operating data for Wisconsin water supplies. Multivariate analyses, controlling for variation in water consumption, population size, and other factors, were used to estimate the colon cancer risk for various drinking-water-related factors. Although this case-comparison study associated colon cancer incidence with the ingestion of chlorinated drinking water, no increased risks were observed between colon cancer incidence and estimated THM exposure in Wisconsin. Current THM levels in these water supplies were, however, generally low, with 98 percent of samples having THM

concentrations of less than 100 μg/L. Colon cancer cases consumed water more frequently from municipal groundwater supplies, and, because groundwaters in the United States have been shown to be contaminated with synthetic volatile organic compounds,[45] the possibility of other water exposures must be considered. A study to examine exposures of this population to organic contaminants in groundwater has been conducted, and the data obtained from this epidemiologic study has been reanalyzed considering these exposures. Preliminary data from this study[44] show higher estimated relative risks (RR = 1.6–2.4) of colon cancer incidence in populations exposed to tetrachloroethylene, trichloroethylene, and 1,1,1-trichloroethane in municipal groundwaters.

Because chloramination has been shown not to produce THMs,[46] epidemiologic studies have been conducted in Massachusetts, where chlorine and ammonia have been used since 1938 to disinfect surface water provided to most communities in the Boston metropolitan area. A recently completed mortality study[47] showed a slight increase in bladder cancer in populations in Massachusetts receiving chlorinated surface water compared with populations receiving chloraminated surface water. To address problems in interpretation of the results of this study, a case-comparison study was conducted of 614 individuals who had died of primary bladder cancer and on 1,074 individuals who had died of other causes.[48] Confounding by age, gender, smoking, occupation, and socioeconomic status was controlled by multiple logistic regression. Preliminary results confirm a higher risk of bladder cancer mortality in populations receiving chlorinated drinking water; the risk of bladder cancer mortality among lifetime consumers of chlorinated water was three times the risk of bladder cancer mortality among lifetime consumers of chloraminated drinking water.

Cardiovascular disease risk. Preliminary data from experimental animals have suggested that chlorination of drinking water may also have long-term implications in cardiovascular disease risk. Carneau pigeons fed a diet containing 80 percent of the recommended daily allowance of calcium showed higher serum cholesterol levels after three months of exposure to 10 mg chlorine/L in water compared with pigeons who drank unchlorinated water.[49] Pigeons on a normal diet with adequate calcium and chlorinated water showed no difference in serum cholesterol from those consuming unchlorinated water. Autopsies of the high-cholesterol pigeons suggested they had developed more atherosclerotic plaques. These findings are currently being confirmed by the USEPA in further animal studies, a human clinical study,[50]

TABLE 5

*Etiology of waterborne outbreaks in surface water systems—1971-85**

Water Supply Deficiency and Resultant Illnesses	Number of Outbreaks	Cases of Illness
Untreated surface water		
Gastroenteritis, undefined	15	1,078
Giardiasis	12	322
Shigellosis	2	278
Campylobacterosis	1	21
Hepatitis A	1	17
Salmonellosis	1	3
Total	32	1,719
Inadequate disinfection of surface water (disinfection-only treatment)†		
Giardiasis	36	12,673
Gastroenteritis, undefined	10	5,247
Campylobacterosis	2	3,022
Gastroenteritis, viral	1	190
Salmonellosis	1	34
Total	50	21,166
Interrupted disinfection of surface water (disinfection-only treatment)		
Gastroenteritis, undefined	13	1,981
Shigellosis	1	50
Giardiasis	3	84
Total	17	2,115
Interrupted disinfection of surface water (filtration and disinfection)		
Gastroenteritis, undefined	2	67
Gastroenteritis, viral	1	25
Hepatitis A	1	6
Total	4	98
Ineffective filtration or pretreatment of surface water (filtration and disinfection)		
Giardiasis	15	7,440
Gastroenteritis, undefined	4	651
Gastroenteritis, viral	1	1,761
Total	20	9,852

*Excluding outbreaks in surface water systems caused by chemical feed, distribution, storage, or miscellaneous deficiencies

†Includes two outbreaks (42 cases) of giardiasis in which filtration facilities were bypassed and one outbreak of campylobacterosis (22 cases) in a system using both groundwater and surface water

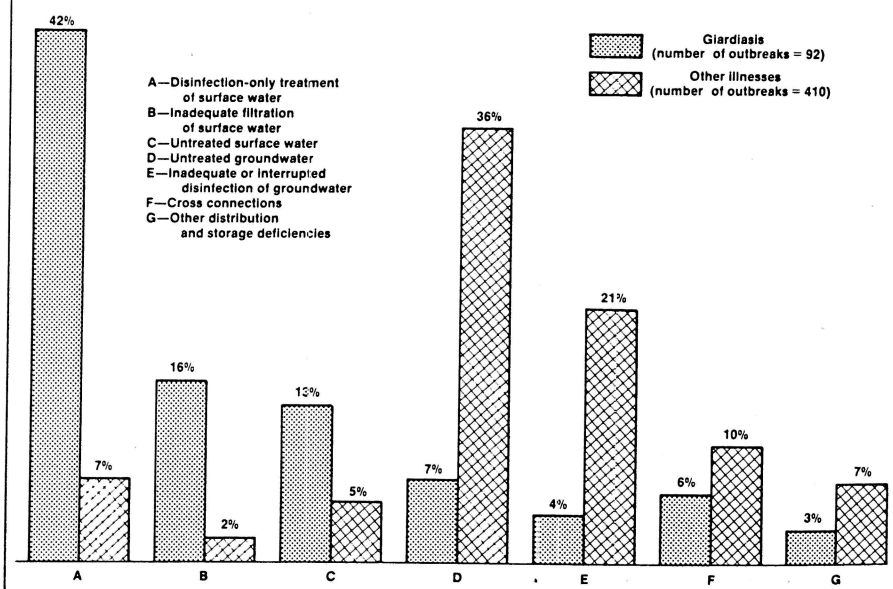


Figure 8. Major water supply deficiencies responsible for waterborne disease outbreaks—1971-85 (*percent of all waterborne outbreaks of giardiasis and all other illnesses, respectively*)

TABLE 6
Types of epidemiologic studies[33]

- I. Experimental
- II. Nonexperimental
  - A. Descriptive
  - B. Analytic
    - 1. Longitudinal
      - a. Cohort
        - (1) Prospective
        - (2) Retrospective
      - b. Case-comparison
    - 2. Cross-sectional

TABLE 7
A guide to strength of association[33]

Rate Ratio or Relative Risk	Strength
1.0-1.2	None
1.2-1.5	Weak
1.5-3.0	Moderate
3.0-10.0	Strong
>10.0	Infinite

TABLE 8
Accuracy of quantitative statement about association between exposure and disease

- I. Precision (lack of random error)
  - A. Size of study population
  - B. Efficiency of information
- II. Validity (lack of systematic error)
  - A. Internal validity
    - 1. Selection bias
    - 2. Observation bias
    - 3. Confounding bias
    - 4. Misclassification
  - B. External validity
    - 1. Scientific generalization
    - 2. Interpreted in context of other information

and an epidemiologic study.[51] Field work has been completed for the cross-sectional epidemiologic study of 2,300 adult residents, aged 40 years or older, in 46 Wisconsin communities supplied with chlorinated and unchlorinated drinking water of varying hardness. This study was designed to determine whether differences in calcium or magnesium intake from water and food and chlorination of drinking water affect blood pressure, serum lipids, or thyroid function. A questionnaire was administered to each participant to obtain data on occupation, health history, medications, dietary history, water use, water supply, and other basic demographic information. Household water samples were collected and analyzed for chlorine residual, pH, calcium, magnesium, lead, cadmium, and sodium. Specimens of fasting blood were collected from each participant and analyzed for total cholesterol, triglycerides, high density and low density lipoproteins, and thyroid hormones (T3, T4, TSH), and blood pressures were determined for each participant. Preliminary data indicate that study participants in the communities with chlorinated water have higher total cholesterol and low density lipoprotein levels. However, the implications for cardiovascular risk are unclear because no relationship was found between high density lipoprotein levels and water chlorination. Whether water chlorination presents a risk for cardiovascular disease must await not only the complete analysis of this epidemiologic study but also the clinical and experimental animal studies currently in progress.

Summary. The most recently reported case-comparison epidemiologic studies have provided further evidence for an association between chlorinated drinking water and colon and bladder cancers and an indication of the magnitude of the potential cancer risk. Based on Monson's guide to interpreting the strength of an association, a weak-to-moderate association between water chlorination and colon cancer was observed in an elderly population in North Carolina. This association was found to be stronger among the elderly who had been exposed to chlorinated water for more than 15 years. Colon cancer mortality and incidence were associated with the use of chlorinated drinking water in Wisconsin, but there was no evidence that THMs accounted for the association. Because surface waters in Wisconsin contain low THM levels (generally less than specified in the NIPDWRs), exposures to THMs may not have been sufficient in this study to detect excess risk by epidemiologic techniques. Colon cancer incidence was also associated with chlorinated municipal groundwaters and increased exposures to other volatile organic compounds in Wisconsin. In a national study, a moderately strong association between chlorinated water and bladder cancer was observed in an otherwise low-risk population (nonsmokers) that had received chlorinated surface water for 60 or more years. Higher bladder cancer risk was also associated with increased water consumption by long-term users of chlorinated surface water. In the Iowa portion of this study, higher relative risks for bladder cancer were observed when the analysis compared only populations receiving drinking water that had been chlorinated prior to filtration with populations receiving unchlorinated water.

In most of the epidemiologic studies, increased risks of colon and bladder cancer in populations receiving chlorinated water were estimated relative to risks in populations receiving unchlorinated water. Because few surface waters are unchlorinated, water exposures from chlorinated surface waters are compared primarily with unchlorinated groundwaters, and contaminants other than chlorinated by-products may be responsible or contribute to these observed cancer risks. Although these studies have consistently found an association between chlorinated drinking water and colon and bladder cancer, no direct evidence has been obtained from epidemiologic data to show that THMs are responsible. It is possible that previous exposures to THMs have not been (or cannot be) accurately estimated and results have thus been biased toward the null hypothesis. As shown by the Wisconsin studies, it is also possible that exposures to THMs have been too low to detect a possible association or that differences in exposures to other water contaminants (synthetic volatile organics in chlorinated municipal groundwaters) might have confounded the results. In Massachusetts, a case-comparison study included populations using the same surface water source disinfected either with chlorine or chloramine, and an increased risk of bladder cancer mortality was observed in the lifetime-in-residence population receiving chlorinated water relative to the population receiving chloraminated water. Because chloraminated water contains lower THM levels, this suggests, but does not provide direct evidence of, a possible association with THMs. Without accurate estimates of previous exposure to THMs and other water contaminants in epidemiologic studies, results to date must be interpreted primarily in terms of exposure to chlorinated water. Although THMs may be associated with these increased cancer risks, other chlorinated by-products or water contaminants may also be involved.

Additional analytic epidemiologic studies to confirm these findings are being conducted in Iowa. Any interpretation as to the causal association of water chlorination and colon and bladder cancers should await the completion of the studies and other relevant research in this area. Although a causal relationship between chlorinated drinking water, THMs, and bladder cancer has not been established, the question may be asked "What proportion of bladder cancer cases would be attributed to exposure to chlorinated drinking water, were the relationship causal?" The answer to this question can help place the issue in perspective. The measure of interest, known as the attributable fraction, may be calculated for exposed individuals only or for the population as a whole.[52-54] The attributable fraction for the exposed individuals is the excess disease occurrence associated with the risk factor.

TABLE 9

Estimated relative risks for colon cancer in North Carolina[37]

Age	Odds Ratio (95 Percent Confidence Interval)	
	1-15 years exposure	*>15 years exposure*
60-69	1.18 (0.94, 1.47)	1.38 (1.10, 1.72)
70-79	1.47 (1.16, 1.84)	2.15 (1.70, 2.69)
80-89	1.83 (1.32, 2.53)	3.36 (2.41, 4.61)

TABLE 10

Relative risks for bladder cancer in nonsmokers served by a chlorinated surface water source[38]

Years at a Residence Served by Chlorinated Water	Relative Risk (95 Percent Confidence Interval)
1-19	1.3 (0.7, 2.2)
20-39	1.5 (0.9, 2.4)
40-59	1.4 (0.9, 2.3)
60+	2.3 (1.3, 4.2)

This fraction will vary over different ranges of exposure, depending on the relative risk for a particular exposure level and the proportion of cancer cases exposed at each level. The attributable fraction for the population (also known as attributable risk, population attributable risk, excess population risk, etiologic fraction) is of more general interest. This quantity is defined as the proportion of all cancer cases (in both exposed and unexposed individuals) that is attributable to or presumed to be caused by the exposure of interest. When calculated from published data on cancer of the bladder,[38] it is estimated that among nonsmokers at otherwise low risk for bladder cancer, approximately 28 percent of the cases of bladder cancer may be attributed to chlorinated water consumption.[55] This figure is the weighted total for the population, which accounts for the varying relative risks and proportions exposed at different levels of exposure.[52-54]

Conclusions

Current USEPA regulations are insufficient to prevent the waterborne transmission of infectious disease, as outbreaks of waterborne disease have occurred in systems that have not exceeded current regulations for coliforms and turbidity. Analysis of data from outbreaks reported in surface water systems shows the need for pretreatment and filtration in addition to disinfection. This treatment is required to ensure the removal and inactivation of waterborne pathogens, especially protozoa such as *Giardia* and *Cryptosporidium*. Outbreaks have occurred in water systems that filter and disinfect in cases in which facilities have been improperly designed or have been operated in a poor or simply casual manner, and this emphasizes the need to pay greater attention to maintaining effective and continuous water treatment. To reduce the occurrence of waterborne outbreaks, the USEPA has proposed criteria for filtration of surface water supplies, disinfection of all surface water sources, and revised regulations for coliforms.

Although the protection of raw water quality is important, it can only be considered one barrier to the transmission of waterborne disease, especially with increasing evidence of the importance of domestic and wild animals in the transmission of waterborne disease. The increasing potential for contamination of surface water sources warrants the maintenance of additional barriers—filtration and disinfection—to ensure adequate margins of safety. The multiple barrier concept has evolved from water treatment experiences, and if properly applied to surface water systems can significantly reduce the risk of waterborne transmission of infectious disease.

Disinfection of drinking water will continue in the United States as the final barrier against waterborne disease, and chlorine will likely continue to be the primary disinfectant. The concerns over the human health effects that may be associated with long-term exposures to chlorine or chlorinated by-products may require changes in disinfection techniques or the use of disinfectants other than chlorine. Additional health research data are required, however, before these decisions can be made. Little is known about the potential adverse effects of the other disinfectants, and unresolved questions remain about the significance of the relatively low cancer risks reported from the epidemiologic studies. Although the risks of chlorination are not as well recognized as the benefits, the prudent public health practice for water systems should be to minimize exposure to chlorine and chlorinated by-products without significantly increasing infectious disease risks. Chlorination may be the final barrier against transmission of pathogens, but it must not be the only barrier because high concentrations are required to inactivate protozoa and sole reliance is placed on the disinfection process. Properly designed and operated filtration plants can make disinfection more effective by removing turbidity and some substances that exert chlorine demand and by reducing microbiological contamination. Because disinfection is part of the multiple barrier concept and not relied on so heavily, lower concentrations of chlorine could be used, which should result in decreased levels of chlorinated by-products.

Acknowledgment

This article was originally prepared for and presented at a preconference seminar of the Pacific Northwest Section of AWWA, May 6, 1987, and subsequently updated and revised for the JOURNAL. Appreciation is expressed to seminar participants for suggesting revisions and to Peter Karalekas, Pat Murphy, Gary Logsdon, William Mullen, and AWWA reviewers who read various drafts and suggested numerous improvements in the manuscript. Updated material on results of recent epidemiologic studies is largely the result of the efforts of Pat Murphy, Terry Young, Chuck Lynch, Sally Zierler, Ken Cantor, and Elaine Zeighami.

This document has been reviewed in accordance with US Environmental Protection Agency policy and approved for publication. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

References

1. National Primary Drinking Water Regulations: Filtration, Disinfection; Turbidity, *Giardia lamblia*, Viruses, *Legionella*, and Heterotrophic Bacteria. Proposed rule, 40 CFR parts 141 and 142. *Fed. Reg.*, 52:212:42718 (Nov. 3, 1987).
2. WOLMAN, A. Preface. *Waterborne Diseases in the United States* (G.F. Craun, editor). Chemical Rubber Publ. Co. Press Inc., Boca Raton, Fla. (1986).
3. National Interim Primary Drinking Water Regulations. USEPA-570/9-76-003, Washington, D.C. (1977).
4. National Interim Primary Drinking Water Regulations: Control of Trihalomethanes in Drinking Water. Final rule, 40 CFR part 141. *Fed. Reg.*, 44:231:68624 (Nov. 29, 1979).
5. National Interim Primary Drinking Water Regulations. Amendments, 40 CFR part 141, *Fed. Reg.*, 45:168:57332 (Aug. 27 1930).
6. National Secondary Drinking Water

Regulations. USEPA-570/9-76-000, Washington, D.C. (1979).
7. National Revised Primary Drinking Water Regulations. Advance Notice of Proposed Rulemaking, 40 CFR part 141. *Fed. Reg.*, 48:194:45502 (Oct. 5, 1983).
8. Drinking water; proposed substitution of contaminants and proposed list of additional substances which may require regulation under the Safe Drinking Water Act, 40 CFR part 141. *Fed. Reg.*, 52:130: 25720 (July 8, 1987).
9. National Primary Drinking Water Regulations: Synthetic Organic Chemicals; Monitoring for Unregulated Contaminants. Final rule, 40 CFR parts 141 and 142. *Fed. Reg.*, 52:130:25690 (July 8, 1987).
10. National Primary and Secondary Drinking Water Regulations: Fluoride, 40 CFR parts 141, 142 and 143. *Fed. Reg.*, 51:63: 11396 (1986).
11. National Primary Drinking Water Regulations: Proposed MCLGs, 40 CFR parts 141, 142 and 143. *Fed. Reg.*, 50:219:46936 (1985).
12. CRAUN, G.F. Waterborne Outbreaks of Giardiasis. *Giardia and Giardiasis* (S.L. Erlandsen and E.A. Meyer, editors). Plenum Press, New York (1984).
13. CRAUN, G.F. Impact of the Coliform Standard on the Transmission of Disease. *Evaluation of the Microbiology Standards for Drinking Water* (C.W. Hendricks. editor). USEPA-570/9-78-00C, Washington, D.C. (1978).
14. BATIK, O.; CRAUN, G.F.; & PIPES, W.O. Routine Coliform Monitoring and Waterborne Disease Outbreaks. *Jour. Envir. Health*, 45:227 (1983).
15. COMMITTEE REPORT. Waterborne Disease in the United States and Canada. *Jour. AWWA*, 73:10:528 (Oct. 1981).
16. National Primary Drinking Water Regulations. Total Coliforms. Proposed rule, 40 CFR parts 141 and 142. *Fed. Reg.*, 52:212:42224 (Nov. 3, 1987).
17. WHITE, G.C. *Handbook of Chlorination.* Van Nostrand Reinhold Co., New York (2nd ed., 1986).
18. CRAUN, G.F. Statistics of Waterborne Outbreaks in the US (1920-80). *Waterborne Diseases in the United States* (G.F. Craun, editor). CRC Press Inc., Boca Raton, Fla. (1986).
19. WHIPPLE, G.C. *Typhoid Fever: Its Causation, Transmission, and Prevention.* John Wiley & Sons, New York (1908).
20. LOGSDON, G.S. & HOFF, J.C. Barriers to the Transmission of Waterborne Disease. *Waterborne Diseases in the United States* (G.F. Craun, editor). CRC Press Inc., Boca Raton, Fla. (1986).
21. LOGSDON, G.S. ET AL. Evaluating Sedimentation and Various Filter Media for Removal of *Giardia* Cysts. *Jour. AWWA*, 77:2:61 (Feb. 1985).
22. LOGSDON, G.S. & RICE, E.W. Evaluation of Sedimentation and Filtration for Microorganism Removal. Proc. AWWA Ann. Conf. (1986).
23. CRAUN, G.F. & JAKUBOWSKI, W. Status of Waterborne Giardiasis Outbreaks and Monitoring Methods. Proc. AWRA Sym. (1987).
24. NAVIN, T.R. & JURANEK, D.D. Cryptosporidiosis: Clinical, Epidemiologic, and Parasitologic Review. *Rev. Infectious Diseases*, 6:313 (1984).
25. TZIPORI, S. Cryptosporidiosis in Animals and Humans. *Microbiol. Rev.* 47:84 (1983).
26. HOFF, J.C. Inactivation of Waterborne Protozoan Cysts. Amer. Soc. for Microbiologists Conf., Atlanta, Ga., Mar. 3, 1987.
27. LOGSDON, G.S. Personal Communication (1987).
28. BELLAR, T.A.; LICHTENBERG, J.J.; & KRONER, R.C. The Occurrence of Organohalides in Chlorinated Drinking Water. *Jour. AWWA*, 66:12:703 (Dec. 1974).
29. ROOK, J.J. Formation of Haloforms During Chlorination of Natural Waters. *Jour. Water Trtmnt. Exam.*, 23:234 (1974).
30. CRAUN, G.F. Epidemiologic Considerations for Evaluating Associations Between the Disinfection of Drinking Water and Cancer in Humans. *Water Chlorination: Chemistry, Environmental Impact, and Health Effects*, Vol. 5 (R.L. Jolley et al, editors). Lewis Publ., Chelsea, Mich. (1985).
31. CRAUN, G.F. Epidemiologic Studies of Organic Micropollutants in Drinking Water. *Sci. Total Envir.*, 47:461 (1985).
32. SYMONS, J.M. ET AL. Treatment for Controlling Trihalomethanes in Drinking Water. USEPA-600/2-81-156, Cincinnati, Ohio (1981).
33. MONSON, R.R. *Occupational Epidemiology.* CRC Press Inc., Boca Raton, Fla. (1980).
34. COMMITTEE ON DRINKING WATER. *Drinking Water and Health*, Vol. 3. Natl. Acad. of Sci., Washington, D.C. (1980).
35. WILKINS, J.R. & COMSTOCK, G.W. Source of Drinking Water at Home and Site-Specific Incidence in Washington County, Maryland. *Amer. Jour. Epidemiol.*, 116: 652 (1982).
36. CRUMP, K.S. & GUESS, H.A. Drinking Water and Cancer: Review of Recent Epidemiological Findings and Assessment of Risks. *Ann. Rev. Public Health*, 3:339 (1982).
37. CRAGLE, D.L. ET AL. A Case-Control Study of Colon Cancer and Water Chlorination in North Carolina. *Water Chlorination: Chemistry, Environmental Impact, and Health Effects*, Vol. 5 (R.L. Jolley et al, editors). Lewis Publ., Chelsea, Mich. (1985).
38. CANTOR, K.P. ET AL. Drinking Water Source and Risk of Bladder Cancer: A Case-Control Study. *Water Chlorination: Chemistry, Environmental Impact, and Health Effects*, Vol. 5 (R.L. Jolley et al, editors). Lewis Publ., Chelsea, Mich. (1985).
39. CANTOR, K.P. Chlorinated Water and Cancer: Is There a Link? *Health and Envir. Digest*, 1:6:1 (1987).
40. CANTOR, K.P. ET AL. Drinking Water Source, Tap Water Intake, and Bladder Cancer: A Case-Control Study. Presented at 6th Conf. on Water Chlorination: Environmental Impact and Health Effects. Oak Ridge, Tenn., May 3-7, 1987.
41. LYNCH, C.F.; VANLIER, S.; & CANTOR, K.P. A Case-Control Study of Multiple Cancer Sites and Water Chlorination in Iowa. Presented at 6th Conf. on Water Chlorination: Environmental Impact and Health Effects. Oak Ridge, Tenn., May 3-7, 1987.
42. YOUNG, T.B.; KANAREK, M.S.; & TSIATIS, A.A. Epidemiologic Study of Drinking Water Chlorination and Wisconsin Female Cancer Mortality. *Jour. NCI*, 67:1191 (1981).
43. YOUNG, T.B.; WOLF, D.A.; & KANAREK, M.S. Case-Control Study of Colon Cancer and Drinking Water Trihalomethanes in Wisconsin. *Intnl. Jour. Epidemiol.*, 16:190 (1987).
44. KANAREK, M.S. & YOUNG, T.B. Case-Control Study of Colon Cancer and Water Chlorination: Volatile Organics in Wisconsin. Presented at 6th Conf. on Water Chlorination: Environmental Impact and Health Effects. Oak Ridge, Tenn., May 3-7, 1987.
45. CRAUN, G.F. Health Aspects of Groundwater Pollution. *Groundwater Pollution Microbiology* (G. Bitton and C.P. Gerba, editors). Wiley & Sons, New York (1984).
46. RICE, R.G. & GOMEZ TAYLOR, M. Occurrence of By-Products of Strong Oxidants Reacting With Drinking Water Contaminants—Scope of the Problem. *Envir. Health Perspectives*, 69:31 (1987).
47. ZIERLER, S.; DANLEY, R.A.; & FEINGOLD, L. Type of Disinfectant in Drinking Water and Patterns of Mortality in Massachusetts. *Envir. Health Perspectives*, 69:275 (1987).
48. ZIERLER, S. ET AL. Bladder Cancer and Chlorinated Drinking Water. Presented at 6th Conf. on Water Chlorination: Environmental Impact and Health Effects. Oak Ridge, Tenn., May 3-7, 1987.
49. RALOFF, J. Calcium, Chlorine, and Heart Disease Linked. *Sci. News*, 124:103 (1983).
50. WONES, R.G. & GLUECK, C.J. Effects of Chlorinated Drinking Water on Human Lipid Metabolism. *Envir. Health Perspectives*, 69:255 (1987).
51. ZEIGHAMI, E.A.; WATSON, A.P.; & CRAUN, G.F. Drinking Water Chlorination and Serum Lipid Levels in Humans. Presented at 6th Conf. on Water Chlorination: Environmental Impact and Health Effects. Oak Ridge, Tenn., May 3-7, 1987.
52. MIETTINEN, O.S. Proportion of Disease Caused by a Given Exposure, Trait, or Intervention. *Amer. Jour. Epidemiol.*, 99:325 (1974).
53. KELSEY, J.L.; THOMPSON, W.D.; & EVANS, A.S. *Methods in Observational Epidemiology.* Oxford Univ. Press, New York (1986).
54. GREENLAND, S. Bias in Methods for Deriving Standardized Morbidity Ratio and Attributable Fraction Estimates. *Statistics in Medicine Journal*, 3:131 (1984).
55. MURPHY, P.A. Review of Previous Epidemiologic Studies Reporting Association Between Drinking Water Disinfection and Cancer. Presented at 6th Conf. on Water Chlorination: Environmental Impact and Health Effects. Oak Ridge, Tenn., May 3-7, 1987.



About the author: *Gunther F. Craun is chief of the Epidemiology and Statistics Section, Microbiology and Hazard Assessment Branch, Toxicology and Microbiology Div., US Environmental Protection Agency, 26 W. Martin Luther King Dr., Cincinnati, OH 45268.*

Occurrence and Significance of Cryptosporidium in Water

Joan B. Rose

Three outbreaks of waterborne disease have been attributed to *Cryptosporidium*—two linked to drinking water and a third to surface water—yet the risk of waterborne disease is unknown because many factors may contribute to transmission. Of 107 surface water samples collected in six western states, 77 were positive for the presence of *Cryptosporidium* oocysts. A high count was found in raw sewage (1,732 oocysts/L), whereas low counts were found in waters without waste discharges (0.04 oocysts/L). *Cryptosporidium* has also been detected in drinking water. Little information is available, however, on oocyst survival in the environment or during sewage and drinking water treatment processes. Further research is necessary to define the variables that will influence the possible presence of infectious oocysts in water. It has been suggested that the epidemiology and transmission of *Cryptosporidium* are similar to *Giardia*. Based on environmental occurrence, the risk of *Cryptosporidium* transmission by the water route may be equal to or greater than that of *Giardia*.

Cryptosporidium has recently been recognized as an important microbial contaminant of water,[1] but its potential for transmission remains unknown. To adequately address the risk of waterborne transmission and waterborne disease, it is necessary to know (1) what the exposure through water is and (2) what disease manifestations occur at these levels of exposure.

During the last five years, a tremendous amount of research has been published on *Cryptosporidium*. Relevant to the occurrence and significance of *Cryptosporidium* in water are (1) specific features of the organism that enhance its potential for transmission by water, (2) documentation of waterborne outbreaks, (3) methods for recovery and detection of *Cryptosporidium* in water, (4) data on occurrence in water, and (5) the ability of the organism to survive in water and water treatment processes. This article reviews literature that pertains to the transmission of *Cryptosporidium* by water and presents original data on the occurrence of *Cryptosporidium* in waters in the western United States.

Taxonomy and life cycle of *Cryptosporidium*

Cryptosporidium is taxonomically described as a coccidian protozoan. It has been placed in the phylum *Apicomplexa*, the order *Eucoccidioridia*, and the family *Cryptosporidiiae*.[2] *Cryptosporidium* was first described in 1907 by Tyzzer[3] as found in the gastric mucosa of mice. Many species were identified and differentiated taxonomically by the host from which the parasite was isolated.[4] It became apparent, however, that many mammalian isolates were able to cause infection in other mammals.

Levine[4] suggested four species designations corresponding to isolates from mammals, birds, reptiles, and fish. This classification has not been validated. Four species are recognized, however—*C. parvum* and *C. muris*,[5] found in mammals, and *C. baileyi* and *C. meleagridis*,[6] found in birds. *Cryptosporidium parvum* is the major species responsible for clinical illness in humans and animals.[7] A distinct isolate associated with adult cattle has recently been described by Anderson.[8] Little is known about its taxonomy or host specificity.

Two aspects of the taxonomy and life cycle of *Cryptosporidium* enhance the

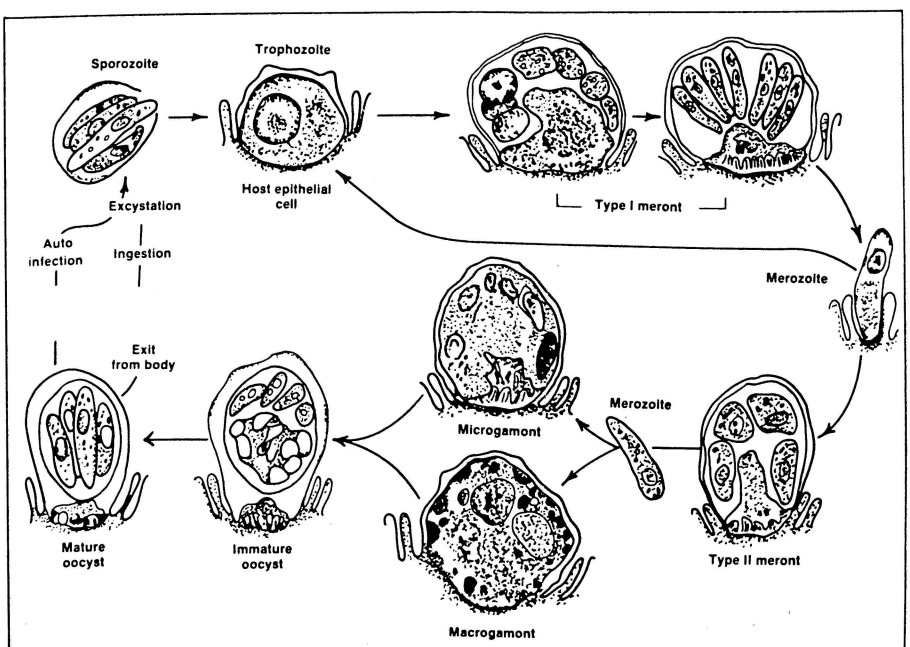


Figure 1. Life cycle of *Cryptosporidium* (*this drawing was originally published by the American Society for Microbiology in* Microbiological Reviews, *50:458 [1986]*)

possibility of waterborne transmission. First, a single species may be responsible for much of the diarrheal illness in mammals, including humans. Second, an environmentally stable oocyst is excreted in the feces of infected individuals.

The organism appears to be ubiquitous. It is found in both domestic animals (cattle, sheep, swine, goats, dogs, and cats) and wild animals (deer, raccoon, foxes, coyotes, beavers, muskrats, rabbits, and squirrels).[7] Fayer and Ungar[9] have recently reviewed the cross-transmission studies on *Cryptosporidium*. Most significant are the data indicating that isolates from cats, cattle, and pigs are able to initiate infection in humans. Conversely, human isolates have produced infection in cats, dogs, cattle, goats, sheep, pigs, mice, and rats. Although *Cryptosporidium* infections may be common in bird populations, isolates from birds, chickens, and turkeys have not produced infections in mammals.[9] The *C. baileyi* found in birds may not be a major source for human infections, yet it is uncertain whether the same is true for *C. meleagridis*.

Cryptosporidium in humans, like many other important waterborne pathogens, completes its life cycle in the gastrointestinal tract. Because it is an obligate parasite, it can replicate only within its host. It is different from other enteric protozoa, such as *Giardia*, in morphology and life cycle. The life cycle of *C. parvum* begins with ingestion of the infectious stage—the oocyst—which releases four sporozoites after excystation. This stage initiates infection within the epithelial cells of the gastrointestinal tract. The sporozoite differentiates into the trophozoite, which undergoes asexual multiplication to form type I meronts and then merozoites, which may infect new host cells. Merozoites from type II meronts produce microgametocytes and macrogametocytes, which undergo sexual reproduction to form the oocyst, which is then excreted in the feces (Figure 1).[9] The oocysts are immediately infective upon excretion.

It appears that *C. parvum* is the major species of concern causing illness in both humans and animals.[7] Many mammals may serve as reservoirs of infection for humans.[7] This cross-species transmission increases the potential for waterborne disease because animals, in addition to humans, may also contaminate water sources. The most significant factor influencing the potential for waterborne transmission of *Cryptosporidium*, however, is the fecal-oral route of transmission from host to host by its environmentally stable oocyst.

Waterborne epidemiology of *Cryptosporidium*

Cryptosporidium is responsible for diarrheal disease and has been transmitted through the water route. It is not known how significant this route of transmission is in comparison to other possible paths, such as person to person. In more than 50 percent of the waterborne outbreaks in the United States, an etiologic agent was not identified.[10] *Cryptosporidium* may have been responsible for some of these outbreaks, yet may have gone unrecognized. Studies on waterborne outbreaks can provide valuable information on sources of contamination and the reliability of water treatment processes. In addition, information on disease in populations, other transmission routes, and infectious dose will help define the epidemiology of waterborne cryptosporidiosis.

Cryptosporidium was first recognized as a pathogen during an outbreak of diarrhea in a turkey flock in 1955,[11] after which it was identified as an infectious agent in cattle and sheep.[12-17] Serological studies indicate widespread infection in calves; neonates are most susceptible, with significant morbidity and mortality. Zoonotic transmission has been documented as previously described; however, this may not be a major transmission route.[9]

In humans, *Cryptosporidium* infections were first identified with immunocompromised individuals[18] and were brought to the attention of the medical community with the occurrence of acquired immune deficiency syndrome (AIDS).[19] *Cryptosporidium* has now been identified in diarrheal specimens from immunocompetent individuals ranging from a 0.12 to 23 percent prevalence.[9] In North America, *Cryptosporidium* has been found in 0.6 to 4.3 percent of the diarrheal cases. Children under two years of age may be the most susceptible, and *Cryptosporidium* has become problematic in day-care centers. Person-to-person transmission has been documented in day-care centers[20,21] and in hospitals[22,23] and may play a major role in the spread of disease.

Cryptosporidium is considered a primary pathogen. Current[7] has speculated, however, that the virulence of isolates may vary. That is, *Cryptosporidium* from different sources may vary in its capacity to cause infection and disease, depending on its virulence. Other investigators have also suggested a similar variation.[24,25] A second factor that will play a role in the initiation of disease is the infectious dose, which has not been well-defined for *Cryptosporidium*. Ernest et al[26] reported 22 percent infection with 100 oocyst inoculum in mice. Miller et al[27] presented data that indicated as few as 10 oocysts could initiate infection in primates. The ability of an organism to cause infection at low levels of exposure enhances the potential for waterborne transmission. Preliminary results suggest that *Cryptosporidium* may have a low infectious dose.

The role of *Cryptosporidium* as a cause of travelers' diarrhea has implicated transmission through contaminated water.[28,29] No definitive proof has been provided, yet *Cryptosporidium* infections were related to infections of other waterborne pathogens such as *Giardia*. Although speculative, illness in Caribbean tourists was associated statistically with the consumption of tap water.

Two waterborne outbreaks caused by the contamination of drinking water by *Cryptosporidium* have been documented. The first was a result of a sewage-contaminated well.[30] The well was chlorinated, although no residuals were

TABLE 1

Recovery efficiencies for Cryptosporidium *from various waters*

Study	Seed Volume *L*	Seed Level per L	Type of Water	Percent Recoveries	
				Ranges	Averages
Ongerth and Stibbs[39]	7-20	10^3-10^4	River	5-22	9.5
Musial et al[38]	378	0.2-2.6	Tap water	9-29	17.4
Rose et al[41]	378	10^3	Tap water	25-80	59
Rose et al[41]	378	0.4	Tap water	31-42	36
Rose et al[46]	378	10^4	Effluent	Not reported	20

TABLE 3

Cryptosporidium *oocyst concentrations in environmental samples*

State	Type of Water	Number of Samples	Number Positive	Oocyst/L Average
Arizona	Treated effluent	20	15	489
	Raw sewage	5	5	1,732
	Streams*	9	8	18
California	Streams	3	1	0.04
Colorado	River*	2	2	0.12
	Treated effluent	2	2	4.0
Oregon	Streams	6	5	0.05
Texas	Reservoirs*	6	6	1.1
	Raw sewage	6	4	4.1
Utah	Lakes and streams*	48	34	8.9
Total		107	82	

*Receiving sewage discharges

TABLE 2

Summary of previous reports of Cryptosporidium *oocysts in sewage and various waters**

Water Source	Number of Samples	Range	Oocysts/L Average	Reference
Arizona				
Effluent	2	5-17	11†	40
Raw sewage	4	850-13,700	5,180	45
Effluent	11	4-3,960	1,063	45
Surface waters	6	0.8-5,800	1,920	45
Washington				
Surface waters	11	2-112	25†	39

*Arithmetic means
†Adjusted values based on recoveries

TABLE 4

Occurrence of Cryptosporidium *oocysts in various waters throughout the western United States*

Water Sampled	Number of Samples	Number of Samples Positive	Percent Positive	Oocysts/L*
Raw sewage	11	10	91	28.4
Treated sewage†	22	20	91	17
Reservoir, lake	32	24	75	0.91
Stream, river	58	45	77	0.94
Filtered drinking water	10	2	20	0.001
Nonfiltered drinking water	4	2	50	0.006

*Geometric means
†Activated sludge

reported. It was suggested that the contamination had percolated through the ground to the well. Oocysts were found in the stools of those with diarrhea, and the incidence of illness (117 cases) was 12 times greater than in the neighboring community. The Norwalk virus, which has been documented in previous waterborne disease outbreaks,[31] was also found in the diarrheal stools. There is some uncertainty regarding the amount of illness that could be attributed to *Cryptosporidium*. Because sewage was the source of the contamination, it might not be too surprising that multiple pathogens were implicated in the outbreak. No oocysts were recovered from the drinking source. However, methods for the recovery of oocysts from water were not well developed at that time.

The second outbreak occurred early in 1987, in Carrollton, Ga., a community of 16,000 people.[32] The increased incidence of student illness at a university clinic on January 20 first alerted the health department, and the Centers for Disease Control was brought in. It was determined that the illness was widespread throughout the community served by the public water system. Those individuals consuming well water had statistically less illness than those consuming city water. *Cryptosporidium* was identified as the etiologic agent through examination of diarrheal specimens.[33] The drinking water underwent conventional treatment (coagulation, sedimentation, filtration, disinfection) and met coliform (1 cfu/100 mL) and turbidity standards (1 ntu). Free chlorine residuals were as high as 1.5 mg/L at the treatment plant. After extensive sampling, oocysts were detected in the treated water.[33] Little published information that documents this outbreak is available. Future reports detailing the Carrollton outbreak of cryptosporidiosis will provide more insight into the waterborne transmission of *Cryptosporidium*.

In New Mexico, 78 cases of cryptosporidiosis were confirmed in 1986 through laboratory diagnosis of patients with diarrhea.[34] Seventy-four percent of the patients lived in the same county, and 32 of these individuals were considered household or day-care contacts of the 24 included in the study. Various risk factors were statistically evaluated to determine a possible source of infection. Drinking untreated surface water was found to be associated with illness. In addition, there may have been an increased risk of infection from swimming in surface waters. This is the first incident for which recreational exposure was suggested as a transmission route. Attendance at a day-care center in which other children were ill was also considered a risk factor, which confounded the analyses.

The previous discussion demonstrates the uncertainty in assessing the risk of waterborne cryptosporidiosis. Infectious dose and virulence variation are ill defined. Other transmission routes may conceal the role water has played as the source of infection. The greatest uncertainty is the contribution of *Cryptosporidium* to outbreaks of unknown etiology or to unrecognized, unreported outbreaks. Considering the difficulties with epidemiologic studies, even during outbreak situations these data probably should not be used to establish the significance of waterborne transmission of *Cryptosporidium*. Perhaps an alternative approach for the assessment of potential waterborne transmission is to evaluate the exposure by defining the occurrence of *Cryptosporidium* in water.

Recovery and detection methods for *Cryptosporidium* oocysts in water

To determine the occurrence of *Cryptosporidium* in environmental samples, the oocysts must be recovered and detected. Methods for environmental samples evolved partially from those used for *Giardia* and from those used in the clinical laboratory. This has included a combination of density gradients and flotations to concentrate and clarify the sample[35] and antibodies specific to the oocyst wall for detection using immunofluorescent techniques.[36-38]

In water samples, the concern is being able to detect low concentrations of oocysts in large volumes of water. Two similar systems have evolved that rely on concentration of the oocysts from water using filters. The method developed by Ongerth and Stibbs[39] employed 293-mm polycarbonate membrane filters. The method consists of first passing 20 L of water through a 5-μm prefilter. The oocysts were concentrated by subsequent passage of the filtrate through a 1.0-μm filter. The oocysts were recovered from the polycarbonate filter through the vibration of the inverted membrane in 200 mL of distilled water. The debris or sediment recovered was pelleted or concentrated using centrifugation, and the sample was clarified using a potassium citrate (1.19 g/mL) density gradient. The sample was filtered through cellulose nitrate membrane filters (1.2 μm) and stained with polyclonal antibody tagged with fluorescein isothiocyanate. The oocysts were detected using an epifluorescent microscope. The second method[40] used a 10-in. (250-mm) polypropylene cartridge filter (1.0-μm pore size) for concentrations of the oocysts from water. This system has an advantage over the polycarbonate system in that it can be easily transported to the sampling site, and large volumes of water (100-1,000 gal [378-3,785 L]) can be processed. A disadvantage is the elution procedure. The cartridge filter was processed with 6 L of a 0.1 percent distilled water solution* by backflushing, cutting apart, and washing the filter. Thus, it was necessary to concentrate 6 L of the eluent to a pellet using centrifugation, in contrast to approximately 300 mL when using the membrane filter method.

The cartridge filter system used a sucrose (1.24 g/mL) flotation to clarify the sample. High recoveries were achieved when 0.1 percent distilled water solution* and 1 percent sodium dodecyl sulfate were used with the sample. Oocysts were detected on a glass slide (or hemacytometer) using a monoclonal antibody and epifluorescent microscopy.

*Tween 80, J.T. Baker Chemical Co., Phillipsburg, NJ.

Further development of the cartridge filter system by Rose et al[41] has included (1) decreasing the eluent volume to 2,700 mL, (2) improving clarification using sucrose at specific gravities of 1.24 and 1.17 g/mL, and (3) using a cellulose nitrate filtration membrane in conjunction with a monoclonal antibody for oocyst detection. Microscopic counts can be used to calculate the numbers in the equivalent volume passed through the membrane filter. This quantification may also be used to evaluate the efficiency of the methods in seeded experiments. Recovery rates for *Cryptosporidium* oocysts are influenced by the volume sampled, oocyst levels, and, most important, water quality. Large volumes, low levels of oocysts, and poor water quality (high turbidity, suspended solids, organic content) may decrease recoveries. Table 1 summarizes various method efficiencies. Average recoveries ranged from 9.5 percent in river water[39] to 59 percent in tap water.[41]

Levels (or counts) of oocysts found in water samples may be adjusted mathematically to reflect a more true concentration based on recovery method efficiencies. But this approach should be used cautiously. Unless seeded recoveries are determined concurrently with each sample tested, accurate determinations cannot be made. Recoveries vary even under controlled laboratory conditions, and characteristics of the water sample at the time of collection will influence this recovery rate.

In addition to poor recoveries, the current techniques have a number of other limitations. Oocysts excreted from birds, which may not be infectious for humans based on transmission studies between mammals and birds,[9] may be detected in some samples, depending on the antibody used. In all previously reported studies, no differentiation has been made between bird or mammalian oocysts.[36-38] The most significant limitation is probably the inability to determine oocyst viability. Viability of oocysts from fecal samples has been assessed through infection in a mouse model or through in vitro excystation.[26,42-44] Obviously, a bioassay system addresses infectivity but is expensive, less quantitative, and variable based on host susceptibility and infectious dose. Excystation is the process by which the oocyst opens up to release the sporozoites. This process may be induced in the laboratory. Excystation of an oocyst preparation may, however, decrease over time; the relationship between percent excystation and infectivity is undefined; and the counting of sporozoites and full and empty oocysts may be imprecise. Application of a bioassay or excystation procedure for determining the viability of oocysts recovered from environmental samples is currently impractical.

Environmental occurrence of *Cryptosporidium* in the western United States

Until 1985, little was known about the occurrence of *Cryptosporidium* in the environment. Because this protozoan is an enteric pathogen found in feces, it follows that the oocysts may be found in sewage and contaminated environments. Musial et al[40] estimated oocyst levels based on recoveries between 5 and 17/L in secondarily treated sewage. Madore et al[45] investigated select wastewater facilities and surface waters, many receiving wastes from dairy farms and beef-packaging plants. Waters receiving agricultural runoff from cattle pastures were also tested. High concentrations of oocysts were found in some sewage samples, averaging 5,180 oocysts/L in raw sewage and 1,063 oocysts/L in treated sewage. Surface waters varied between 0.8 and 5,800 oocysts/L. Ongerth and Stibbs[39] reported the presence of *Cryptosporidium* in several rivers in western Washington at levels between 2 and 112 oocysts/L (estimated from recoveries). A summary of these reports is presented in Table 2.

New information has come from more comprehensive investigations begun in 1986 on waters throughout the western United States for the occurrence of *Cryptosporidium*. Samples were collected using the cartridge filtration method. Filters were shipped to Arizona and processed using the methods previously described.[41] All data are reported at the levels observed in the samples without any adjustment because of recovery efficiencies.

Thus far, 107 samples have been collected from Arizona, California, Colorado, Oregon, Texas, and Utah. Various waters were sampled, including raw sewage, effluents (activated sludge), rivers, streams, lakes, and reservoirs. Many of the waters sampled were receiving treated sewage discharges. The results are summarized in Table 3. Of the 107 samples, 77 percent were positive for *Cryptosporidium*. Arithmetic means were calculated and ranged from 4.1 to 1,732 oocysts/L in treated sewage and from 0.04 to 18 oocysts/L in streams, reservoirs, and lakes. Streams sampled in Oregon and California had the lowest levels of contamination (0.05 and 0.04 oocysts/L, respectively), whereas waters sampled in Arizona and Utah were higher (18 and 19 oocysts/L, respectively). The higher concentrations were detected in surface waters receiving sewage discharges.

A wide variation in oocyst concentrations in the waters sampled was observed, with high levels detected occasionally in individual samples. This may reflect the variation in (1) collection of the grab samples, (2) recovery efficiencies influenced by the changes in water quality, or (3) contamination of the waters. To account for this variation, geometric means were calculated for these same samples by water types (Table 4). For raw and treated sewage, 91 percent of the samples were positive for *Cryptosporidium*, with average concentrations of 28.4 and 17 oocysts/L, respectively. The levels of oocysts detected in reservoirs or lakes and in streams or rivers were similar (0.91 and 0.94 oocysts/L, respectively), with 75 and 77 percent of the samples positive, respectively. The majority of these samples were receiving sewage effluents.

In addition, 14 drinking water samples were collected (Table 4). Of the 10 filtered samples, no oocysts were detected in waters receiving conventional treatment (coagulation, sedimentation, rapid sand filtration, disinfection). Oocysts were detected in one sample from drinking water after treatment by direct filtration. But the plant was not operating optimally because the mixers for the coagulants and ozonator were not functioning. One of two samples collected from waters receiving filtration without coagulation was positive for *Cryptosporidium* oocysts. Levels of oocysts in filtered drinking waters were low, averaging 0.001 oocysts/L (geometric mean). Two of four samples of unfiltered, chlorinated drinking water were positive for *Cryptosporidium*. Again, low levels were detected (0.006 oocysts/L).

Surface drinking water supplies in two distinct areas were sampled and tested for *Cryptosporidium*, *Giardia*, total coliform and fecal coliform bacteria, and turbidity. Six samples were collected from one area, area A, which included four reservoirs and two rivers. These were multiuse reservoirs and were open for recreational purposes. Three of the waters were receiving effluent discharges. Both waters were conventionally treated prior to distribution.

Six samples were collected from rivers in a second area, area B. These waters were in protected watersheds, closed to any public use, and were treated solely by disinfection. Samples were collected in October and November, at which time the weather was rainy in both areas A and B.

Table 5 contrasts area A with area B. Bacterial and turbidity concentrations were consistently 10 to 300 times higher in samples collected in area A. *Cryptosporidium* concentrations were also higher in area A, in which 100 percent of the samples were positive (averaging 0.99 oocysts/L), in comparison with 83 percent of the samples in area B, averaging 0.02 oocysts/L. Waterfowl were found at all the reservoirs in area A, however, and may have contributed to the contamination. Only one sample was positive for *Giardia* from each area. Concentrations were 0.29 and 0.006 cysts/L for

TABLE 5

Levels of Cryptosporidium, Giardia, *bacteria, and turbidity in surface waters from areas A and B*

	Turbidity	Total* Coliforms Per 100 mL	Fecal* Coliforms Per 100 mL	Number Positive/ Number Collected	*Cryptosporidium* Oocysts/L†	Number Positive/ Number Collected	*Giardia* Cysts/L†
Area A	11.3	1,354	437	6/6	0.99	1/6	0.29
Range	2-33	200-24,000	110-8,000		0.19-3.0		
Area B	1.5	4.3	1.5	5/6	0.02	1/6	0.006
Range	0.08-4	0-30	0-10		0.01-0.13		

*Geometric means
†Arithmetic means

areas A and B, respectively. *Cryptosporidium* oocysts were detected more frequently and at higher concentrations than *Giardia*.

The poorer quality water in area A is reflected by the levels of bacteria, turbidity, and parasites. No statistical evaluations have been made because of the limited number of samples. It is, therefore, uncertain whether bacterial indicators or turbidity would be useful surrogates for the parasites.

The results presented on the investigation of waters in the western United States suggest that *Cryptosporidium* is ubiquitous in the water environment. Concentrations may vary 3 to 4 logarithms, depending on the types of wastes entering the water. *Cryptosporidium* can be found in source waters used for potable supplies and has occasionally been detected in treated drinking water. The significance of these findings is twofold: (1) drinking water treatment plants may be challenged with varying concentrations of *Cryptosporidium* oocysts in the source water, and (2) treatment processes should ensure adequate removal or inactivation of this potential pathogen.

Removal of *Cryptosporidium* by water treatment processes

Water treatment plays a significant role in the prevention of waterborne disease. It has long been recognized, however, that *Giardia* cysts are more resistant to disinfection than are bacteria or viruses. Therefore, in addition to disinfection, filtration has been recommended to ensure removal of parasite cysts. The oocysts of *Cryptosporidium* are smaller than the cysts of other protozoa and are the smallest of the coccidia, averaging 4 to 5 μm in diameter, with a spherical or slightly ovoid shape.[9] Removal and inactivation efficiencies for *Cryptosporidium* oocysts by filtration and disinfection are unknown, as these investigations are just beginning. Preliminary data are available that suggest the efficiency of some of these treatment processes.

Both secondary wastewater and wastewater after sand filtration have been examined for the occurrence of *Cryptosporidium*.[41] Based on average numbers of oocysts, an 87 percent removal could be estimated for the filtration step. A survey of a drinking water treatment plant employing filtration reported a large number of oocysts recovered off the filter backflush (2,906/L).[46] This indicates that *Cryptosporidium* will be concentrated on the filter. Comparison of oocyst levels in the source water to those in the finished water indicated a 91 percent reduction. These conclusions should be viewed cautiously because the data are limited and are not temporal. Also, both the wastewater and drinking water filtration systems were sand filters and were utilized without the addition of coagulants or polymers. A major outbreak of *Cryptosporidium* was, however, associated with a conventional rapid sand filtration plant that produced water meeting coliform and turbidity standards.[47] Various deficiencies may have been involved in the plant's failure to remove the oocysts. These included no mechanical agitation during the flocculation process and restarting filters without backwashing. Regardless of the operational problems, the plant was meeting current regulations. It may be that turbidity or coliform bacteria are not adequate indicators for *Cryptosporidium*. Currently, removal efficiencies of oocysts by various types of filtration are unknown. Operational variables that may influence oocyst breakthrough or surrogate indicators for efficient removals are undefined.

The efficacy of water disinfection is also unknown for *Cryptosporidium*. A few investigations have reported on the effectiveness of a number of disinfectants used in the laboratory.[48-50] Only one study included sodium hypochlorite, which has relevance to use in water disinfection. Campbell et al[50] reported on the effectiveness of a 3 percent solution of sodium hypochlorite (undiluted bleach). Newborn mice were used to ascertain oocyst viability. Oocysts in rat gut homogenates were mixed with an equal volume of the disinfectant and solutions were incubated at room temperature and 4°C for 2 and 18 h, respectively. The concentration of the disinfectant available initially and at the end of 2 or 18 h was not determined. It could be assumed that the gut homogenate had some chlorine demand. No quantitative determinations of inactivation were made. Although a 3- to 4-logarithm reduction may not be significant in clinical samples, it could be very significant in environmental samples. Nevertheless, infection was obtained in mice after 18 h exposure to undiluted bleach. Bacterial pathogens under similar conditions were readily destroyed. Although oocyst counts in this study were only slightly decreased after 18 h, the counting accuracy was not determined and no attempts were made to distinguish empty and full oocysts. *Cryptosporidium* may be extremely resistant to disinfection, but no assessment can be made on its resistance or susceptibility to water disinfectants until the experimental data on oocyst inactivation by failure to excyst or infect under controlled water disinfection conditions are reviewed. It may be stated that under conditions such as those observed during the outbreak in Carrollton, Ga., oocysts were able to survive routine disinfection practices, whereas coliform bacteria were not.

Potential for waterborne transmission of *Cryptosporidium*

There is no doubt that *Cryptosporidium* has the attributes of a waterborne pathogen. Yet the role water plays in its transmission is difficult to determine.

Although methods have evolved to study the occurrence of *Cryptosporidium* in water, recovery inefficiencies and an inability to determine viability are major limitations. The survival of oocysts in the environment and removals or inactivation by sewage- and drinking-water-treatment processes are unknown. Infectious dose and virulence variation are also undefined. Despite these limitations, it may be concluded that *Cryptosporidium* can be commonly found in water and high levels of contamination can occasionally occur. Water treatment operators currently have no basis for evaluating the adequacy of treatment processes for removal of *Cryptosporidium* oocysts.

A recent review by Current[7] concluded that: (1) the epidemiology and transmission of *Cryptosporidium* are similar to *Giardia* and (2) *Cryptosporidium* may now be included as a cause of human diarrheal illness and, in some cases, is the most common protozoan identified.

The importance of waterborne giardiasis in the United States has been recognized during the last decade. Based on environmental occurrence, the poten-

tial for waterborne transmission of *Cryptosporidium* may be equivalent to or greater than that of *Giardia*. Further research on the biology and epidemiology of *Cryptosporidium*, as well as its occurrence and its survival in water, will further delineate the potential for waterborne cryptosporidiosis.

Acknowledgment

The author thanks Kelley Riley, Hamid Darbin, Lee Landeen, Yin Ping, and Charles P. Gerba, and Charles R. Sterling for supplying the monoclonal antibodies for *Cryptosporidium*. This work was supported by the US Environmental Protection Agency under grant CR-813536-01-0. This article has not been subject to agency review and therefore does not necessarily reflect the views of the agency; no official endorsement should be inferred.

References

1. *Fed. Reg.*, 52:25732 (July 8, 1987).
2. LEVINE, N.D. Phylum II, Apicomplexa Levine 1970. *Illustrated Guide to the Protozoa* (J.J. Lee, S.H. Hutner, and E.C. Bovee, editors). Society for Protozoology, Lawrence, Kan. (1985).
3. TYZZER, E.E. A Sporozoan Found in the Peptic Glands of the Common Mouse. *Proc. of the Soc. of Exp. Biol. Med.*, 5:12 (1907).
4. LEVINE, N.D. Taxonomy and Review of the Coccidian Genus *Cryptosporidium* (Protozoa, Apicomplexa). *Jour. Protozool.*, 31:94 (1984).
5. UPTON, S.J. & CURRENT, W.L. The Species of *Cryptosporidium* (Apicomplexa: Cryptosporidiidae) Infecting Mammals. *Jour. Parasitol.*, 71:625 (1985).
6. CURRENT, W.L.; UPTON, S.J.; & HAYNES, T.B. The Life Cycle of *Cryptosporidium baileyi* n. sp. (Apicomplexa, Cryptosporidiidae) Infecting Chickens. *Jour. Protozool.*, 33:289 (1986).
7. CURRENT, W.L. *Cryptosporidium*: Its Biology and Potential for Environmental Transmission. *Critical Rev. Envir. Control*, 17:21 (1987).
8. ANDERSON, B.C. Abomasal Cryptosporidiosis in Cattle. *Vet. Pathol.*, 24:235 (1987).
9. FAYER, R. & UNGAR, B.L.P. *Cryptosporidium* and Cryptosporidiosis. *Microbiol. Rev.*, 50:458 (1986).
10. LIPPY, E.C. & WALTRIP, S.C. Waterborne Disease Outbreaks: 1946-1980—A Thirty-five Year Perspective. *Jour. AWWA*, 76:2:60 (Feb. 1984).
11. SLAVIN, D. *Cryptosporidium meleagridis* (sp. nov.). *Jour. Comparative Pathol.*, 65:262 (1955).
12. ANDERSON, B.C. & BULGIN, M.S. Enteritis Caused by *Cryptosporidium* in Calves. *Vet. Med. Small Clin.*, 76:865 (1981).
13. ANDERSON, B.C. Is Cryptosporidial Infection Responsible for Diarrhea? *Calif. Vet.*, 36:9 (1982).
14. ANDERSON, B.C. Cryptosporidiosis in Idaho Lambs: Natural and Experimental Infections. *Jour. Am. Vet. Med. Assn.*, 181:151 (1982).
15. BARKER, I.K. & CARBONELL, P.L. *Cryptosporidium agni* sp. n. From Lambs and *Cryptosporidium bovis* sp. n. From a Calf With Observations on the Oocyst. *Z. Parasitenkd.*, 44:289 (1974).
16. ANGUS, K.W. ET AL. An Outbreak of Diarrhea Associated With Cryptosporidiosis in Naturally Reared Lambs. *Vet. Rec.*, 110:129 (1982).
17. TZIPORI, S.; CAMPBELL, K.W.; & CLERIHEW, L.W. Diarrhea Due to *Cryptosporidium* Infection in Artificially Reared Lambs. *Jour. Clin. Microbiol.*, 14:100 (1981).
18. MEISEL, J.L. ET AL. Overwhelming Water Diarrhea Associated With Cryptosporidium in an Immunosuppressed Patient. *Gastroenterol.*, 70:1156 (1976).
19. Cryptosporidiosis: An Assessment of Chemotherapy of Males With Acquired Immune Deficiency Syndrome (AIDS). *Morbid. & Mortal. Weekly Rept.*, 31:589 (1982).
20. Cryptosporidiosis Among Children Attending Day-Care Centers: Georgia, Pennsylvania, Michigan, California, New Mexico. *Morbid. & Mortal. Weekly Rept.*, 33:599 (1984).
21. TAYLOR, J.P. ET AL. Cryptosporidiosis Outbreak in a Day-Care Center. *Amer. Jour. Diseases of Children*, 139:1023 (1985).
22. BAXBY, D.; HART, C.A.; & TAYLOR, C. Human Cryptosporidiosis: A Possible Case of Hospital Cross-Infection. *Brit. Med. Jour.*, 287:1760 (1983).
23. KOCH, K.L.; PHILLIPS, D.J.; & CURRENT, W.J. Cryptosporidiosis in Hospital Personnel: Evidence for Person-to-Person Transmission. *Ann. Intern. Med.*, 102:593 (1984).
24. TZIPORI, S. Cryptosporidiosis in Animals and Humans. *Microbiol. Rev.*, 47:84 (1983).
25. FAYER, R. ET AL. Factors Contributing to Clinical Illness in Calves Experimentally Infected With a Bovine Isolate of *Cryptosporidium*. *Proc. Helminthol. Soc. Wash.*, 52:64 (1985).
26. ERNEST, J.A. ET AL. Infection Dynamics of *Cryptosporidium parvum* (Apicomplexa: Cryptosporidiidae) in Neonatal Mice (*Mus musculus*). *Jour. Parasitol.*, 75:796 (1987).
27. MILLER, R.A.; BRONSDON, M.A.; & MORTON, W.R. Determination of the Infectious Dose of *Cryptosporidium* and the Influence of Inoculum Size on Disease Severity in a Primate Model. Proc. Ann. Mtg. Amer. Soc. Microbiol., Washington, D.C. (1986).
28. JOKIPII, L.; POHJOLA, S.; & JOKIPII, A. Cryptosporidiosis Associated With Traveling and Giardiasis. *Gastroenterol.*, 89:838 (1985).
29. MA, P. ET AL. Cryptosporidiosis in Tourists Returning From the Caribbean. *New England Jour. Med.*, 312:647 (1985).
30. D'ANTONIO, R.G. ET AL. A Waterborne Outbreak of Cryptosporidiosis in Normal Hosts. *Ann. Intern. Med.*, 103:886 (1985).
31. GERBA, C.P.; SINGH, S.N.; & ROSE, J.B. Waterborne Viral Hepatitis and Gastroenteritis. *Critical Rev. in Envir. Control*, 15:213 (1985).
32. *Cryptosporidium*: A Carrollton, Ga., Case History. South Georgia Regional Mtg., Ground Water and Poll. Control Assn. (1987).
33. JURANEK, D. Personal communication (1987).
34. Cryptosporidiosis New Mexico, 1986. *Morbid. & Mortal. Weekly Rept.*, 36:561 (1987).
35. GARCIA, L.S. ET AL. Techniques for the Recovery and Identification of *Cryptosporidium* Oocysts From Stool Specimens. *Jour. Clin. Microbiol.*, 18:185 (1983).
36. STERLING, C.R. & ARROWOOD, M.J. Detection of *Cryptosporidium* sp. Infections Using a Direct Immunofluorescent Assay. *Pediatric. Infect. Dis.*, 5:5139 (1986).
37. GARCIA, L.S.; BREWER, T.C.; & BOUCKNER, D.A. Fluorescence Detection of *Cryptosporidium* Oocysts in Human Fecal Specimens by Using Monoclonal Antibodies. *Jour. Clin. Microbiol.*, 25:1:119 (Jan. 1987).
38. STIBBS, H.H. & ONGERTH, J.E. Immunofluorescence Detection of *Cryptosporidium* Oocysts in Fecal Smears. *Jour. Clin. Microbiol.*, 24:517 (1986).
39. ONGERTH, J.E. & STIBBS, H.H. Identification of *Cryptosporidium* Oocysts in River Water. *Appl. Envir. Microbiol.*, 53:672 (1987).
40. MUSIAL, C.E. ET AL. Detection of *Cryptosporidium* in Water Using Polypropylene Cartridge Filters. *Appl. Envir. Microbiol.*, 53:687 (1987).
41. ROSE, J.B. ET AL. Detection of *Cryptosporidium* From Wastewater and Freshwater Environments. *Water Sci. & Technol.*, 18:233 (1986).
42. FAYER, R. & LEEK, R.G. The Effects of Reducing Conditions, Medium, pH, Temperature, and Time on in Vitro Excystation of *Cryptosporidium*. *Jour. Protozool.*, 31:567 (1984).
43. SPEER, C.A. & REDUKER, D.W. Oocyst Age and Excystation of *Cryptosporidium parvum*. *Can. Jour. Zool.*, 64:1254 (1986).
44. SUNDERMAN, C.A.; LINDSAY, D.S.; & BLAGBURN, B.L. In vitro Excystation of *Cryptosporidium baileyi* From Chickens. *Jour. Protozool.*, 34:1:28 (1987).
45. MADORE, M.S. ET AL. Occurrence of *Cryptosporidium* Oocysts in Sewage Effluents and Select Surface Waters. *Jour. Parasitol.*, 73:702 (1987).
46. ROSE, J.B. ET AL. Detection of *Cryptosporidium* and *Giardia* in Environmental Waters. *Advances in Water Analysis and Treatments*. AWWA, Denver, Colo. (1987).
47. LOGSDON, G.S. Evaluating Treatment Plants for Particulate Contaminant Removal. *Jour. AWWA*, 79:9:82 (Sept. 1987).
48. ANGUS, K.W. ET AL. Evaluation of the Effect of Two Aldehyde-Based Disinfectants on the Infectivity of Faecal *Cryptosporidia* for Mice. *Res. Vet. Sci.*, 33:379 (1982).
49. PAVLASEK, I. Effect of Disinfectants in Infectiousness of Oocysts of *Cryptosporidium* sp. *Cesk. Epidemiol. Mikrobiol. Immunol.*, 33:97 (1984).
50. CAMPBELL, I. ET AL. Effect of Disinfectants on Survival of *Cryptosporidium* Oocysts. *Vet. Res.*, 111:414 (1982).



About the author: *Joan B. Rose is a postdoctoral research associate in the Department of Microbiology, University of Arizona, Tucson, AZ 85721. Rose has been involved in research on methods development for the recovery of parasites and viruses from environmental samples for five years and has been conducting a survey of waters for* Cryptosporidium *and* Giardia *for the last year and a half.*

MASSACHUSETTS DEPARTMENT OF PUBLIC HEALTH
DIVISION OF COMMUNICABLE DISEASE CONTROL

GIARDIASIS FACT SHEET

What is giardiasis?

Giardiasis is a gastrointestinal infection caused by a microscopic parasite called *Giardia lamblia*. This protozoan is the most common parasite causing gastrointestinal illness in the United States. Giardiasis is a common problem in day-care centers, various institutions where personal hygiene is poor, and in areas where drinking water is not filtered. Recently, *Giardia* has been found to cause large outbreaks of disease where water supplies are contaminated with the organism.

How is giardiasis spread?

A *Giardia* infection is acquired when you ingest food or water which has been contaminated with the cyst stage of the parasite. The parasite will then multiply in the small intestine, form cysts, and be passed out with a bowel movement. Therefore, any food or drink which has become contaminated with the stool of an infected person or animal can transmit the parasite. The infection is also spread person-to-person when hands which are contaminated with an infected person's stool are brought in contact with the mouth. This is the main way that giardiasis is spread in day-care centers and other institutions where the personal hygiene of children and disabled people may be poor.

How are animals involved in the spread of giardiasis?

Giardia cysts have been found in the stools of many animals including rodents, dogs, cats, cattle, and wild animals. Animals living near water supplies, such as beaver and muskrats, have been found to be infected with *Giardia*. However, the importance of these animals in causing human disease is unclear and is being researched.

What are the symptoms of giardiasis?

Symptoms of giardiasis appear within four weeks (usually 7 to 10 days) after ingesting the parasite. The most common symptoms are diarrhea, foul stools, abdominal cramps, bloating, increased gas, weakness, and weight loss.

Do all people who are infected with Giardia get sick?

No. Some people who are infected with the parasite may only have minor symptoms and some people may not have any symptoms at all. However, these people can still pass Giardia cysts in their stool and become a source of infection for others.

How is giardiasis diagnosed?

Giardiasis is usually diagnosed through a laboratory examination of a stool sample. Your physician will forward the stool sample to a laboratory which will use a microscope to look for the parasite. The disease can also be diagnosed through a sample of fluid or a biopsy from the small intestine.

What is the treatment for giardiasis?

There are several medications which are effective in treating the infection. They are only available by a prescription from your physician. Other treatments such as intravenous fluids and diarrhea medications may also be recommended by your physician.

How can giardiasis be prevented?

Giardiasis can be prevented by practicing good hygiene and using caution before drinking water from an unknown source.

Some general guidelines are:

1. Always thoroughly wash your hands with soap and water before meals, before preparing food, after using the bathroom, after changing diapers, and after playing with your pets.

2. Do not drink untreated water from a surface water supply such as a pond, lake, or stream. Although the water may appear to be clean, it may contain Giardia cysts which cannot be seen without a microscope. If only untreated water is available, boil the water before drinking it.

3. If you are taking care of a person with giardiasis, use extra precautions after contact with the person's stool (for example, after changing diapers). Promptly and carefully dispose of any material which has been contaminated with stool and always wash your hands after such contact.

4. If your source of drinking water is from a well or another surface water supply, do not allow humans or animals to defecate (have bowel movements) near the water. If such contamination is unavoidable, you should consider installing a water filter designed to filter out Giardia cysts.

Are there any health regulations for people with giardiasis?

Yes. In order to protect the public, all employees of food-related businesses (for example; restaurants, food stores, food processing plants) who have giardiasis are required by law to be absent from work until they have two consecutive negative stools taken at least 48 hours apart. This law also applies to foodhandlers who are household contacts of a person with giardiasis. In addition, it is recommended that children with giardiasis be carefully monitored if they are in a day-care center or similar situation.

Where can I get further information?

You can obtain further information from your physician or your local board of health.

Giardia Cyst Concentrations in River Water

Jerry E. Ongerth

Water samples from three pristine rivers in the Pacific Northwest were analyzed for *Giardia* cyst presence and concentration using a membrane-filtration–immunofluorescence-assay procedure. A total of 222 samples were collected either monthly or bimonthly over a nine-month period from 17 sampling stations on three rivers and 12 tributaries. Cyst recovery efficiency was monitored using samples seeded with cysts at levels ranging from 0.5 to 50 cysts/L. The recovery efficiency of the procedure averaged 21.8 percent ± 6 percent through 26 sets of samples. *Giardia* cysts were found in 94 (43 percent) of the samples. The corresponding cyst concentrations calculated from the recovery efficiency and the sample volume ranged from 0.1 to 5.2 cysts/L. The distribution of cyst concentrations in positive samples was lognormal. Both the magnitude of cyst concentrations (as indicated by the mean value) and the variability (as indicated by the slope of the distributions) differed among the three rivers. No statistically supportable seasonal variations were found. The principal conclusion was that *Giardia* cysts appear to be continuously present, though at low concentrations, even in relatively pristine rivers.

The presence of *Giardia lamblia* cysts in sources of public water supply has been documented in many areas of the United States and Canada.[1] It has been described as one of the most common etiological agents contributing to outbreaks of waterborne gastroenteritis.[2] Control of *Giardia* cysts in water treatment has been challenging because their removal by filtration requires consistently efficient operation and specialized analytical techniques,[3] and because they are relatively resistant to conventional disinfectants.[4]

Knowledge of *Giardia* cyst concentrations in water is relevant to public health protection for several reasons, yet no data on cyst concentrations in water have been reported. First, the risk of infection through consuming cyst-contaminated water must be directly proportional to cyst concentration, assuming uniform cyst viability and infectivity characteristics. Second, the concentration of cysts in untreated sources of water supply undoubtedly depends on the nature and magnitude of sources (and sinks) throughout the watershed. Examination of surface streams in remote areas has shown that the frequency of cyst discovery is directly related to the intensity of human activity in the watershed.[5] High levels of *Giardia* cysts have been found in municipal sewage treatment plant effluents,[6,7] suggesting that cyst concentrations in streams receiving such effluents would be affected proportionately. Third, the effectiveness of water treatment for *Giardia* cyst removal or inactivation is finite and defined by prior work[3,4] in terms of a percentage of the initial cyst concentration. Accordingly, a treatment plant using a raw water source downstream of a sewage treatment plant discharge would be expected to have a higher cyst concentration in the finished water than would the same facility treating raw water from a watershed with no wastewater sources.

This study was motivated by the importance of cyst concentrations to water quality planning, the current lack of data on cyst concentrations in water, and by preliminary work that indicated the practicality of measuring cyst concentrations in relatively pristine water sources. The work reported here was designed to satisfy four objectives: (1) to demonstrate the characteristics and capabilities of a small-volume, membrane-filtration–immunofluorescence-assay (MF–IFA) procedure for quantification of *Giardia* cysts; (2) to determine the concentration of *Giardia* cysts in water from three Pacific Northwest watersheds with different characteristics; (3) to determine the nature of variations in the *Giardia* cyst concentration as a function of time, both short-term and seasonal; and (4) to examine the influence of watershed characteristics on cyst concentrations.

A nine-month study was conducted, including regular collection and analysis of samples from 17 sampling stations on

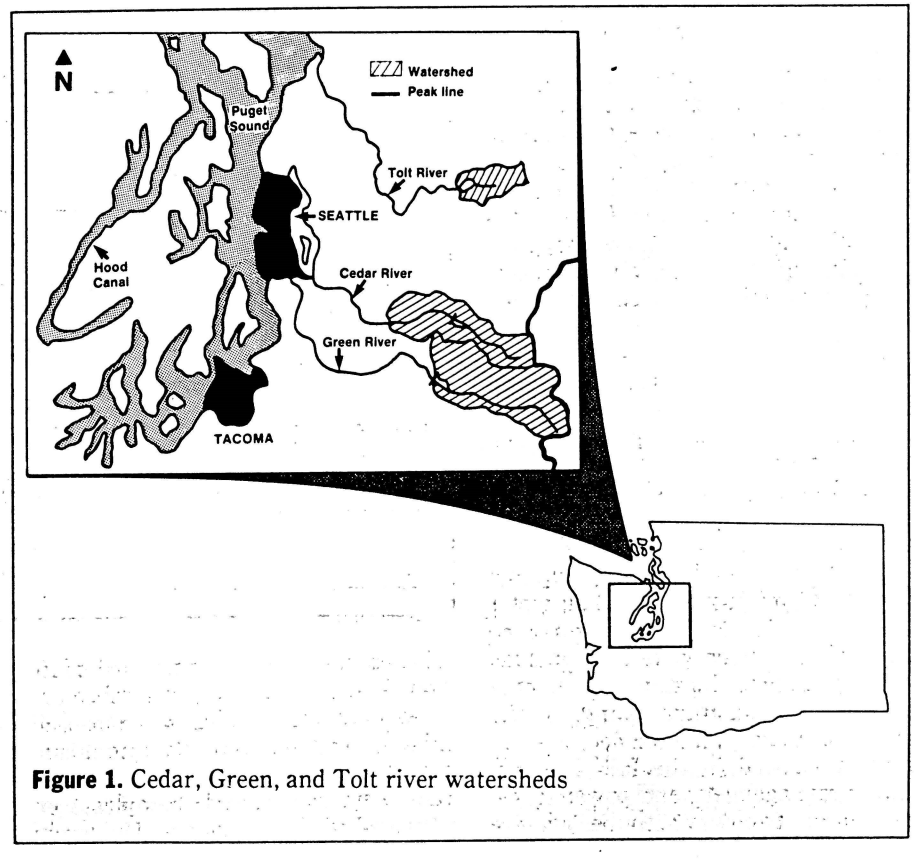


Figure 1. Cedar, Green, and Tolt river watersheds

three rivers and 12 tributaries, to accomplish these objectives. Samples were collected once or twice per month from tributaries or from main-stem stations, respectively. Four sets of consecutive bihourly samples were collected to examine short-term concentration variations over 24-h periods. Sample volumes of 40 L (10 gal) were used for all routine analyses. A few larger samples (120 and 400 L) were analyzed to determine recoveries with larger sample volumes and to check cyst concentrations below the normal limit of detection. All samples were processed in the laboratory using an MF-IFA procedure for recovery, detection, and identification of cysts.

Analysis of more than 200 samples collected over the nine-month period yielded useful information about cyst concentrations in water. *Giardia* cysts were consistently present in the rivers examined, at concentrations ranging from 0.05 to 0.8 cysts/L. The average cyst concentration differed from river to river, although the degree of variability in cyst concentrations was similar from river to river. Sampling above and below stream impoundments with residence times of from 30 to 200 days indicated that cyst concentrations were not reduced by reservoir transit.

Materials and methods

Sample collection. Water samples of approximately 40 L (10 gal) were collected from 17 sampling stations on or tributary to the Cedar, Green, and Tolt rivers, which drain the western slope of the central Cascade Mountains in Washington (Figure 1). Sampling locations were selected to examine cyst concentrations from watersheds with differing characteristics and as a function of transit along the main stem of each river, including passage through an impoundment of substantial size.

The watersheds of each river are controlled by municipal water departments for public water supply. No public access is permitted in the Tolt River watershed, although closely supervised logging and timber management are allowed. In the Cedar River watershed, only very limited public access (such as guided educational tours) is permitted. Other closely supervised activities include logging and timber management, railroad and power transmission rights-of-way maintenance, and research. Public access is permitted in the upper portion of the Green River watershed, extending to a limit of 23 mi above the public water supply diversion. Public activities in the upper Green River watershed include camping, fishing, hunting, snowmobiling, and cross-country skiing. In the lower watershed a limited deer and elk hunt is allowed in the fall. Logging, timber management, and power transmission rights-of-way activities also are allowed under closely controlled conditions in the Green River watershed.

Samples were collected from well-mixed, representative locations and placed in new 20-L disposable containers* that were not reused. Samples were delivered to the laboratory (University of Washington, Seattle) within 4-6 h of collection. Processing was initiated upon receipt of samples and was concluded within 48 h. This article covers the sampling period Jan. 1 to Sept. 30, 1987.

Water sample processing. Sample processing for *Giardia* cyst recovery, identi-

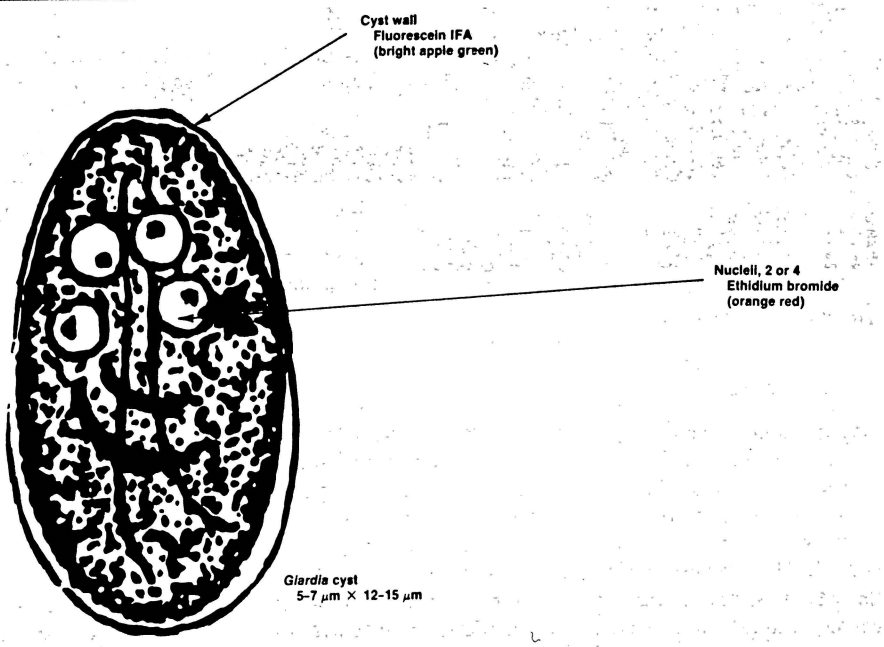


Figure 2. Schematic of *Giardia* cyst stained with fluorescein IFA and ethidium bromide

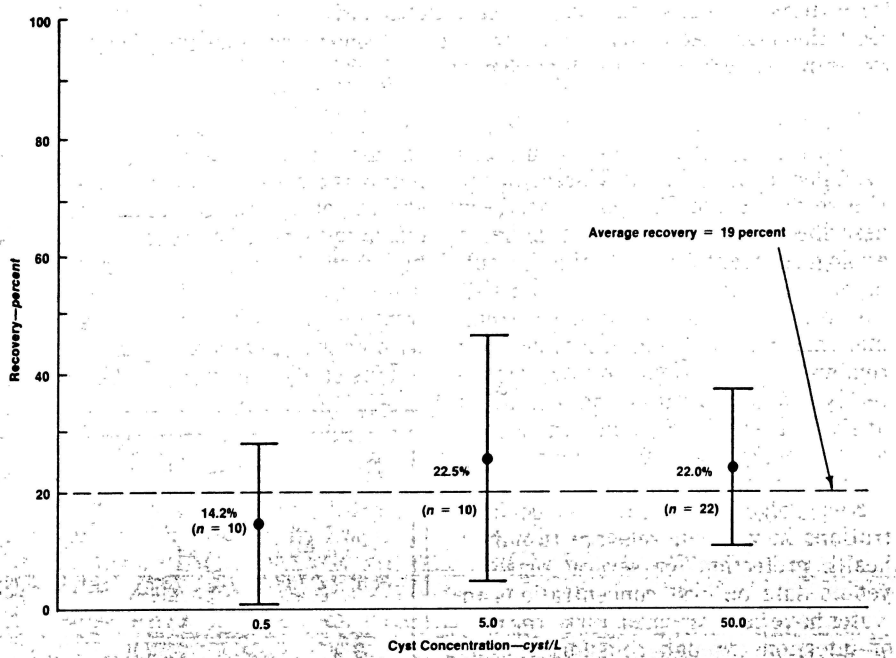


Figure 3. Percentage of cyst recovery versus cyst concentration

TABLE 1
Giardia *cysts concentration summary, including expected values for zero samples for the Cedar, Green, and Tolt rivers*

River	Median Concentration *cysts/L*	Concentration at − 1s	Concentration at + 1s	Coefficent of Variation
Cedar	0.17	0.08	0.54	2.20
Green	0.20	0.08	0.83	3.19
Tolt	0.13	0.06	0.38	1.92

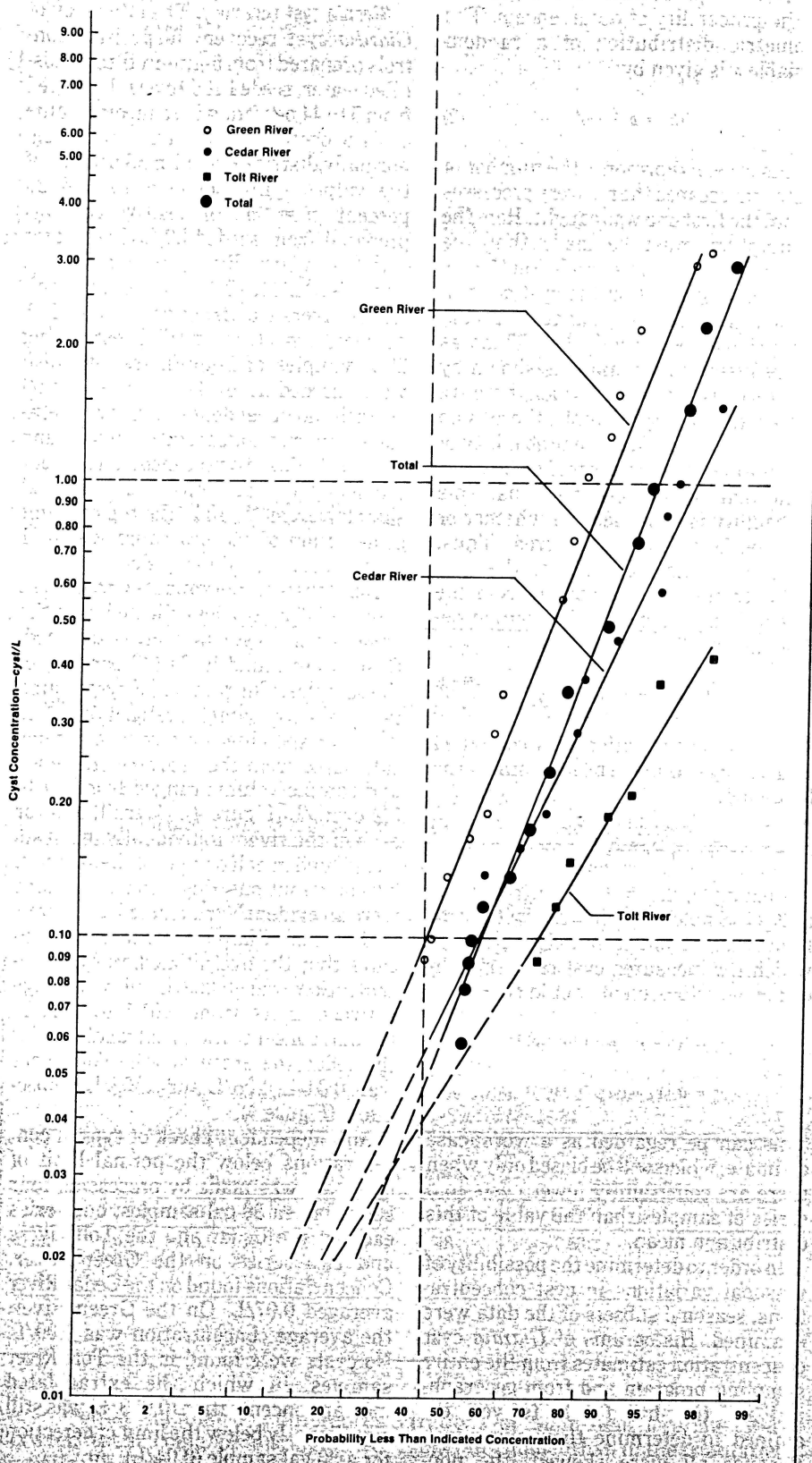


Figure 4. Lognormal probability plot of *Giardia* cyst concentration in the Cedar, Green, and Tolt rivers

fication, and counting was performed in batches of five samples, with negative and positive controls added to each batch for quality control and quantification of cyst recovery efficiency. Samples were batched according to watershed, with negative controls processed between batches and positive controls processed after all other samples to avoid contamination. Positive controls were prepared by adding purified *G. lamblia* cysts to (seeding) 20 L of either 5-μm-filtered distilled water or unfiltered river water to produce a concentration of approximately 50 cysts/L. Cysts for positive controls were of human origin, propagated in gerbils inoculated from axenically cultured trophozoites. Negative controls consisted of 20 L of distilled water, prefiltered by a 5-μm pore size membrane.

Water samples and controls were processed in accordance with the following procedure, and all filtrations were done with polycarbonate membranes.† Samples were mixed thoroughly and filtered through a 293-mm-diameter, 5-μm pore membrane at 250 mm Hg vacuum. A 53-μm monofilament nylon mesh was used as a prefilter. After filtration, the filter membrane was carefully removed and mounted faceup on a 30-cm × 30-cm glass plate. Particles were recovered from the filter surface by alternately rinsing the filter surface from top to bottom with a stream of 0.2-μm-filtered distilled water applied with a wash bottle and by squeegeeing with a 4-cm × 1-mm flexible rubber blade, directing the rinse water into a collection pan. The rinse and squeegee procedures were repeated twice, producing a particle-containing liquid rinse volume of approximately 200 mL. This volume was reduced by centrifuging in 50-mL centrifuge tubes at 650 × g for 15 min and aspirating to 10 percent of original volume. The remaining material was resuspended and combined to form a homogeneous 40–50-mL concentrate. *Giardia* cysts were separated from heavier and lighter debris by layering the concentrate on a gradient of 40 percent potassium citrate as described elsewhere.[8] The cyst-containing particle fraction was harvested from the potassium-citrate-concentrate interface and deposited by vacuum filtration (250 mm Hg) on a 13-mm-diameter, 5-μm pore size membrane contained in an in-line filter holder.‡ The filter was rinsed three times with 5 mL of 0.2-μm-filtered distilled water and kept moist prior to MF-IFA staining.

MF-IFA procedure. The MF-IFA procedure used in this study is similar to that described elsewhere,[8] with modifications to increase processing efficiency. The procedure was applied to particles retained on the 13-mm-diameter, 5-μm pore size filter while in the in-line filter holder.

The first reagent used was a polyclonal rabbit anti-*Giardia* cyst serum prepared by procedures described elsewhere.[8] This serum was diluted 1:150 with phosphate-buffered saline (PBS, pH 7.6) containing 0.1 percent bovine serum albumin (BSA) (essentially fatty-acid-free).§ The MF-IFA was completed using fluorescein-isothiocyanate- (FITC-) labeled goat anti-rabbit serum immunoglobulin G (IgG)

*Cubitainer, VWR Scientific, San Francisco, Calif.
†Nuclepore Corp., Pleasanton, Calif.
‡Model SX00 01300, Millipore Corp., Bedford, Mass.
§Sigma Chemical Co., St. Louis, Mo.

(antiheavy and light chains),* which was diluted 1:40 with PBS containing 0.1 percent BSA.

The MF-IFA reagents were applied to the filters while in the 13-mm filter holders, using antiserum volumes of 0.25 mL. Filter holder ports were stoppered to retain the serum during incubation. Filters were incubated at 37°C for 30 min for both sera. After incubation, each filter was rinsed with three 10-mL volumes of PBS. In the final step, 0.2 mL of ethidium bromide† at 50 μg/mL in PBS was applied to each filter and incubated for 10 min at 5°C. Following a final PBS rinse, filters were mounted on glass slides in elvanol under a glass coverslip as described elsewhere.[8]

Cyst identification and counting. Filters were examined by epifluorescence microscopy at ×250 or ×400 magnification.‡ *Giardia* cysts were identified by the following criteria: size, shape, FITC stain color and distribution, ethidium bromide stain, and brightfield illumination appearance. All features have been described elsewhere,[9] except for the ethidium bromide feature. The addition of ethidium bromide consistently stained the nucleii of *Giardia* cysts processed by membrane filtration (Figure 2). This enabled visualization of the two to four nucleii as red-orange brightly fluorescing objects toward one end of the cyst. This partly overcomes the disadvantage of identifying cysts on polycarbonate filters that cannot be cleared to permit phase contrast examination for internal structure components. Using this procedure, the entire area of each filter was examined. The position of cystlike objects was recorded by the initial examiner for reexamination by a second experienced examiner for independent corroboration.

Statistical analysis and calculations. The number of cysts (n) counted on a filter was consistently a fraction of the actual number of cysts (n_s) occurring in the sample. The n_s was estimated by dividing the number of cysts counted by the recovery percentage (p), measured in positive controls. The actual cyst concentration (c_s) was then estimated by dividing by the sample volume (v):

$$c_s = n/(p \cdot v) \qquad (1)$$

In a significant proportion of samples, no cysts were found. Given a cyst recovery efficiency that was always less than 100 percent, for samples in which no cysts were found the probability that cysts may have been present but escaped detection is finite and can be estimated using a geometric model. This model describes the distribution of the number of independent trials taken before a positive result (whose probability of occurrence is p, in which $0 \leq p \leq 1$) occurs. For this application, the value of the recovery percentage p is the measure of the probability of occurrence p. The geometric distribution of a random variable k is given by:

$$f(k) = p(1-p)^k \qquad (2)$$

In this case, k represents the number of cysts that escaped the recovery processes before the first one was caught. Here the assumption must be made that the probability of escape for each cyst $(1 - p)$ was not dependent on the cyst concentration and does not change markedly when the concentration is low. This was a reasonable assumption, as shown by Figure 3. In other words, when there are few cysts in a large sample, there is no reason to believe that the probability of any one cyst being recovered is different from that of any other or that this probability is dependent on whether or not another cyst is recovered. Thus, when no cysts were found, the cyst concentration was computed from the mean of the geometric distribution defined in Eq 2.[10]

$$k_o = E(k) = (1-p)/p \qquad (3)$$

The cyst concentration was computed by dividing this mean by v, obtaining the following:

$$c_o = k_o/v$$

For example, the cyst concentration for a 40-L sample in which no cysts were found, and from a sample batch for which the measured cyst recovery efficiency was 19 percent, would be:

$$c_o = [(1 - 0.19)/0.19]/40\ \text{L}$$

$$c_o = 0.11\ \text{cysts/L}$$

This can be regarded as a worst-case estimate, which will be biased only when there are consistently fewer cysts in a series of samples than the value of this distribution mean.

In order to determine the possibility of seasonal variations in cyst concentrations, seasonal subsets of the data were examined. Histograms of *Giardia* cyst concentration estimates from the entire sampling program and from geographical and time-based subsets were examined to determine their symmetry. Because all were skewed, the nonparametric Kruskal-Wallis (K-W) one-way statistic was applied for one-way group comparisons. Pairwise comparisons of cyst estimates between rivers were also done with a K-W test.[11] When such multiple comparisons were performed, the critical p value, which is usually taken to be 0.05, was divided by the number of comparisons made according to a Bonferroni adjustment factor.[10]

Results

***Giardia* cyst recovery.** The efficiency of *Giardia* cyst recovery in positive controls prepared from 5-μm-prefiltered distilled water, seeded at 50 cysts/L, ranged from 5 to 44 percent with a median value of 21.8 percent. The values were log-normally distributed, with 85 percent of the values lying between 15 and 29 percent (n = 26). In positive controls prepared from seeded 20-L river water samples (Cedar River, station CPR-1, Sept. 1-Oct. 31, 1987) the recovery efficiency averaged 28 percent, $s = \pm 13$ percent, n = 11. In parallel tests using 20-L samples of 5-μm-filtered distilled water seeded at levels of 0.5, 5, and 50 cysts/L, no dependence of recovery efficiency on cyst concentration was found (Figure 3). Based on the median recovery efficiency (22 percent) and a typical sample volume of 40 L, the typical limit of detection of the procedure was 0.11 cysts/L, calculated using Eq 1.

***Giardia* cyst concentrations in river water.** A total of 222 samples collected from the three river systems were examined. Cysts were found in 94 (43 percent) of the samples. The number of cysts found in the positive samples ranged from 1 to 24. Corresponding cyst concentrations calculated from the recovery efficiency and sample volume ranged from 0.1 to 5.2 cysts/L (Figure 4). Overall, and for each of the rivers individually, no cysts were found in half or more of the samples. The distributions of cyst concentrations were all evidently truncated by the limit of detection. Simple extrapolation indicates that the overall median cyst concentration was 0.063/L with a range between ± 1s from 0.017 to 0.24/L. Median concentrations extrapolated for the Cedar, the Green, and the Tolt rivers were 0.04/L, 0.06/L, and 0.003/L, respectively (Figure 4).

An independent check of typical concentrations below the normal limit of detection was made by processing four series of ten 30-gal samples, one series each on the Cedar and the Tolt rivers and two series on the Green River. Concentrations found on the Cedar River averaged 0.07/L. On the Green River, the average concentration was 0.09/L. No cysts were found in the Tolt River samples, in which the extrapolated median concentration (0.003/L) was still significantly below the limit of detection for a 30-gal sample (0.04/L).

A more conservative picture was developed by calculation of an expected (most probable) value of cyst concentration for each zero sample using Eq 4. A comparison of the data processed in this way for each of the rivers showed that although they each had cyst concentrations in the same general range (0.05-0.5/L), and

*Cooper Biochemical, Malvern, Pa.
†Sigma Chemical Co., St. Louis, Mo.
‡Zeiss Model 14, Carl Zeiss Inc., Thornwood, N.Y.

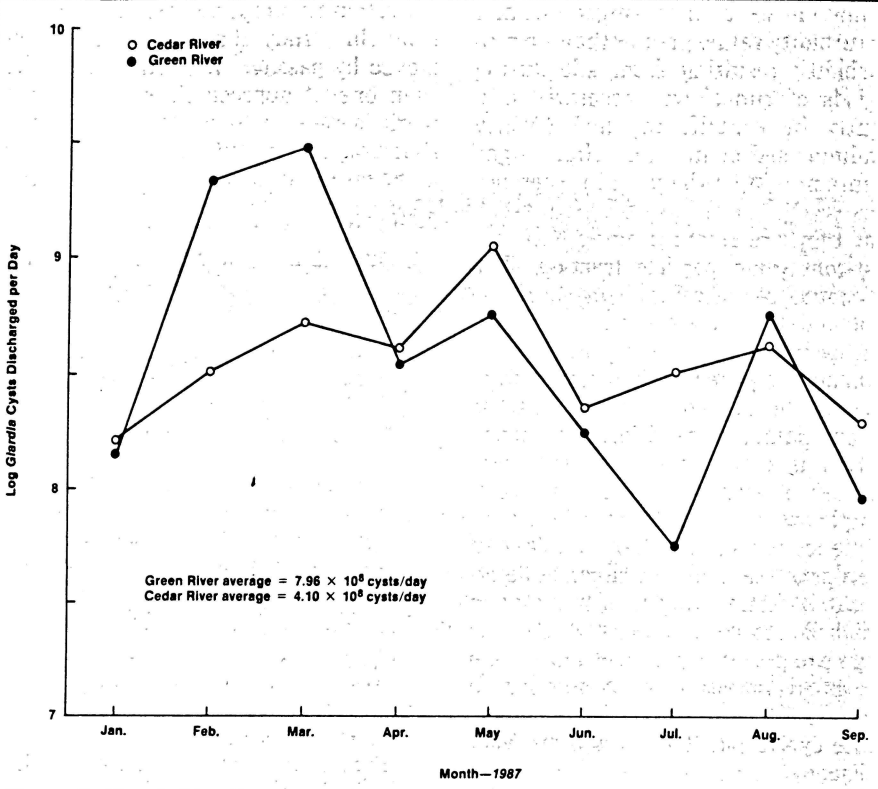


Figure 5. Total *Giardia* cyst discharge by month on the Cedar and Green rivers from January through September 1987

TABLE 2
Characteristics of reservoirs on the Cedar, Green, and Tolt rivers

River	Reservoir Name	Catchment Area *sq mi*	Volume *acre-ft*	Surface Area *acres*	Residence Time *days*
Cedar	C. Morse	143	40,000	1,680	100±
Green	H. Hansen	220	26,000	700	30-50
Tolt	Tolt	19	56,000	850	200±

TABLE 3
Quantiles of Giardia *cyst concentration by season in the Green, Cedar, and Tolt rivers—January-September 1987*

Season	Quantile 0.10	0.25	0.50	0.75	0.90	Number of Samples *n*	Statistical Significance K-W	*p*
Winter	0.09	0.10	0.12	0.37	0.49	48	2.68	0.26
Spring	0.07	0.08	0.11	0.24	0.44	60		
Fall	0.06	0.08	0.10	0.46	0.59	45		

although variations in concentration were similar (similar *s*), differences between them could be distinguished statistically (Table 1).

Comparison of cyst concentrations among the three rivers using the K-W test found that those on the Green River were higher than those on both the Cedar and the Tolt rivers ($p \leq 0.05$) but that the Cedar River cyst concentrations could be distinguished from the Tolt River concentrations only at $p \leq 0.10$. Cyst concentrations in individual tributaries were essentially comparable. They were not statistically distinguishable from each other, river by river. Concentrations at main-stem locations were generally higher than in the tributaries.

Cyst concentrations measured in mainstem rivers were compared for sampling stations above and below a reservoir. The Cedar, Green, and Tolt rivers each have a major impoundment in the reach studied (Table 2). Using the K-W test, the concentrations found above and below each of the three reservoirs could not be distinguished, even at a significance level as low as $p \leq 0.25$. Median cyst concentrations above and below the Cedar, Green, and Tolt reservoirs were 0.12 and 0.22, 0.27 and 0.32, and 0.16 and 0.21 cysts/L, respectively.

Seasonal changes in cyst concentrations were examined by dividing the data for each river into three-month periods corresponding approximately to months of snow cover and freezing temperatures (January-March), cool temperatures and high runoff (April-June), and dry, warm conditions (July-September). The median cyst concentration decreased from 0.12 to 0.10/L from winter to fall; however, by the K-W test the changes were not significant ($p \leq 0.26$), as shown in Table 3. A plot of mass loading of cysts calculated from monthly average cyst concentrations and monthly average river discharges for the farthest downstream sampling points on the Cedar and the Green rivers shows an irregular pattern of variation within a relatively narrow range (Figure 5).

Discussion

This study demonstrated that *Giardia* cysts were continuously present in three rivers in Washington at concentrations ranging from 0.05 to about 1.0 cyst/L during the period from January through September 1987. These observations contrast with the previous impression that *Giardia* cysts were intermittently present in water, an impression probably derived from the intermittent nature of waterborne giardiasis outbreaks.[2]

Several observations regarding temporal variations in cyst concentrations were made. The range of variation found over the nine-month sampling period in each river, i.e., from $-1s$ to $+1s$, is less than a factor of 2 (Figure 4). This is comparable to the concentration variations in dissolved water quality constituents for the same rivers. The data collected at 1-3-h intervals over daily cycles show that cyst concentrations do not vary significantly over time periods of this length. These data should be viewed in light of the likely sources of cysts and location of sampling stations in the watershed. Because human access and activities in the three watersheds are strictly controlled, cyst sources are assumed to be exclusively the animal populations. Cyst shedding by animals ranging from beaver, coyote, and bobcat to deer and elk has been confirmed in these watersheds by examination of fecal samples not reported here.

The cyst concentration levels in the three rivers were statistically distinguishable even though the differences in median concentration were only 10 to 20 percent. Although differences in characteristics of the three watersheds can be described in terms of features that may be relevant to levels and distribution of animal and human activity, the small differences in cyst concentrations among the three watersheds did not justify efforts to identify causal relationships.

The cyst concentrations found in this study may be compared with those reported for the Youghiogheny River at McKeesport, Pa.[6] Analysis of 37 samples of 100 gal each by the US Environmental Protection Agency (USEPA) method[12] resulted in finding cysts in each of the samples with numbers ranging from 1 to 438. Quality control results indicated an average cyst recovery efficiency of 7.7 percent (range from 3 to 13.8 percent). Using the average recovery efficiency, the cyst concentration range for that study was 0.03 to 15/L. The author made a limited comparison (not reported here) of the USEPA method and the method reported here. Samples were taken from a single source at the same time and were processed independently by the two methods. Based on the results, the authors believe that the USEPA method underestimates cyst concentration. In 15 samples processed over a two-month period, no cysts were found in 100-gal samples using the USEPA method. Cysts were found in six of the fifteen 20-gal samples processed by the method reported here; the median concentration was 0.05/L, with the range between ± 1*s* from 0.03 to 0.10/L. Based on this comparison of limited data, the authors expect that examination will reveal significantly higher cyst concentrations in rivers elsewhere, particularly where wastewater cyst sources are present as described for the Youghiogheny River[6] and where water temperature and physical conditions permit cyst survival.

The procedures described in this article proved effective and practical for finding and quantifying *Giardia* cysts in a project of major magnitude. The method has several advantages. Its applicability to small samples permits processing in the laboratory. It also permits examining the entire particle concentrate with reasonable efficiency. These features lend a degree of control not possible in procedures requiring field application and the processing of large particle volumes, resulting in examination of aliquots that must be assumed representative. Although this procedure has advantages, it is not entirely without problems. Variations in cyst recovery ranged from 7 to 44 percent. These variations could not be accounted for except in terms of features of test materials, including cyst antigen characteristics, stain reactivity, processing solution variations, and variations in the particle composition of the water being processed.

The limit of detection of the procedure used in this study was 0.11 cysts/L for the median recovery efficiency (22 percent) using a 40-L sample. Consistent results were achievable when processing waters with turbidities up to 2.5 ntu. Sample processing and microscopic examination were increasingly difficult for turbidity values greater than 1.5 ntu. Turbidity resulting from silt during periods of runoff was separated efficiently by centrifuging and density gradient sedimentation. High algae counts presented the most interference because their settling velocities are such that they are retained along with the cyst-containing particle fraction. The procedure as described can easily be applied to achieve a lower limit of detection by increasing the sample volume. This may require distributing the final particle concentrate to more than one 13-mm-diameter final filter. The concentration is determined from the total number of cysts identified, the total sample volume, and the cyst recovery efficiency for that batch of samples. An appropriate sample volume can be determined by conducting a pilot study in which 20- to 40-L aliquots of a single large sample (100 gal, for example) are processed along with one or more seeded controls. This will establish the approximate cyst concentration and recovery efficiency.

The time and cost of processing 40-L samples based on examination of a single 13-mm-diameter filter were determined in the course of the project. This can be expressed in terms of time and materials. One experienced technician can process a complete batch of five water samples, plus negative and positive controls, in a 40-h week. Including the cost of labor, chemicals, 293- and 13-mm filters, and amortization of an epi-illumination UV-microscope (at a first cost of $10,000), the total cost per sample was between $250 and $300. This included 25 percent indirect labor costs and overhead costs of 23 percent.

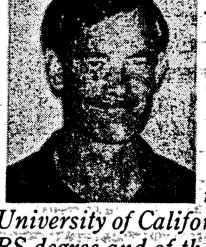
Conclusions and recommendations

Based on application of the small volume MF-IFA method used in this study, the concentration of *Giardia* cysts present in relatively pristine waters was in the range of 0.05 to 1.0/L. Further work is needed to better define factors contributing to variations in cyst recovery using this procedure. Better understanding of this aspect should help to improve the limit of detection.

Giardia cysts should be considered to be present in surface waters at a relatively constant concentration that may depend on the magnitude of sources in the watershed and on factors affecting cyst persistence in water. Further work is required to identify the nature and effect on cyst concentrations of such factors as watershed characteristics, animal population characteristics, and the influence of human activities, including urban runoff and wastewater discharges. Previous work shows that cysts are subject to degradation in the environment, particularly in warmer water (data not reported here). It appears from this study that cysts are not removed by passage through a reservoir, even one of appreciable size. Further work is needed to identify conditions that would contribute to cyst removal or degradation with downstream passage.

References

1. AKIN, E.A. & JAKUBOWSKI, W. Drinking Water Transmission of Giardiasis in the United States. *Water Sci. Technol.*, 18:10:219 (1986).
2. CRAUN, G.F. Waterborne Outbreaks of Giardiasis: Current Status. *Giardia* and *Giardiasis* (S.L. Erlandsen, and E.A. Meyer, editors). Plenum Press, New York (1984).
3. HENDRICKS, D.W.; BELLAMY, W.D.; & AL-ANI, M. Removal of *Giardia* Cysts by Filtration. Proc. Envir. Engrg. Specialty Conf., Los Angeles, Calif., June 1984. ASCE, New York (1985).
4. HIBBLER, C.M. ET AL. Inactivation of *Giardia* Cysts With Chlorine at 0.5°C and 5°C. AWWA Res. Fdn., Denver, Colo. (1987).
5. SUK, T.J.; RIGGS, J.L.; & NELSON, J.L. Water Contamination With *Giardia* in Back-Country Areas. Proc. Natl. Wilderness Res. Conf., Ft. Collins, Colo., July 23-26, 1985. Intermountain Research Station, Ogden, Utah (1987).
6. SYKORA, J.L. ET AL. Monitoring of Water and Wastewater for *Giardia*. Proc. 1986 AWWA WQTC, Portland, Ore., Nov. 16-20.
7. MCHARRY, M.J. Detection of *Giardia* in Sewage Effluent. *Jour. Protozool.*, 31:362 (May 1984).
8. ONGERTH, J.E. & STIBBS, H.H. Identification of *Cryptosporidium* Oocysts in River Water. *Appl. Envir. Microbiol.*, 53:672 (1986).
9. RIGGS, J.L. ET AL. Detection of *Giardia lamblia* by Immunofluorescence. *Appl. Envir. Microbiol.*, 45:698 (1983).
10. HOEL, P.G.; PORT, S.C.; & STONE, C.J. *Introduction to Probability Theory*. Houghton Mifflin, Boston, Mass. (1971).
11. HOLLANDER, M. & WOLFE, D.A. *Nonparametric Statistical Methods*. John Wiley & Sons, New York (1983).
12. *Standard Methods for the Examination of Water and Wastewater*. APHA, AWWA, and WPCF, Washington, D.C. (16th ed., 1985).



About the author: *Jerry E. Ongerth is an assistant professor in the Department of Environmental Health, University of Washington, Seattle, WA 98195. Ongerth is a graduate of the University of California, Berkeley, with a BS degree and of the University of Michigan, Ann Arbor, with MS and PhD degrees, all in the field of civil and sanitary engineering. His work has been published by* Applied and Environmental Microbiology, Journal of Clinical Microbiology, American Journal of Public Health, *and* Journal WPCF.

Protect Yourself

There are several ways for you to treat raw water to make it safe to drink. The most certain treatment to destroy giardia is to boil water for at least 1 minute. Boiling also will destroy other organisms causing waterborne disease. At high altitudes, you should maintain the boil for 3 to 5 minutes for an added margin of safety.

Chemical disinfectants such as iodine or chlorine tablets or drops are not yet considered as reliable as heat in killing giardia, although these products work well against most waterborne bacteria and viruses that cause disease. The amount of iodine or chlorine necessary to kill giardia depends on water temperature, pH, turbidity, and contact time between the chemical and the parasite. Until current research determines the right amount of chemical and duration of contact time that will work against giardia under a variety of water conditions, chemicals cannot be recommended for routine disinfection of water for giardia. In an emergency where chemical disinfection is necessary, use an iodine-based product, since iodine is often more effective than chlorine. If possible, filter or strain the water first, and then allow the iodine to work at least 30 minutes before you drink the water. If the water is cold or cloudy, wait at least an hour, or use more iodine.

For short trips, take a supply of water from home or other domestic source.

Protect Others

Giardia can be readily transmitted between humans and animals. Feces (human or animal waste) can contain the organism. Waste should be buried 8 inches deep and at least 100 feet away from natural waters.

Dogs, like people, can get infected with giardiasis. Unless they are carefully controlled, dogs can contaminate the water and continue the chain of infection from animals to humans. For this reason, their inclusion in your travel plans should be carefully considered.

February 1981

GPO : 1981 O - 338-682

Is The Water Safe?

Think Before You Drink



United States Department of Agriculture

Forest Service

FS-359

A Hidden Hazard

We hope your visits to your National Forests will be enjoyable, and they will be if you avoid hazards that may be encountered in the great outdoors. One hidden hazard you should know about is a disease that may be contracted from drinking untreated "natural" water. The disease is an intestinal disorder called GIARDIASIS (gee-ar-*dye*-a-sis). It can cause you severe discomfort.

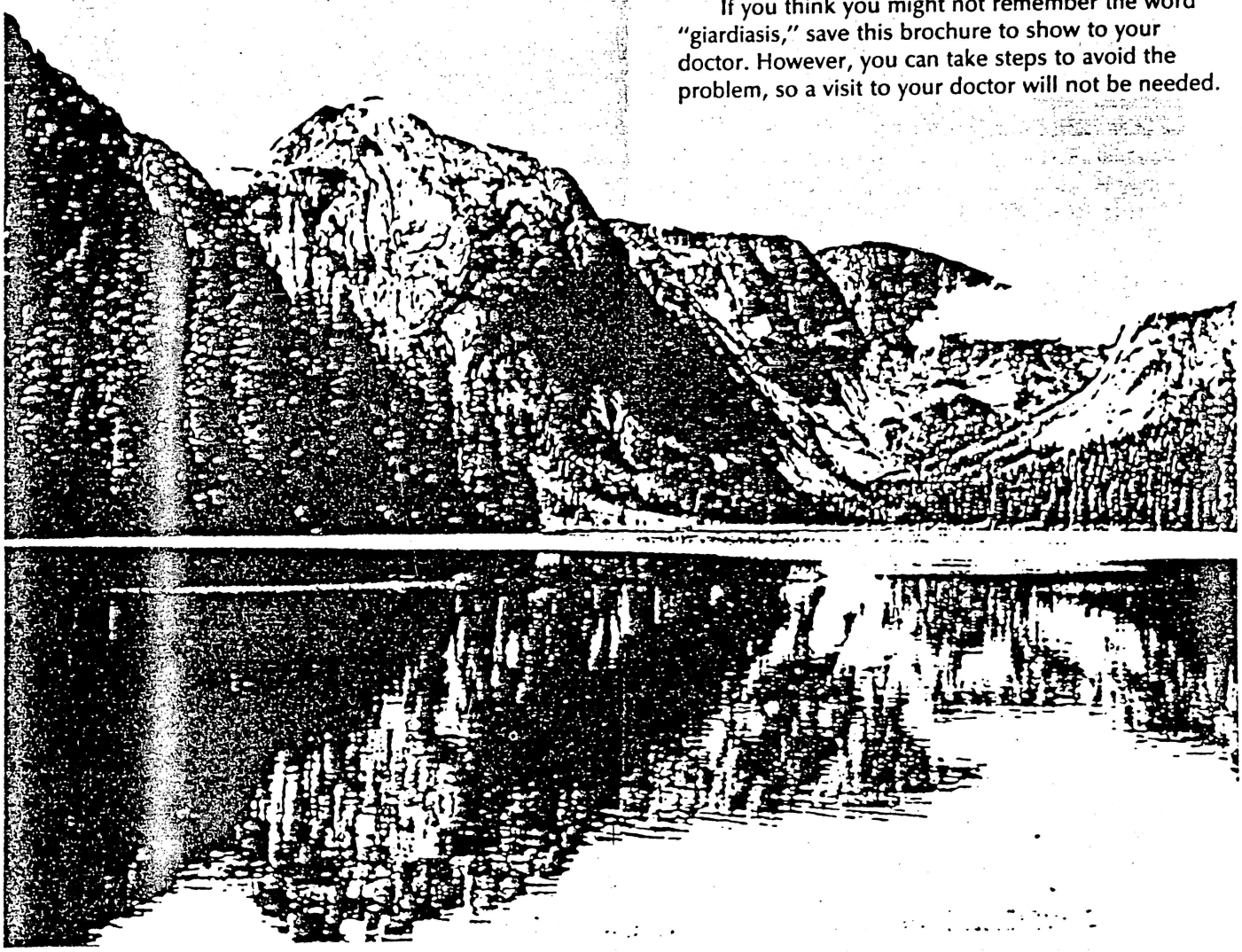
The disease is caused by a microscopic organism, *Giardia lamblia*. The cystic form of giardia may be found in mountain streams and lakes. These natural waters may be clear, cold, and free-running. They can look, smell, and taste good. You may see wildlife drinking without hesitation from these sources. All of these indicators sometimes lead people to mistakenly assume that natural waters are safe to drink. Giardia may or may not be present, but you should be aware of possible danger.

The Disease—Symptoms and Treatment

Although giardiasis can be incapacitating, it is not usually life threatening. After ingestion by humans, giardia normally attach themselves to the small intestine.

Disease symptoms usually include diarrhea, increased gas, loss of appetite, abdominal cramps, and bloating. Weight loss may occur from nausea and loss of appetite. These discomforts may first appear a few days to a few weeks after ingestion of giardia, and may last up to 6 weeks. Most people are unaware that they have been infected and have often returned home from vacations before the onset of symptoms. If not treated, the symptoms may disappear on their own, only to recur intermittently over a period of many months. Other diseases can have similar symptoms, but if you have drunk untreated water you should suspect giardiasis and so inform your doctor. With proper diagnosis the disease is curable with medication prescribed by a physician.

If you think you might not remember the word "giardiasis," save this brochure to show to your doctor. However, you can take steps to avoid the problem, so a visit to your doctor will not be needed.



Causes of a Waterborne Giardiasis Outbreak

Thomas E. Braidech and Richard J. Karlin

In November 1981, a waterborne giardiasis outbreak occurred within the Highlands Water and Sanitation District in Colorado. Although the immediate cause of the outbreak was reduced chlorine contact time because of a pump failure, numerous design and operational deficiencies existed at the plant. Lack of chemical pretreatment, improper backwashing procedures, poor application of raw water to the filter, and failure to monitor plant conditions all contributed to the outbreak. Turbidity and bacteriological records did not indicate any problems, confirming the crucial role of proper design, installation, and operation of the multibarrier technique in preventing waterborne giardiasis outbreaks.

Giardiasis is an intestinal disease most often characterized by nausea, diarrhea, and loss of appetite. In humans, the causative organism is *Giardia lamblia*, a flagellated protozoan that colonizes the upper small intestine of many warm-blooded animals.[1] The organism is transmitted among humans and other animals by means of cysts passed in excreted fecal material. If an infected animal or human defecates in or near a stream, the cysts can then spread via the water. Consumption of water containing cysts of this organism is a principal method of contracting the disease.

During the fall of 1981, a giardiasis outbreak involving approximately 20 of the 165 people served by the system occurred at Highlands Water and Sanitation District (HWSD) in Colorado. The reported cases were evenly distributed throughout the service area. The service area, located approximately 2.5 mi (4 km) northwest of Aspen, Colo., is characterized by rental units, private residences, and restaurants adjacent to a ski area. Surface water from Maroon Creek serves as the raw water source for the system. The stream originates high in the mountains to the south of the district and is fed mainly by snowmelt and groundwater infiltration. Beaver, an important carrier of *Giardia lamblia* cysts,[1] inhabit the watershed.[2] The HWSD has been supplying drinking water to the area for 18 years and never before had reported an outbreak of waterborne disease. The treatment system was the unit installed when the district was formed.

The chronology of the outbreak began on Oct. 31, 1981, when residents of the district contacted the water plant operator to complain that they were out of water. Investigations showed that the district's 150 000-gal (5.7-ML) in-line storage tank was empty. A failure in the pumping system at the treatment plant was determined to be the cause of the water outage. Using an average consumption of 150 gpcd (568 L/d per capita), it was calculated that the pump had failed on approximately October 25th. This malfunction was corrected, and the plant was put back into service to refill the reservoir on that same day.

In late November 1981, the local health department began to receive reports of illness among residents of the district. Symptoms of the illness included diarrhea, bloating, cramping, gas, and vomiting. Subsequently, a team of local and state health department investigators conducted an epidemiologic study to determine the nature and extent of the problem.[2] Symptomatology, coupled with stool examinations, confirmed that the outbreak was, indeed, giardiasis.

Based on a previous arrangement, the HWSD was tied into the city of Aspen distribution system in mid-December 1981. No further cases of confirmed giardiasis were reported after the connection took place. Although both utilities use the same raw water source, the Aspen water treatment plant provides complete treatment, including coagulation, settling, filtration, and postchlorination. This change benefited the HWSD by providing it with a high quality finished water, thus mitigating the chance of future outbreaks of giardiasis. Because of this change in supply, the HWSD treatment plant was shut down and left in the condition that existed when the outbreak was identified. This afforded an opportunity for a detailed examination of the system to determine what circumstances led to the giardiasis outbreak.

Findings

On Jan. 20–21, 1982, approximately one month after shutdown, the treatment plant was examined by representatives of the Colorado Department of Health and the US Environmental Protection Agency (USEPA), Region VIII. The following is a discussion of what was learned during this investigation.

The Highlands treatment plant was designed as a 100-gpm (6.3-L/s) package plant with two dual-media filters totaling 50 sq ft (4.6 m^2) in area. From bottom to top, the filters were designed with 18 in. (0.46 m) of gravel, 8 in. (0.2 m) of sand, and 30 in. (0.76 m) of anthracite. Treatment consisted of prechlorination, plain sedimentation (detention time of 60 min), and filtration.[3] No provision was made for coagulant addition or postfiltration chlorination (Figure 1).

Investigation of the treatment plant and records disclosed the following:

- Inspection of the treatment unit showed that although it was structurally sound, sand had passed from the filter into the clearwell, indicating possible deficiencies in the media support, the underdrain system, or both.
- Observation of the surface of the filter indicated that the filter media directly below the settling basin overflow had washed out (Figure 2). These washout areas in the filter media, which were at least 10 in. (25 cm) deep in the anthracite, were apparently caused by the practice of restarting when the filter bays were devoid of water. This probably allowed water to short-circuit through the filter in this area.
- Analysis of the filter by probing

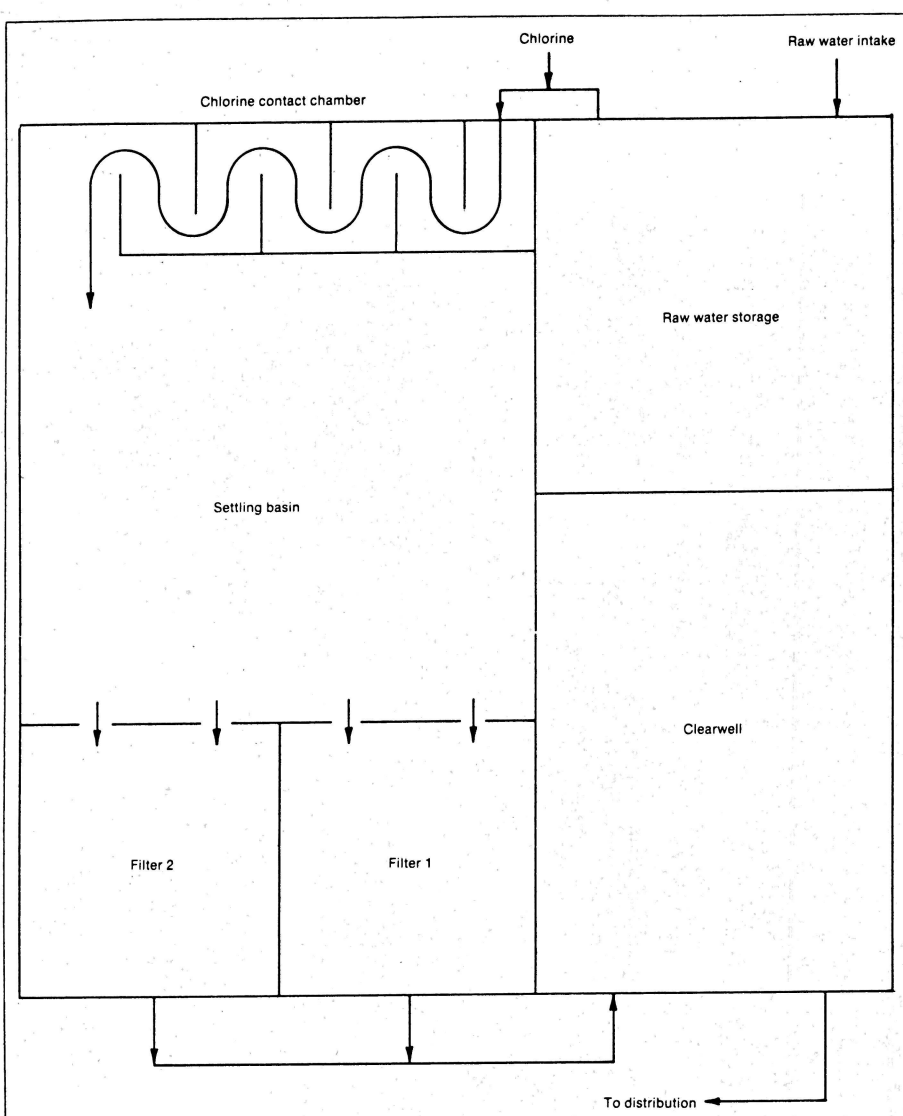


Figure 1. Diagram of Highlands Water and Sanitation District drinking water treatment plant

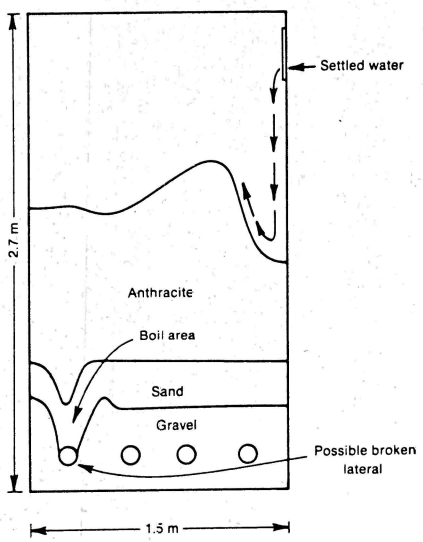


Figure 2. Cross section of filter bay showing washout of anthracite

with a metal rod[4] to determine the level of the media disclosed that the gravel level in both filters was uneven. A deviation of up to 8 in. (20 cm) below and above the average gravel depth was noted in both filters. This indicated that underdrain problems may have existed in the filters. It appeared that broken laterals were the probable cause of these blowout areas. This, however, could not be confirmed by examination because of the lack of equipment with which to excavate the filter beds.

- A test backwash of both filters resulted in "boil" areas with nonuniform bed expansion during the early phases of the backwash, again indicating underdrain deficiencies. Attempts to backwash the filters were complicated by difficulties with the automatic backwash controls, which were not functioning. Conversations with the operator indicated that he had been manually backwashing for some time and that backwashing was performed at approximately monthly intervals during periods of low turbidity. A review of plant records showed that the filter had been backwashed approximately one month prior to the failure of the plant.[5]
- Numerous mudcakes were uncovered at the interface between the sand and anthracite, indicating inefficient backwashing procedures. The interface was clearly defined with little mixing of the media despite the apparent underdrain deficiencies.
- Daily turbidity readings for October and November 1981 were below the maximum contaminant level (MCL) of 1 ntu. Records maintained at the treatment plant indicated that the daily turbidity varied from 0.28 to 0.71 ntu during this period. Turbidity on Oct. 31, 1981, the date of the reported water outage, was 0.44 ntu. These levels of turbidity are representative of levels normally found in the ambient water of the Colorado high country during the fall and were accepted as representative.
- No coliform bacteria were detected in the two routine samples collected in October 1981 or in the one sample collected in November, the period associated with the outbreak. The bacteriological MCL of not more than 1 coliform/100 mL of water was not violated.
- Chlorination was accomplished by using a diluted laundry bleach (sodium hypochlorite) solution, which was applied by a positive displacement metering pump rated at 15 gpd (56.8 L/d) maximum. At the time of inspection it was set to pump 8.1 gpd (30.7 L/d). Based on the reported dilution ratio used at the plant,[5] approximately 0.38 mg total chlorine/L was being applied at the time of the water outage. The actual chlorine residual in the distribution system and the chlorine demand of the raw water during this period are unknown because of the lack of plant data.

Discussion

The multibarrier technique (i.e., coagulation–flocculation, sedimentation, filtration, and disinfection) has been shown to be an effective method of treatment for the removal of cysts and cyst-sized particles from drinking water.[6,7] Indeed, this mode of treatment plant operation

has become the most widely used operation procedure in the industry. The method relies on the concept of using several steps in the treatment of raw water. Therefore, if one link in the treatment chain fails or is not operating correctly, safe potable water can still be produced.

The treatment train used at the HWSD plant did not adhere to the multibarrier concept. In fact, the lack of chemical pretreatment was the most significant design deficiency identified in terms of cyst removal. Inadequate pretreatment, i.e., coagulation-flocculation and sedimentation, of water prior to granular filtration has been shown to allow the passage of cysts into the finished water.[8-11] This investigation confirmed that filtration alone, without proper pretreatment, is incapable of continuously removing *Giardia* cysts. Drinking water facilities for treating surface water, or any water suspected of harboring *Giardia*, must include adequate pretreatment if cyst removal is expected.

Jarroll et al[12] showed that *Giardia lamblia* cysts are deactivated at the conventional chlorine dosages and holding times, e.g., 2 mg/L at pH 6 or 7 for 60 min at 5°C, used in the drinking water industry. This indicates that the response of *Giardia* to chlorine is similar to that of other waterborne organisms and, therefore, it would be killed by either a high chlorine dosage and short contact time or a low chlorine dosage and long contact time. After the pump breakdown at the HWSD plant was repaired, the need to supply water to the distribution system allowed water to reach the consumers shortly after treatment. This eliminated the long storage time (estimated to have been 7-10 days) during which the cysts either settled in the reservoir or were deactivated by long contact with low-level chlorine. Cysts could also have been resuspended from the tank sediment upon refilling. Despite possible short-circuiting, apparently settling, chlorine contact time, or both had been effective in preventing previous outbreaks of giardiasis.

The condition of the filters and underdrains was such that cysts could not have been removed reliably even if the multibarrier technique had been properly applied. The probing of the filters, which revealed unevenness in the gravel support media and sand in the clearwell, also indicated breaks in the underdrain laterals. These breaks may have occurred during manual backwashing, which caused sudden surges of water to the underdrain system. Subsequently, water could short-circuit through the filter in the area of the break, giving rise to the formation of the mudcakes found at the sand-anthracite interface. The mudcakes would tend to aggravate the situation by sealing off areas of the filter, thereby further increasing the velocity of the water and the short-circuiting through the filter. Given the evidence of sand in the clearwell, *Giardia* cysts, if present in the raw water, clearly could have passed through the filter.

The mounds and voids found in the anthracite at the surface of the filter bed were caused by a design that allowed water to cascade onto the empty filter from the settling chamber (Figure 2) after backwashing. The resulting shallow depths of media would exacerbate the short-circuiting problems and enhance the subsequent passage of cysts into the finished water.

Routine maintenance, including probing of the media and observation of clearwell conditions and backwash cycles, should be standard operational practices at all water treatment plants using granular media. Logsdon[11] reports that the practice of using extremely long filter runs with multiple start and stop cycles could result in cyst breakthrough.

Neither coliform nor turbidity tests indicated a potential problem. Although both of these tests are useful operational parameters, these analyses alone do not assure the absence of *Giardia* cysts in the finished water, particularly in granular-media plants where coagulation is not practiced or is inadequate. Indeed it has been the authors' experience[13] that meeting the MCL for these two parameters is of little or no value in determining whether the finished water of a given system may contain cysts.

Conclusions

The most likely cause of the HWSD outbreak was the presence of viable *Giardia* cysts in the potable water system. Three major factors led to the presence of these cysts in the distribution system: (1) a drastic reduction in the chlorine contact time available for disinfection; (2) the absence of chemical pretreatment, i.e., coagulation-flocculation, prior to sedimentation; and (3) the poor design, function, and operation of the filtration system.

It appears that the best alternative for eliminating the potential for outbreaks of giardiasis is to adhere to the multiple-barrier concept in treating water. Specifically, this should include chemical addition for coagulation-flocculation, sedimentation, and filtration followed by disinfection. Experience[13] has shown that systems in which the raw water turbidity is generally less than 1 ntu year-round have tended to eliminate chemical additives for coagulation-flocculation, which may place those served by the system in jeopardy. Further, operation and maintenance programs are commonly inadequate in small systems, particularly with regard to the condition of the filter bed. There must be a concerted effort to upgrade these programs to detect deficiencies in a drinking water treatment system and to eliminate the inadequacies that may contribute to the outbreak of disease.

Acknowledgments

John R. Blair and Jerry C. Biberstine were of great assistance in the inspection and analysis of the HWSD facility.

References

1. Waterborne Transmission of Giardiasis. Proc. USEPA Sym., Sept. 18-20, 1978. EPA-600.9-79-001 (June 1979).
2. Istre, G.R.; Dunlop, T.S.; & Gaspard, G.B. Waterborne Giardiasis at a Mountain Resort: Evidence for Possible Acquired Immunity. Unpubl., State of Colo. (1982).
3. Koch, F.O. Operating Manual, Highlands Water and Sanitation District, Water Supply and Distribution System. Pitkin County, Aspen, Colo.
4. American Water Works Association. *Water Quality and Treatment.* McGraw-Hill Book Co., New York (3rd ed., 1971).
5. Nelson, R. Colorado Department of Health Activity Report. Denver, Colo. (Jan. 13, 1982).
6. Logsdon, G.S. & Lippy, E.C. The Role of Filtration In Preventing Waterborne Disease. *Jour. AWWA*; 74:12:649 (Dec. 1982).
7. Logsdon, G.S. & Fox, K.R. Getting Your Money's Worth From Filtration. *Jour. AWWA*, 74:5:249 (May 1982).
8. Kirner, J.C.; Littler, J.D.; & Angelo, L.A. A Waterborne Outbreak of Giardiasis in Camas, Washington. *Jour. AWWA*, 70:1:35 (Jan. 1978).
9. Lippy, E.C. Tracing a Giardiasis Outbreak at Berlin, New Hampshire. *Jour. AWWA*, 70:9:512 (Sept. 1978).
10. Logsdon, G.S. et al. Alternative Filtration Methods for Removal of Giardia Cysts and Cyst Models. *Jour. AWWA*, 73:2:111 (Feb. 1981).
11. Logsdon, G.S.; DeWalle, F.B.; & Hendricks, D.W. Filtration as a Barrier to Passage of Cysts in Drinking Water. *Giardia and Giardiasis* (S.L. Erlandsen and E.A. Meyer, editors.) Plenum Press, New York (1984).
12. Jarroll, E.L.; Bingham, A.K.; & Roger, E.A. Effect of Chlorine on *Giardia lamblia* Cysts Viability. *Appl. & Envir. Microbiol.*, 41:483 (Feb. 1981).
13. Hopkins, R.S. et al. Waterborne Disease in Colorado: Report on Two Years' Surveillance of Eleven Waterborne Outbreaks. Final Rept. EPA Contract 68-03-2927, Colo. Dept. of Health, Denver, Colo. (Jan. 14, 1982).



About the authors: *Thomas E. Braidech is clean lakes coordinator with the US Environmental Protection Agency, Region VIII, 1860 Lincoln St., Denver, CO 80295. Richard J. Karlin is chief of the Drinking Water Section, Colorado Department of Health, 4210 E. 11th Ave., Denver, CO 80220.*

Giardia lamblia and Water Supply

Shun Dar Lin

Giardiasis is now recognized as the most common identified waterborne intestinal disease in the United States. This article describes the morphology and life cycle of the causative agent, *Giardia lamblia*, the detection of *Giardia* and the effectiveness of water treatment processes in removing it, and the epidemiology and clinical aspects of giardiasis.

For most of the 300 years since its discovery, *Giardia lamblia* was considered nonpathogenic because many of the individuals who harbored it did not get sick. Only in the last two decades has this organism been recognized as the most common identified pathogenic intestinal protozoan in the United States and as the cause of flagellate diarrhea (giardiasis).

Often called "traveler's disease," giardiasis is an affliction not only of travelers but also of skiers, campers, hikers, hunters, and fisherman who drink untreated water from mountain streams or inadequately treated water in recreational areas. Although outbreaks of waterborne giardiasis usually occur in small communities where water receives little or no treatment, some outbreaks have been associated with municipal and semipublic supplies that met the US Environmental Protection Agency's coliform and turbidity standards. No federal or state standard has been established to protect the public from giardiasis, and research into the removal and control of *Giardia* cysts is handicapped by the lack of an effective method for detecting the cysts in water.

This article describes the morphology, life cycle, and detection of *Giardia lamblia*; the pathogenesis, transmission, diagnosis, treatment, prevention, and epidemiology of giardiasis; and the removal of *Giardia* cysts by water treatment practices.

Morphology

Giardia lamblia was first discovered in 1681 by Leeuwenhoek, who found the organism in his own stools.[1] The taxonomy of this species has been confused in the past, and even today it is often called *G. intestinalis* or *G. enterica*. It was named for Giard, who studied the parasite, and for Lambl, who first described it.[2] *Giardia lamblia* is a flagellated protozoan belonging to the class Zoomastigophorasida, order Diplomonadorida, and family Hexamitidae.[3] *Giardia lamblia* has a trophozoite form (Figure 1) and a cyst form (Figure 2).



Giardia *trophozoites multiply by binary fission, the nuclei dividing first, followed by the locomotive apparatus and the sucking disc, and finally the cytoplasm.*

Trophozoite. The trophozoite of *G. lamblia* is one of the most easily recognized intestinal protozoa.[1,3-8] Its body is dorsoventrally flattened and pear-shaped, is bilaterally symmetrical, and has two anterior, vesicular nuclei and four pairs of flagella, which are used for swimming. Each nucleus has a large endosome, which, combined with a large sucking disc (adhesive disc) on the ventral side, gives the appearance of a "monkey face." Using the sucking disc, it can attach to flat surfaces.

The dorsal side of the trophozoite is convex. Along the longitudinal median line there are two parallel, slender median rods or axostyles, which are not true axostyles.[1,3] A pair of large, curved, transverse, darkly staining median bodies lie behind the sucking disc. These median bodies are unique to *Giardia* and are composed of microtubules arranged either irregularly or in ribbons. It has been suggested that they may help support the posterior end of *Giardia* or be involved in its energy metabolism.

The length of the trophozoite ranges from 9 to 21 μm, the width from 5 to 15 μm, and the thickness from 2 to 4 μm. Movement is erratic, occurring as a swaying and dancing motion. Because of their appearance and movement, *G. lamblia* trophozoites are easily identifiable in fresh preparations.

Since the trophozoites usually live in the duodenum and jejunum of humans, they appear only in the feces. Both trophozoites and cysts can be found in diarrhea feces along with unusual amounts of mucus, but trophozoites do not appear consistently.

Cyst. In an unfavorable environment the parasite encysts, and it is the cysts that are usually found in stools. During encystation, the flagella are retracted internally and appear as four pairs of delicate curved rods. The thick, resistant cyst wall is distinctly visible, and all cell contents usually shrink away from the posterior end, leaving a clear space. Characteristically oval or ellipsoid and slightly asymmetric in shape (8-14 μm long, 7-10 μm wide),[5,6] cysts from different hosts or even from the same host exhibit variation in size and shape.

Tombes et al[9] used scanning electron and phase microscopy to study the surface of *Giardia* cysts collected from feces of mice, guinea pigs, dogs, mule deer, and humans. They observed that the surfaces were relatively smooth without any characteristic features and that cysts from different hosts appeared to be indistinguishable. However, the cyst size they reported (approximately 10×6 μm) was smaller than described elsewhere.

Young cysts have only two nuclei, but mature ones contain four, located at one end. Starch inclusion in young cysts gives them the name "blue bodies."[5]

The median rods, fibrils, flagella, and endosome usually stain conspicuously. The characteristics of cysts can be examined in a formalinized stool specimen, with iodine solution added to render them more conspicuous.[4] *Giardia* trophozoites and cysts can be identified with microscopy after fixation (Schaadinn's fixative) and staining (Heidenhain's hematoxylin).[3] Cysts can be concentrated either by zinc sulfate flotation or by formalin-ether sedimentation. Sugar solution for flotation is unsatisfactory.[3]

Rendtorff and Holt[10] reported that *G. lamblia* cysts can survive in tap water and remain infective for 16 days, the longest time period tested.

Life cycle

Giardia lamblia lives in the duodenum, jejunum, and upper ileum of humans (Figure 3), with the sucking disc of the trophozoite fitting over the surface of an epithelial cell.[1,6] In a severe infection the parasites cover nearly every cell. The trophozoites multiply in the human intestine by binary fission,[1,8] the nuclei dividing first, followed by the locomotive apparatus and the sucking disc, and finally the cytoplasm.

When conditions in the duodenum are unfavorable, encystment occurs, usually in the large intestine. During encystment, the cell divides into two, so that each newly formed cell has only two nuclei. The sucking disc and flagella, however, multiply so that each newly formed cell contains one sucking disc and four flagella.

It has been calculated that as many as 14 billion parasites could occur in a diarrhea stool, but in a moderate infection a stool may contain 300 million cysts.[1] However, *Giardia* does not appear consistently in the stools of all patients, as there are three patterns of excretion, i.e., high, low, and mixed.[11]

Infection of humans occurs by ingestion of cysts. The cysts pass through the stomach and into the duodenum, where division of the cytoplasm is immediately completed. Within 30 min of ingestion, a cyst hatches out two trophozoites. The parasites proceed to multiply and to colonize the duodenum. To avoid the high acidity of the duodenum, *Giardia* often tend to be located in the biliary tract and gall bladder.[8]

Transmission

Transmission of giardiasis from host to host may occur by ingestion of *G. lamblia* cysts in contaminated drinking water and foods or by infected persons who may have cysts on their body or clothes. Campers, hunters, and hikers who drink untreated water from mountain streams are at increased risk. An obvious source of human contamination could not be identified in many of the water supplies studied. It is suspected that some wild and domestic animals, such as beaver, rats, rabbits, and dogs, may play an important role in the transmission of giardiasis to humans. Also, the incidence of giardiasis is found to be high in homosexual males,[12] suggesting that fecal-oral transmission by sexual activity is possible.

Davies et al[13] recently reported that *Giardia* cysts obtained from humans, dogs, cats, and beaver were not host-specific. *Giardia* cysts from humans infected dogs, cats, and beaver; *Giardia* from beaver infected dogs; *Giardia* from dogs or cats were cross-transmitted. It can be assumed that cysts from dogs, cats, and beaver would infect humans.

Pathogenesis

Giardia lamblia has long been considered nonpathogenic or an opportunistic pathogen for humans because cysts are often found in large numbers in the stools of asymptomatic persons. The response to exposure to *Giardia lamblia* is quite variable, with some individuals more sensitive to its presence than others. Children are more frequenlty affected than adults, and there is considerable evidence to suggest that protective immunity can be acquired.[1] Yardly and Bayless[14] discussed factors that affect human susceptibility, including infective dosage, host, enteric bacterial infection, and malnutrition.

Rendtorff[15] conducted a series of studies with five volunteer prisoners and found that none of the five was infected after receiving a single *Giardia lamblia* cyst orally in a gelatin capsule. Of 22 men who received 25-cyst dosages, only 6 became infected. However, various dosages from 10 to 1 million cysts given to 40 other men produced 100-percent infection. The results of these experiments suggest that (1) a small number of cysts in water can readily produce an infection in a susceptible host, (2) the dosage is not related to the persistence of infection, (3) examination of a stool from a *Giardia*-positive person might have a negative result, and (4) there are possibly different parasite strains involved in infection by *Giardia* cysts.

Giardiasis is not fatal but can be extremely uncomfortable. *Giardia lamblia* is capable of producing discomfort by its toxic effects in allergic individuals, by its traumatic and irritative effects, and by its spoliative action, i.e., by diverting nutrients.[8] It is not, however, a tissue invader. The incubation period is about eight days, and the prepatent period, before *Giardia* can be detected in the stool, is 10–30 days.[7]

G. lamblia attaches itself by means of its sucking disc to the surface of the epithelial cells of the intestine and bowel.[8] A dense coating of *Giardia* trophozoites on the intestinal epithelium interferes with the absorption of fats and other nutrients. The parasite does not lyse host cells but appears to feed on mucous secretions.[1] This may cause a disturbance of intestinal function and irritation or low-grade inflammation of duodenal or jejunal mucosa. Consequently, the patient suffers acute or chronic diarrhea and steatorrhea. At various times during the infection the stools may be watery, semisolid, greasy, bulky, and foul-smelling, but they never contain blood. At Aspen, Colo., during an outbreak of giardiasis, about five

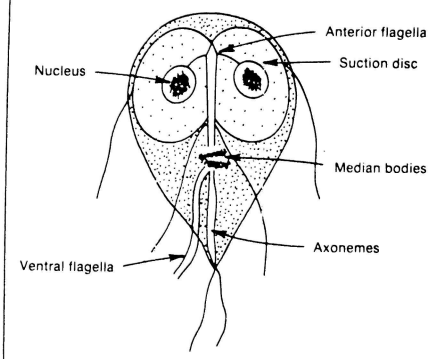


Figure 1. *Giardia lamblia* trophozoite

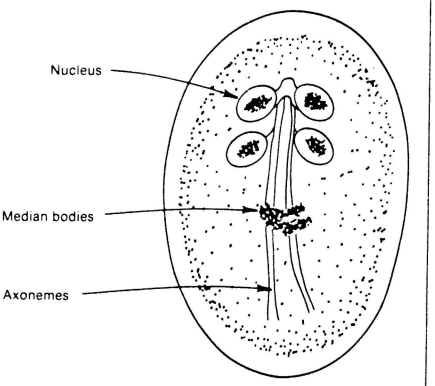


Figure 2. *Giardia lamblia* cyst

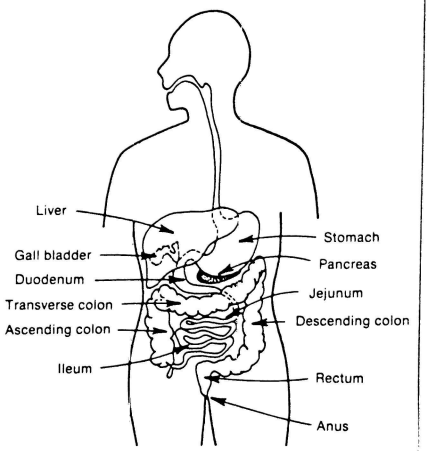


Figure 3. The human digestive system

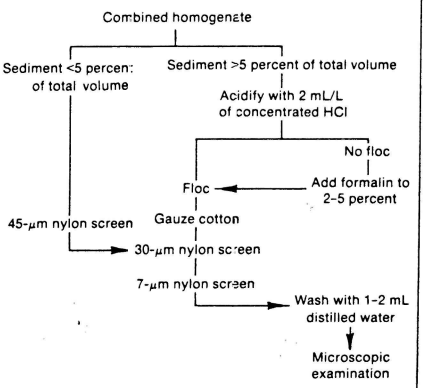


Figure 4. Flow diagram of sediment processing for detecting *Giardia* cysts in water

stools per day were observed for one to two months.

The symptoms range from mild diarrhea, malaise, weakness, fatigue, dehydration, weight loss, distension, flatulence, anorexia, cramplike abdominal pain, and epigastric tenderness to steatorrhea and malabsorption.[1-8] Some may be due to interference with fat absorption as well as to mechanical irritation of the bowel. They may last for long periods and may be intractable or hard to eliminate. The bile ducts and gall bladder may also be infected, causing mild catarrhal cholangitis, cholecystitis, jaundice, and colitis.[1,6]

Diagnosis

Chronic diarrhea as well as the symptoms mentioned previously can be clinically diagnosed. The cases can be categorized as follows:[8] (1) silent case: no symptoms; (2) intestinal: chronic enteritis and acute enterocolitis; (3) general: fever, anemia, and allergic manifestations; and (4) chronic cholecystopathy. The acute stage usually lasts only three to four days and is often not recognized at the time as being due to giardiasis, but sometimes may last for months.[16]

Kamath and Murugasu[17] evaluated the four laboratory diagnostic methods for detecting *G. lamblia* by studying 21 Malaysian children who had acute or chronic diarrhea or were suffering from malabsorption. These researchers found that mucosal impression smears and intestinal biopsies gave the highest number of positive tests—12 infections. Duodenal aspirates resulted in 10 positive tests, and stool examination was positive in only six cases. Because the biopsy method is tedious and time-consuming, Kamath and Murugasu recommended mucosal impression smears for *G. lamblia* as an initial step in routine intestinal biopsies. *Giardia* in the duodenum can also be detected by "Enterotest," which involves passing through the body a lead-weighted gelatin capsule on a string to which the parasites cling.[18]

Nevertheless, microscopic examination of the stool is widely used, and identification of distinctive *Giardia* cysts in formed stools or cysts and trophozoites in liquid stools is definitive. The drawbacks are that the excretion of the parasite may be intermittent and that the recovery methodology is imperfect. Stool samples should be collected properly on alternate days, using both direct smears and concentration with zinc sulfate or with the formalin-ether technique. Examination of the duodenal contents and intestinal biopsy are used only for confirmation when stool examinations are negative.[16]

Treatment of giardiasis

Usually, only the symptomatic patient requires treatment. However, it has been suggested that all members of the patient's family be treated simultaneously to avoid reinfection.[1]

Three drugs are available in the United States for treating giardiasis: quinacrine,* metronidazole,† and furazolidone.‡ The details of treatment are discussed elsewhere.[16] Quinacrine is widely used and effective in the treatment of giardiasis;[4,8,16] metronidazole is an alternative for children; furazolidone is an antibiotic and not widely used. Drugs found useful in other countries include acranil,[8] diiodohydroxyquin,[14] tinidazol, and nimorazole.[16] However, all of these drugs have potential problems.

TABLE 1
Outbreaks of waterborne giardiasis in the United States resulting from water system deficiencies

Year	Number of Outbreaks	Number of Cases	Reference
1965	1	123	26
1969	1	19	26
1970	1	34	26
1961-70	3	176	27
1971-72	3	112	28
1972	4	124	26
1973	4	73	26
1974	4	4 930	26
1971-74	12	5 127	29
1975	1	9	26
1976	3	629	26
1977	4	1 053	26
1971-78	24	12 004	30
1979	2		31

Prevention

The precautions generally practiced for the prevention of amebiasis are applicable to giardial infection and are based on breaking up the chain of transmission. Water treatment, food sanitation, and personal hygiene are the most important measures for the prevention of giardiasis. Human feces should be disposed of in a sanitary way, water supplies should be protected against fecal contamination by proper treatment and good watershed management practices, and drinking water should be boiled when necessary.

Commonly practiced chlorination (0.5 mg residual chlorine/L) of water supplies is inadequate as the sole treatment for destruction of cysts. Rapid sand filtration preceded by coagulation removes nearly all cysts; properly operated slow sand filters or diatomaceous earth filters completely remove them. Cross-connections between public water supplies and private auxiliary supplies, and backflow connections in plumbing systems should be avoided. For small quantities of water, Jarroll et al[19] claimed that a saturated solution (double strength) of iodine effectively destroyed *Giardia* cysts at 20°C with a 20-min exposure.

The personal health and sanitary practices of people who prepare and serve foods in public eating places should be supervised. Hand washing after defecation and before preparing or eating food is important. Special attention should be given to the education of preschoolers about personal hygiene.

Epidemiology

Giardia lamblia occurs worldwide and is the etiologic agent in waterborne giardiasis outbreaks. In about 50 percent of the disease outbreaks, however, the etiology is unknown. Healy[20] concluded from a literature review that, on the basis of stool examinations, the prevalence of *G. lamblia* infection among children in the United States ranged from 4 to 22 percent, whereas the rate for adults was from 2 to 15 percent. This variation may be due to differences in sampling frequencies and test procedures. *Giardia lamblia* was found in 7.4 percent of 35 299 people tested in the United States.

Harter et al[21] recently conducted a survey of intestinal parasites in two counties of Washington state. They reported that the prevalence of *G. lamblia* among 518 one- to three-year-old children was 7.1 percent and was unrelated to sources of drinking water (surface or well), day-care center attendance, or parental occupation. Conditions identified as high-risk for *Giardia* infection included a history of drinking untreated surface water and the presence in the family of two or more siblings between the ages of three and ten. In 47 families with children that had acquired a primary infection, 10 (21.3 percent) other family members subsequently became infected with *Giardia* as secondary cases.

Fifty-two percent of 419 Indochinese immigrants from Vietnam, Laos, and Cambodia in San Diego County, Calif., had intestinal parasites. Most of the refugees studied had symptoms and hematologic findings suggestive of parasitism.[22] Eighteen percent were found

*Atabrine, Winthrop Laboratories, New York, N.Y.
†Flagyl, Pharmaceutical Specialties, Morgantown, N.C.
‡Furoxone, Eaton Laboratories, Landsdale, Pa.

to be infected by *G. lamblia*. The infection was found to be unrelated to gender but was more prevalent in children.[22] In Prachinburi Province, Thailand, *G. lamblia* was found in 54 (11.9 percent) of 453 Cambodian refugees residing in Ban Kaeng Holding Center.[23] Among Amerindian populations of Amazonia, Lawrence et al[24] found that 24 percent of the inhabitants of acculturating villages were infected with *G. lamblia*, whereas only 5 percent were infected in newly contacted villages. The lowest occurrence of *G. lamblia* (1.5 percent) was recorded in Labrador, Canada, among 401 people between the ages of 1 and 72.[25]

Outbreaks of waterborne giardiasis in the United States have been reported in AWWA committee reports and other literature.[26-46] Detailed reviews were made by Craun.[26,30] The number of outbreaks resulting from water system deficiencies and the number of cases of giardiasis are summarized in Table 1. Craun[30] indicated that 24 recognized outbreaks of waterborne giardiasis occurred during 1971-78. Ten outbreaks were caused by surface waters treated with chlorine only, and eight were caused by untreated surface water. Ineffective filtration of surface water was responsible for the three outbreaks with the largest number of cases. Two outbreaks resulted from untreated groundwater supplies; the cause of one was undetermined. Nine outbreaks occurred in Colorado, three in Utah, and two each in Montana, New Hampshire, and Vermont. Six cases occurred in other states. Giardiasis outbreaks continue to increase in the United States, and undoubtedly many more cases occur than are reported.

Examples of outbreaks. During the fall and winter of 1954-55, an outbreak of gastroenteritis, which was characterized by the exceptionally prolonged duration of many of the cases, occurred in Portland, Ore. The outbreak affected at least 50 000 people of both sexes and all ages. An epidemiologic survey concluded that *G. lamblia* was the only possible etiologic agent for such an outbreak.[32]

The first documented outbreak of waterborne giardiasis in the United States was probably the outbreak at Aspen, Colo., during the 1965-66 ski season. An epidemiologic survey showed that 11 percent of 1094 skiers were infected.[33] Gleason et al[34] found that 5 percent of the permanent population remained infected after the epidemic.

Until the 1974 outbreak at Rome, N.Y., waterborne giardiasis outbreaks generally involved small municipal systems or semipublic systems in mountainous areas of the United States, particularly in New England, the Pacific Northwest, and the Rocky Mountains.[26,29] The Rome outbreak (November 1974-June 1975) was the largest outbreak of waterborne giardiasis ever reported in the United States. Epidemiologic studies estimated that 4800-5300 people (10 percent of the population) were affected.[33] This was the first time that *G. lamblia* cysts were actually recovered from water and clarifier sediment samples.[26,35,36] The city of Rome used a surface source of good bacteriological quality. Chlorination with 0.8 mg combined residual chlorine/L was the only treatment. The watershed was sparsely populated, but the source may have been contaminated by human and animal wastes.

During late April and early May of 1976 a giardiasis outbreak occurred in Camas, Wash. Approximately 600 of the population of 6000 people showed clinical signs of infection.[37] The city used surface water and well water sources—two mountain creeks and seven deep wells. The well waters were not contaminated, but *G. lamblia* cysts were detected in raw surface water and in samples from the distribution system. The watersheds of the two surface water sources were well isolated, with no human habitation and limited human activity.[36,37] *Giardia* cysts were isolated from trapped beaver, and it is possible that beaver active in the watershed were carriers of the organism. The water treatment system included mixed-media pressure filters and chlorination. Prior to the outbreak, interruptions in chlorination often occurred and the pretreatment processes were ineffective. *Giardia lamblia* cysts passed through the filter because of media loss, media disruption, and inadequate pretreatment. During the outbreak, however, the finished water was found to meet turbidity and coliform count standards.[37]

A second outbreak of waterborne giardiasis resulting from inadequate filtration occurred in Berlin, N.H., during April and May 1977.[38-40] About 7000 of the city's population of 15 000 people were affected. The majority (76 percent) of the infections were asymptomatic and ran a self-limited course without treatment.[40] The Berlin water plant used the Upper Ammonoosuc River and the Androscoggin River as independent water supply sources. *Giardia lamblia* cysts were recovered from both raw water sources and from the treated water. The Ammonoosuc plant uses eight pressure filters and chlorination without coagulation-sedimentation. Numerous deficiencies in the condition and operation of the filters could have permitted cysts to pass through the filters. Water from the Androscoggin River was treated conventionally with chemical coagulation, upflow clarification, rapid sand filtration, and chlorination. An engineering evaluation concluded that contamination resulted from joint leakages and faulty construction of a common wall separating the filtered and unfiltered waters, which allowed the water to bypass the filters.[38,39] Humans or beaver could have been responsible for contaminating the source waters.[38,40]

An epidemiologic study indicated that 429 (58 percent) of 741 residents of Vail, Colo., reported diarrheal illness during February, March, and April 1978.[41] Within a two-day period in April, 37 cases of laboratory-confirmed giardiasis were reported. There were statistically significant differences between those who drank no water and those who drank one or more glasses each day, but no difference was noted on the basis of age, sex, or length of residence. None of the seven separate Vail Valley water districts could be implicated as the source of the outbreak.

A waterborne giardiasis outbreak related to chlorination occurred in Bradford, Pa., from September to December 1979.[31] Epidemiologic investigations indicated that 5.4 percent of the residents had giardiasislike illnesses, with 407 cases recorded. *Giardia* cysts were isolated from raw and treated waters and from the stool of a beaver trapped in one of the water supply reservoirs. The city water was treated only with chlorination, and high coliform counts and turbidity had been observed prior to the outbreak.

Since the increase in travel to Russia began in 1970, giardiasis has become a "travel disease" for people who visit the Soviet Union. Twenty-three of 80 members (29 percent) of the Olympic Boxing Team and 84 of 164 (51 percent) US scientists were infected with giardiasis after visiting the Soviet Union in 1970. *Giardia lamblia* cysts were detected in the stools of some of these travelers, and epidemiologic investigations confirmed that the giardiasis was caused by consumption of tap water in Leningrad.[26]

In October 1976 a high incidence of diarrhea was reported among an American tour group that had traveled to Madeira Island, Portugal.[44] Results of a mail survey indicated that 39 percent of the responding 859 travelers had had diarrhea; in 42 percent of these, the diarrhea lasted for longer than a week. Twenty-seven of 58 (47 percent) ill patients had *G. lamblia* cysts in their stools. Tap water and ice cream or raw vegetables consumed on the island were implicated. There was no evidence of continuing transmission of giardiasis to American tourists visting Madeira 8 to 12 months after the outbreak.

Twenty-three of 54 campers who hiked and camped in the Uinta Mountains of Utah from Sept. 5 to 17, 1974, had diarrhea during and after the trip.[45] The stools of 22 out of 28 (79 percent) symptomatic campers contained *G. lamblia* cysts, whereas the stools of 4 out of 14 (29 percent) asymptomatic campers con-

tained cysts. Although the remote stream used as a water source by the campers was implicated as the vehicle of transmission, *G. lamblia* cysts were not found in the stream water or in the intestines or feces of mammals living in the drainage area, possibly because of poor methods of cyst recovery. On the basis of data from 25 other groups of campers, Barbour et al[45] concluded that campers who use water from mountain streams risk acquiring giardiasis.

An endemic giardiasis outbreak occurred among travelers visiting Cattail Cove State Park, south of Lake Havasu City, Ariz., from June through September 1979.[31] Most of the cases were reported in California. Four of 74 (5.4 percent) cases were stool-positive for *Giardia* cysts. The shallow well water serving the recreation area was chlorinated and pumped to two storage facilities. Cross-connections and poor plumbing may have resulted in contamination of the drinking water by an irrigation system that sprayed sewage effluent.

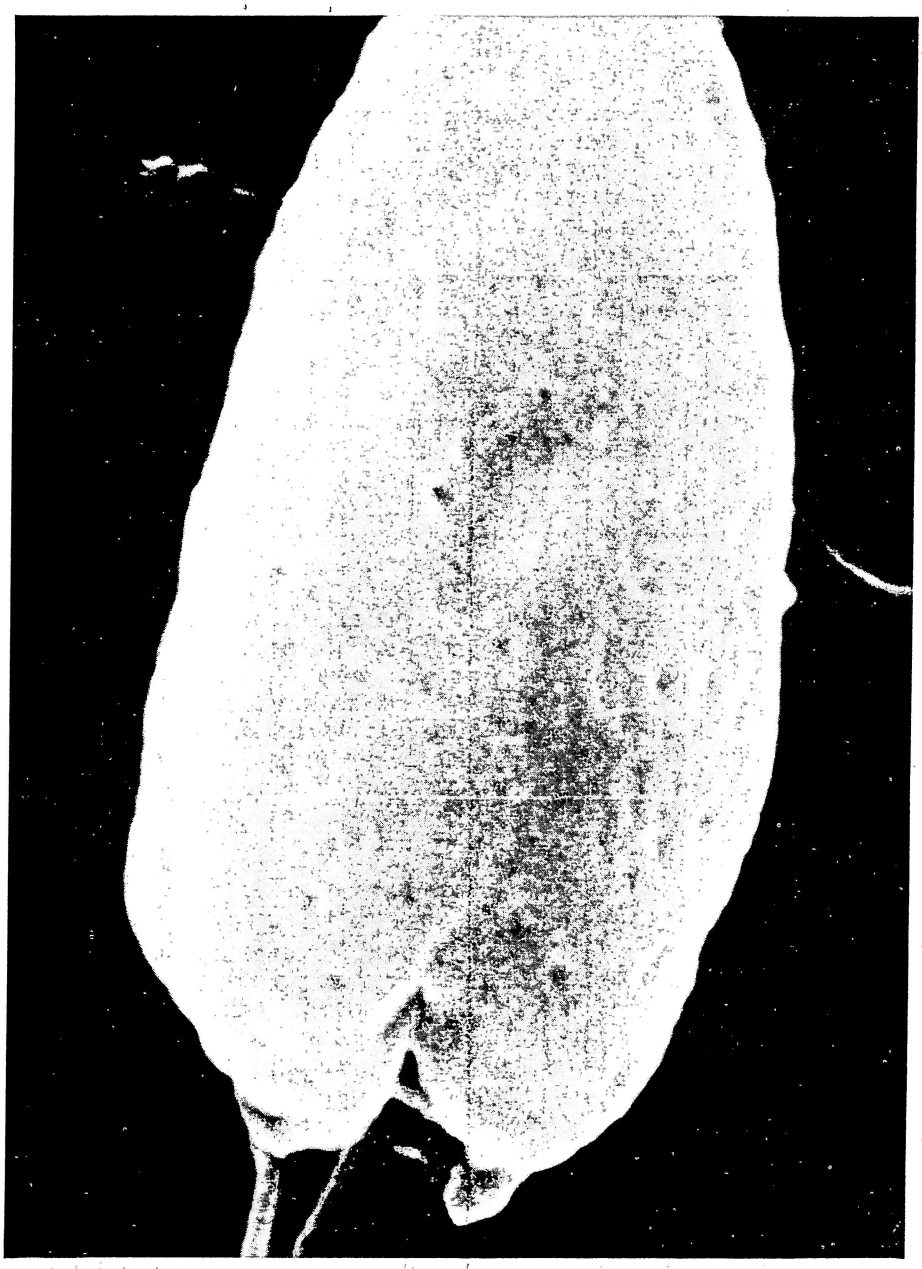
Thus, outbreaks of giardiasis can be caused by lack of filtration, improper filter operations, inadequate chlorination, cross-connections, or drinking contaminated mountain stream waters. The AWWA Committee on Waterborne Disease recommended that complete reporting of such outbreaks be continued and that the data be used by regulatory agencies to establish standards and surveillance programs.[46]

Detection methods

Culture. *Giardia* (*G. duodenalis, G. muris,* and *G. agilis*) trophozoites from several hosts have been successfully cultured monoxenically or axenically on artificial media.[47-53] Most of the cultures used have been complex and have incorporated animal serum. Meyer and his co-workers[49-51] reported that *Giardia* trophozoites could be isolated and cultured in the presence of yeast. Andrews et al[54] described a method that used density-layer centrifugation and nylon fiber columns for purification of *G. muris* trophozoites from the intestine of the mouse. They claimed that centrifugation of trophozoites on metrizamide medium, (specific gravity 1.10), followed by incubation on a nylon fiber column at 37°C for 120 min, yielded up to 10 million viable, purified trophozoites from each infected mouse. Feely and Eriandsen[55] used Hanks balanced salt solution and low temperatures for isolation and purification of *Giardia* trophozoites from rat intestines.

No satisfactory method for culturing *G. lamblia* cysts in water samples is currently available. The difficulty lies in getting the trophozoites to excyst on laboratory media.

Clinical methods. Of the four methods for detecting *G. lamblia* cysts in patients, the mucosal impression smears technique is the best for routine purposes, but stool examination is the most widely used technique.



Within 30 min of ingestion, a Giardia *cyst hatches out two trophozoites, which multiply and colonize the small intestine. In a severe infection, the parasites cover nearly every surface cell of the duodenum, jejunum, and upper ileum.*

During examination of stools for intestinal protozoa, the direct saline wet-mount method is most commonly used, and cultivation is least used. There is no standard, recommended procedure for preparing, fixing, preserving, and staining stool samples to detect *G. lamblia.* Stool samples can be concentrated by zinc sulfate flotation or formalin-ether sedimentation; the former is the better method for recovery of *G. lamblia* cysts. According to the study by Levine,[3] sugar flotation is not recommended. Polyvinyl-alcohol fixative, Schaudinn's fixative, and formalin are used for fixing *Giardia* cysts. Samples can be preserved in formalin or Lugol's iodine solution. Gomori-Wheatley trichrome stain, Lugol's solution, iodine, Noland's solution, and Kohn's Chlorazol Black E can be used for staining cysts. Merthiolate- iodine formalin, sodium acetate acid- formalin, and phenol-alcohol-formalin can be used for fixing and staining cysts.

It is difficult to assess the true prevalence of giardiasis in a population. The variability in the proportion of a population that is infected by *G. lamblia* (as recorded by various stool surveys) probably results not only from differences between various populations but also from other factors: (1) differences in stool examination techniques used, (2) the use of preservatives, (3) the number of stools examined, and (4) the inherent variability with which *G. lamblia* is excreted.[20] When a giardiasis outbreak is reported, the methods of stool examination should be detailed.

Recently developed methods, such as membrane filtration with syringe,[10] excystation,[56] electron microscopy,[57] and the fluorescent-antibody technique,[58] have improved the detection and knowledge of *G. lamblia*. The viability of *Giardia* cysts suspended by the excystation procedure was consistently lower than the viability of those determined by the eosin-exclusion techique. However, since some cysts that take up the dye are not viable, these results may be in question.

Detection in water. The detection of *G. lamblia* cysts in water is more difficult than detection by clinical methods because the concentrations of cysts in water are usually low. Jakubowski[59] reviewed the methodologies for detecting *Giardia* cysts in water. The excystation technique may subsequently lead the way to the development of culture methods, but currently microscopic examination is the method of choice. For detecting *G. lamblia* cysts in water, concentration and separation techniques are critical.

The method of detecting *G. lamblia* cysts in water that is included in the fifteenth edition of *Standard Methods*[60] was first developed by Jakubowski et al.[61] The development of the methodology, the so-called "EPA method," has been described in detail by Jakubowski.[59] The method includes concentration, separation, and microscopic examination of the cysts.

The water sample is filtered aseptically through a *Giardia*-sampling device, which consists of an inlet hose, a plastic filter holder with a 10-in.- (25-cm-) long yarn-wound orlon filter (7 μm porosity), an outlet hose, a water meter, and a limiting orifice flow-control valve with a flow rate of 3.15×10^{-5} m^3/s. The line pressure of 100 to 500 kPa is satisfactory, but a pump should be used if there is no water pressure. A sample volume of 500 gal (1900 L) should be filtered over an 18- to 24-h period;[60] a 100-gal (380-L) sample volume is suggested when concurrent epidemiologic or animal surveys are performed.

When the device is completely drained, the filter holder is opened and the filter cartridge is removed aseptically and placed in a labeled plastic bag, which is then sealed. The labeled bag is in turn placed in a second plastic bag, which is sealed, refrigerated, and transported to the laboratory for separation.

In the laboratory, the filter cartridge is aseptically removed and placed in a tray or pan; the orlon fibers are cut into four approximately equal lengths and removed from the stainless steel support. Each fiber portion is then blended at low speed for 10 s with 250 mL isotonic saline or distilled water and filtered through a coarse screen. All four fiber portions are then placed in a sealable plastic bag that has one corner open, and the bag is squeezed to extract the residual fluid, which is combined with the homogenate (filtrate) in a 1- to 1.5-L graduated cylinder. The filtrate is allowed to settle for 15 min.

If the amount of sediment from the combined homogenate is less than 5 percent of the total volume, the homogenate is filtered through 47-mm-diameter, 45-, 30-, and 7-μm-porosity nylon screens. The 7-μm screen is transferred with forceps to the inside wall of a 50-mL beaker that contains 1 to 2 mL of isotonic saline.

The procedure followed after settling is outlined in Figure 4. Two drops of 7-μm-screen washing concentrate are mixed with one drop of Lugol's iodine solution on a clean microscope slide with a cover slip. The slide is examined under 10× and 43× objectives.

A step-by-step analysis of the procedure indicated that 42 percent of cysts were lost in the preparation of a homogenate with an orlon filter. There was a 58 to 71 percent loss of cysts when a 7-μm-mesh nylon screen process was used and a >90 percent loss if flocculation was used to clarify the homogenate. The overall efficiency of the EPA method is between 3 and 15 percent, with an average of 6.3 percent.[59]

A better detection and identification methodology for *G. lamblia* cysts in water is urgently needed. Improvements to the EPA method should include techniques for concentration, separation of the cysts from the concentrating material, identification of the cysts, evaluation of potential interfering organisms, and determination of viable cysts. The method should be cost-effective, less time-consuming, and relatively uncomplicated so that it can be performed by skilled but not highly specialized laboratory technicians. Without a practical method of detecting *Giardia* cysts in water, further research on removal or control of cysts is handicapped.

Water treatment

Outbreaks of waterborne giardiasis result from deficiencies in water treatment, contamination of water sources that receive no (or inadequate) treatment, or contamination of the water after treatment. These outbreaks generally involve small municipal water systems or semipublic water systems in recreational areas. There is no evidence that such outbreaks occur in well operated systems with conventional or adequate treatment processes.

Disinfection. Epidemiologic studies indicate that most outbreaks of waterborne giardiasis have been due to consumption of untreated surface water or surface water treated with chlorine disinfection alone, as was the case at Aspen, Colo.,[33] and Rome, N.Y.[35] Data indicate that chlorine disinfection with normal dosage and contact time is insufficient to destroy *G. lamblia* cysts.[46] High dosages of chlorine and longer contact times are required in water treatment systems in which sedimentation and filtration cannot be employed.

The early concepts of the high resistance of *G. lamblia* cysts to disinfection were based on the results for *Entamoeba histolytica*, for which viability was determined by eosin exclusion. If a cyst remains colorless when exposed to eosin dye, it is considered viable; when it is penetrated and stained by the dye, it is considered dead. Results of recent studies suggest that eosin exclusion consistently gave higher estimates of cyst viability than can be found by in vitro excystation. Hoff[62] recommended that the results of early disinfection studies using eosin exclusion be disregarded. The recently developed in vitro excystation method may be applied to disinfection studies on *Giardia* cysts.

Using excystation, Jarroll et al[63] studied the effects of chlorine dosage on *G. lamblia* cyst viability under a variety of conditions. Cyst survival was generally found to increase as buffer pH increased. Water temperature, chlorine concentration, and contact time were important in cyst survival. Increasing chlorine dosage at the same temperature and increasing water temperature resulted in corresponding increases in inactivation rates. At 25°C, exposure to 1.5 mg chlorine/L for 10 min killed all cysts at pH 6, 7, and 8. At 15°C, exposure to 2.5 mg chlorine/L for 10 min killed all cysts at pH 6, but at pH 7 and 8 small numbers of cysts remained viable after 30 min but not after 60 min. At 5°C, exposure to 1 mg chlorine/L for 60 min failed to kill all the cysts at pH 6, 7, and 8; exposure to 2 mg chlorine/L killed all cysts at pH 6 after 60 min, all cysts at pH 7 after 10 min, and all cysts at pH 8 after 30 min. These results demonstrate that *G. lamblia* cysts can be destroyed by chlorine.

Rice et al[64] reported similar results, which indicated that *G. muris* cysts were as resistant as or more resistant than *G. lamblia* cysts. Since *G. muris* cysts are easily obtained, this organism can be used as a model for studies of human parasitic protozoa.

Ultraviolet radiation has been considered as a potential alternative to chlorine for disinfection in small water systems. Rice and Hoff[65] found that *G. lamblia* cysts were highly resistant to germicidal ultraviolet radiation at a maximum dosage of 42 000 μW-s/cm^2. The percentage of survival, compared with the control excystation, varied from 73 to 95 percent. From this, one can conclude that ultraviolet irradiation cannot be used as a cysticide.

Jarroll et al[19] tested six disinfectants that are used for treating small quan-

tities of water for their ability to destroy *G. lamblia* cysts. Excystation was the criterion of viability. The disinfectants used were water-sterilizing tablets (A), Globaline tablets (B), EDWGT (C), 2 percent tincture of iodine (D), saturated iodine (E), and bleach (F). The tests were performed on two different water samples (clear and cloudy) and at two temperatures (3° and 20°C).

At 20°C all six disinfectants completely destroyed the cysts in both waters. However at 3°C, in cloudy water, disinfectant E was less than completely effective; and in clear water, four disinfectants (B, D, E, and F) failed to inactivate all of the cysts. The failure of these disinfectants was due to insufficient halogen residuals or to short contact times, and not to an extreme resistance of the cysts to the halogens. The study showed that very high levels of chlorine and iodine will kill *G. lamblia* cysts. A total chlorine residual of 6.2 mg/L after a 30-min contact time at pH 7.9 and 3°C was sufficient to inactivate *G. lamblia* cysts in both clear and cloudy waters.

Filtration. Studies on the removal of asbestos, bacteria, *Giardia* cysts, and viruses by coagulation, sedimentation, and filtration have been reviewed by Logsdon et al.[66,67] Proper coagulation, the key to effective filtration, depends on water temperature, pH, the constituents of the raw water, dosages of coagulant and coagulant aid, mixing time, and mixing intensity. Some of these factors are beyond the control of plant operators.

Slow sand filters, granular media filters, or diatomaceous earth (DE) filters may be used for filtration. Slow sand filters, generally used by small water supply systems, are not frequently found in the United States. Slow sand filtration is a biological rather than a physical-chemical process and is effective for removing microorganisms and particulates. About 90 percent of 7- to 12-μm particles (the size of *G. lamblia* cysts) are removed by slow sand filters.[66] Research into the removal of *Giardia* cysts by slow sand filters is being conducted at Colorado State University under the sponsorship of the US Environmental Protection Agency.[67]

Rapid sand filtration is widely used in the United States by large cities as well as by small communities. For effective granular media filtration, water must be properly coagulated. Baylis et al[68] reported that *Entamoeba histolytica* cysts were effectively removed (99.99 percent) from water by coagulation and rapid sand filtration. During World War II, US Army data also showed that many more *Entamoeba histolytica* cysts passed through rapid sand filters at 6.4 to 9.6 gpm/sq ft (4.4 to 6.6 mm/s) when poorly coagulated or uncoagulated water was filtered.[69]

Recently, Logsdon et al[70,71] found that *G. muris* could break through dual-media filters when raw water was inadequately coagulated or not coagulated at all. In addition, cysts might pass through the filter during times when the coagulant dose was interrupted, when the filtration rate was abruptly increased, or when a breakthrough of turbidity occurred. Nevertheless, a dual-media filter operating at 4 gpm/sq ft (2.7 mm/s) with proper coagulation of the raw water removed 99 percent or more of cysts. Similar results were obtained in a filtration study of *G. lamblia* cysts at the University of Washington, where a rapid sand filter with optimum coagulation removed >99 percent of cysts. Only 15 percent of cysts were removed from uncoagulated water.[67]

Logsdon et al[67] emphasized that AWWA's water quality goal of 0.1 ntu was a good one. To assure protection of public health, filtration plants should produce water with a turbidity of 0.1 ntu rather than 1.0 ntu.

Diatomaceous earth filtration for water treatment was first investigated during World War II.[69] Since then, it has been shown to be effective in removing algae, bacteria, and viruses. The US Army data[69] indicated that DE filtration could remove essentially all *E. histolytica* cysts and cyst-sized particles. Although removal of particles in the 7-20-μm size range is not necessarily related to turbidity removal, pressure diatomite filtration in Duluth, Minn., produced a filtered water turbidity of <0.1 ntu.

Recent research showed that DE filtration was just as effective for removing *G. lamblia* cysts as for removing those of *E. histolytica*.[70,71] Diatomaceous earth filtration was effective for removing 9-μm-diameter radioactive beads (used as models for *G. lamblia* cysts), *G. muris* cysts, and *G. lamblia* cysts. To assure the most effective filter performance, the filter should be precoated with a thickness of 0.2 lb/sq ft (1.0 kg/m^2) of DE, and body feed should always be used. Current research at the University of Washington confirmed these results. Logsdon and Lippy[67] reported that cyst removals in four DE filter runs ranged from 99.03 percent to >99.87 percent in 12 separate determinations.

Filtration of surface water supplies is required to provide a second barrier against the transmission of waterborne diseases. It also helps to reduce the load on the disinfection process, thereby increasing the efficiency of disinfection, which is the primary means of disease control.

Conclusions

Research is needed on the viability, isolation, and enumeration of *G. lamblia* cysts; the removal of cysts by coagulation, flocculation, sedimentation, and filtration; and the inactivation of cysts by disinfection. Water treatment processes should result in the inactivation of 100 percent of *G. lamblia* cysts.

References

1. SCHMIDT, G.D. & ROBERTS, L.S. *Foundations of Parasitology*. The C.V. Mosby Co., St. Louis, Mo. (1977).
2. MOFFET, H.L. *Clinical Microbiology*. J.B. Lippincott Co., Philadelphia, Pa. (2nd ed., 1980).
3. LEVINE, N.D. *Giardia lamblia*: Classification, Structure, Identification. In: Waterborne Transmission of Giardiasis. EPA-600/9-79-001 (1979).
4. MEYER, M.C. & OLSON, O.W. *Essentials of Parisitology*. Wm. C. Brown Co., Dubuque, Iowa (2nd ed., 1975).
5. GARCIA, L.S. & ASH, L.R. Diagnostic Parasitology. *Clinical Laboratory Manual*. The C.V. Mosby Co., St. Louis, Mo. (1975).
6. JAWETZ, E.; MELNICK, J.L.; & ADELBERG, E.A. *Review of Medical Microbiology* (12th ed., 1976).
7. MARKELL, E.K. & VOGE, M. *Medical Parasitology*. W.B. Saunders Co., Philadelphia, Pa. (1981).
8. CHATTERJEE, K.D. *Parsitology: Protozoology and Helminthology in Relation to Clinical Medicine* (10th ed., 1975).
9. TOMBES, A.S.; LANDFRIED, S.S.; & WILLIAMS, L.D. Surface Morphology of *Giardia* Cysts Recovered from a Variety of Hosts. In: Waterborne Transmission of Giardiasis. EPA-600/9-79-001 (1979).
10. RENDTORFF, R.D. & HOLT, D.J. The Experimental Transmission of Human Intestinal Protozoan Parasites. IV. Attempts to Transmit *Endamoeba coli* and *Giardia lamblia* Cysts in Water. *Amer. Jour. Hygiene*, 60:3:327 (Nov. 1954).
11. DANZIGER, M. & LOPEZ, M. Numbers of *Giardia* in Feces of Infected Children. *Amer. Jour. Tropical Medicine & Hygiene*, 24:2:237 (Mar. 1975).
12. SCHMERIA, M.J.; JONES, T.C.; & KLEIN, H. Giardiasis: Association with Homosexuality. *Annals Internal Medicine*, 88:6:801 (June 1978).
13. DAVIES, R.B.; KUKUTAKI, K.; & HIBLER, C.P. Cross Transmission of *Giardia*. EPA-600/51-82-013 (Jan. 1983).
14. YARLEY, J.H. & BAYLESS, T.M. Giardiasis. *Gastroenterol.*, 52:2:301 (Feb. 1967).
15. RENDTORFF, R.C. The Experimental Transmission of Human Intestinal Protozoan Parasites. II. *Giardia lamblia* Cysts Given in Capsules. *Amer. Jour. Hygiene*, 59:2:209 (Mar. 1954).
16. WOLFE, M.S. Managing the Patient with Giardiasis: Clinical, Diagnostic and Therapeutic Aspects. In: Waterborne Transmission of Giardiasis. EPA-600/9-79-001 (1979).
17. KAMATH, K.R. & MURUGASU, R. A Comparative Study of Four Methods for Detecting *Giardia lamblia* in Children with Diarrheal Disease and Malabsorption. *Gastroenterol.*, 66:1:16 (Jan. 1974).
18. BEZJAK, B. Evaluation of a New Technique for Sampling Duodenal Contents in Parasitologic Diagnosis. *Amer. Jour. Digestive Disorders*, 17:9:848 (Sept. 1972).
19. JARROLL, E.L.; BINGHAM, A.K.; & MEYER, E.A. *Giardia* Cyst Destruction: Effectiveness of Six Small-Quantity Water Disin-

fection Methods. *Amer. Jour. Tropical Medicine & Hygiene*, 29:1:8 (Jan. 1980).
20. HEALY, G.R. The Presence and Absence of *Giardia lamblia* in Studies on Parasite Prevalence in the USA. In: Waterborne Transmission of Giardiasis. EPA-600/9-79-001 (June 1979).
21. HARTER, L.; FROST, F.; & JAKUBOWSKI, W. *Giardia* Prevalence Among 1- to 3-Year-Old Children in Two Washington State Counties. *Amer. Jour. Public Health*, 72:4:386 (Apr. 1982).
22. HOFFMAN, S.L. ET AL. Intestinal Parasites in Indochinese Immigrants. *Amer. Jour. Tropical Medicine & Hygiene*, 30:2:340 (Mar. 1981).
23. KEITTIVUT, B. ET AL. Prevalence of Schistosomiasis and Other Parasitic Diseases Among Cambodian Refugees Residing in Ban Kaeng Holding Center, Prachinburi Province, Thailand. *Amer. Jour. Tropical Medicine & Hygiene*, 31:5:988 (Oct. 1982).
24. LAWRENCE, D.N. ET AL. Epidemiologic Studies Among Amerindian Populations of Amazonia. III. Intestinal Parasitoses in Newly Contacted and Acculturating Villages. *Amer. Jour. Tropical Medicine & Hygiene*, 29:4:530 (July 1980).
25. SOLE, T.D. & CROLL, N.A. Intestinal Parasites in Man in Labrador, Canada. *Amer. Jour. Tropical Medicine & Hygiene*, 29:3:364 (May 1980).
26. CRAUN, G.F. Waterborne Outbreaks of Giardiasis. In: Waterborne Transmission of Giardiasis. EPA-600-9-79-001. (1979).
27. CRAUN, G.F. & MCCABE, L.J. Review of the Causes of Waterborne-Disease Outbreaks. *Jour. AWWA*, 65:1:74 (Jan. 1973).
28. MCCABE, L.F. & CRAUN, G.F. Status of Waterborne Diseases in the US and Canada. *Jour. AWWA*, 67:2:95 (1975).
29. CRAUN, G.F.; MCCABE, L.J. & HUGHES, J.M. Waterborne Disease Outbreaks in the United States: 1971-1974. *Jour. AWWA*, 68:8:420 (Aug. 1976).
30. CRAUN, G.F. Outbreaks of Waterborne Disease in the United States: 1971-1978. *Jour. AWWA*, 73:7:360 (July 1981).
31. LIPPY, E.C. Waterborne Disease: Occurrence is on the Upswing. *Jour. AWWA*, 73:1:57 (Jan. 1981).
32. VEAZIE, L.; BROWNLEE, I.; & SEARS, H.J. An Outbreak of Gastroenteritis Associated with *Giardia lamblia*. In: Waterborne Transmission of Giardiasis. EPA-600/9-79-001 (June 1979).
33. MOORE, G.T. ET AL. Epidemic Giardiasis at a Ski Resort. *New England Jour. Medicine*, 281:8:402 (Aug. 1969).
34. GLEASON, N.N. ET AL. A Stool Survey for Enteric Organisms in Aspen, Colorado. *Amer. Jour. Tropical Medicine & Hygiene*, 19:3:480 (May. 1970).
35. SHAW, P.K. ET AL. A Community-Wide Outbreak of Giardiasis with Documented Transmission by Municipal Water. *Annals Internal Medicine*, 87:4:426 (Oct. 1977).
36. JURANEK, D. Waterborne Giardiasis. In: Waterborne Transmission of Giardiasis. EPA-600/9-79-001 (June 1979).
37. KIRNER, J.C.; LITTLE, J.D.; & ANGELO, L.A. A Waterborne Outbreak of Giardiasis in Camas, Washington. *Jour. AWWA*, 70:1:35 (Jan. 1978).
38. LIPPY, E.C. Tracing a Giardiasis Outbreak at Berlin, New Hampshire. *Jour. AWWA*, 70:9:512 (Sept. 1978).
39. LIPPY, E.C. Water Supply Problems Associated With a Waterborne Outbreak of Giardiasis. In: Waterborne Tranmission of Giardiasis. EPA-600/9-79-001 (June 1979).
40. LOPEZ, C.E. ET AL. Waterborne Giardiasis: A Community-Wide Outbreak of Disease and High Rate of Asymptomatic Infection. *Amer. Jour. Epidemiol.*, 112:4:495 (Oct. 1980).
41. JONES, W.E. & EDELL, T.A. Giardiasis in Vail, Colorado. In: Waterborne Transmission of Giardiasis. EPA-600/9-79-001 (June 1979).
42. Center for Disease Control. Giardiasis in Travelers. *Morbidity & Mortality Weekly Rept.*, 19:455 (1970).
43. WALZER, P.D.; WOLFE, M.S.; & SCHULTZ, M.G. Giardiasis in Travelers. *Jour. Infectious Diseases*, 124:2:235 (Aug. 1971).
44. LOPEZ, C.E. ET AL. Giardiasis in American Travelers to Madeira Island, Portugal. *Amer. Jour. Tropical Medicine & Hygiene*, 27:6:1128 (Nov. 1978).
45. BARBOUR, A.G.; NICHOLS, C.R.; & FUKUSHIMA, T. An Outbreak of Giardiasis in a Group of Campers. *Amer. Jour. Tropical Medicine & Hygiene*, 25:3:384 (May 1976).
46. AWWA Committee Report. Waterborne Disease in the United States and Canada. *Jour. AWWA*, 73:10:528 (Oct. 1981).
47. KARAPETYAN, A.E. Methods of *Giardia lamblia* Cultivation. *Tsitologia*, 2:379 (1960).
48. KARAPETYAN, A.E. In Vitro Cultivation of *Giardia duodenalis*. *Jour. Parasitol.*, 48:2:337 (Apr. 1962).
49. FORTESS, E. & MEYER, E.A. Isolation and Axenic Cultivation of *Giardia* Trophozoites from the Guinea Pig. *Jour. Parasitol.*, 62:5:689 (Oct. 1976).
50. MEYER, E.A. *Giardia lamblia*: Isolation and axenic cultivation. *Exp. Parasitol.*, 27:1:179 (Feb. 1976).
51. MEYER, E.A. The Propagation of *Giardia* Trophozoites in Vitro. In: Waterborne Transmission of Giardiasis. EPA-600/9-79-001 (June 1979).
52. GILLIN, F.D. & DIAMOND, L.S. Axenically Cultivated *Giardia lamblia*: Growth, Attachment and the Role of L-cysteine. In: Waterborne Transmission of Giardiasis. EPA-600/9-79-001 (June 1979).
53. SAHA, T.K. & GHOSH, T.K. Invasion of Small Intestinal Mucosa by *Giardia lamblia* in Man. *Gastroenterol.*, 72:3:402 (Mar. 1977).
54. ANDREWS, J.S. JR.; ELLNER, J.J.; & STEVENS, D.P. Purification of *Giardia muris* Trophozoites by Using Nylon Fiber Columns. *Amer. Jour. Tropical Medicine & Hygiene*, 29:1:12 (Jan. 1980).
55. FEELY, D.E. & ERIANDSEN, S.L. Isolation and Purification of *Giardia* Trophozoites From Rat Intestines. *Jour. Parasitol.*, 67:1:59 (Jan. 1981).
56. BINGHAM, A.K. ET AL. Induction of *Giardia* Excystation and the Effect of Temperature on Cyst Viability as Compared by Eosin-Exclusion and in Vitro Excystation. In: Waterborne Transmission of Giardiasis. EPA-600/9-79-001 (June 1979).
57. LUCHTEL, D.L.; LAWRENCE, W.P.; & DEWALLE, F.B. Electron Microscopy of *Giardia lamblia* Cysts. *Appl. & Envir. Microbiol.*, 40:4:821 (Oct. 1980).
58. RIGGS, J.L. ET AL. Detection of *Giardia lamblia* by Immunofluorescence. *Appl. & Envir. Microbiol.* 45:2:698 (Feb. 1983).
59. JAKUBOWSKI, W. Methods for Detection of *Giardia* Cysts in Water Supplies. In: Waterborne Transmission of Giardiasis. EPA-600/9-79-001 (June 1979).
60. *Standard Methods for the Examination of Water and Wastewater*. APHA, AWWA, and WPCF. Washington, D.C. (1980).
61. JAKUBOWSKI, W. ET AL. Large-Volume Sampling of Water Supplies for Microorganisms. *Jour. AWWA*, 79:12:702 (1978).
62. HOFF, J.C. Disinfection Resistance of *Giardia* Cysts: Origins of Current Concepts and Research in Progress. In: Waterborne Transmission of Giardiasis. EPA-600/9-79-001 (June 1979).
63. JARROLL, E.L.; BINGHAM, A.K.; & MEYER, E.A. Effect of Chlorine on *Giardia lamblia* Cyst Viability. *Appl. & Envir. Microbiol.*, 41:2:483 (Feb. 1981).
64. RICE, E.W.; HOFF, J.C.; & SCHAEFFER, F.W. III. Inactivation of *Giardia* Cysts by Chlorine. *Appl. Microbiol.*, 43:1:250 (Jan. 1982).
65. RICE, E.W. & HOFF, J.C. Inactivation of *Giardia lamblia* Cysts by Ultraviolet Irradiation. *Appl. & Envir. Microbiol.*, 42:3:546 (Sept. 1981).
66. LOGSDON, G.S. & FOX, K. Getting Your Money's Worth From Filtration. *Jour. AWWA*, 74:5:249 (May 1982).
67. LOGSDON, G.S. & LIPPY, E.C. The Role of Filtration in Preventing Waterborne Diseases. *Jour. AWWA*, 74:12:649 (1982).
68. BAYLIS, J.R.; GULLANS, O.; & SPECTOR, B.K. The Efficiency of Rapid Sand Filters in Removing the Cysts of Amoebic Dysentery Organisms from Water. *Public Health Repts.*, 50:46:1567 (Nov. 1936).
69. US Army. Efficiency of Standard Army Purification Equipment and Diatomite Filters in Removing Cysts of *Endamoeba histolytica* from Water. War Dept. Rept. 834. Washington, D.C. (July 3, 1944).
70. LOGSDON, G.S.; SYMONS, J.M.; & HOYE, R.L. Water Filtration Techniques for Removal of Cysts and Cyst Models. In: Waterborne Transmission of Giardiasis. EPA-600/9-79-001 (June 1979).
71. LOGSDON, G.S. ET AL. Alternative Filtration Methods for Removal of *Giardia* Cysts and Cyst Models. *Jour. AWWA*, 73:2:111 (Feb. 1981).



About the author: *Shun Dar Lin, a scientist in the Water Quality Section, Illinois State Water Survey, P.O. Box 697, Peoria, IL 61652, has 23 years of experience in research as well as three years in teaching. A graduate of National Taiwan University, Taipei (BS, civil engineering), the University of Cincinnati, Ohio (MS, sanitary engineering), and Syracuse University, N.Y. (PhD, sanitary engineering), Lin is a member of AWWA, ASCE, WPCF, and the* Standard Methods *committee. His work has been published previously in such journals as* Journal WPCF, Journal Environmental Engineering Division—ASCE, Water and Sewage Works, *and* Public Works.

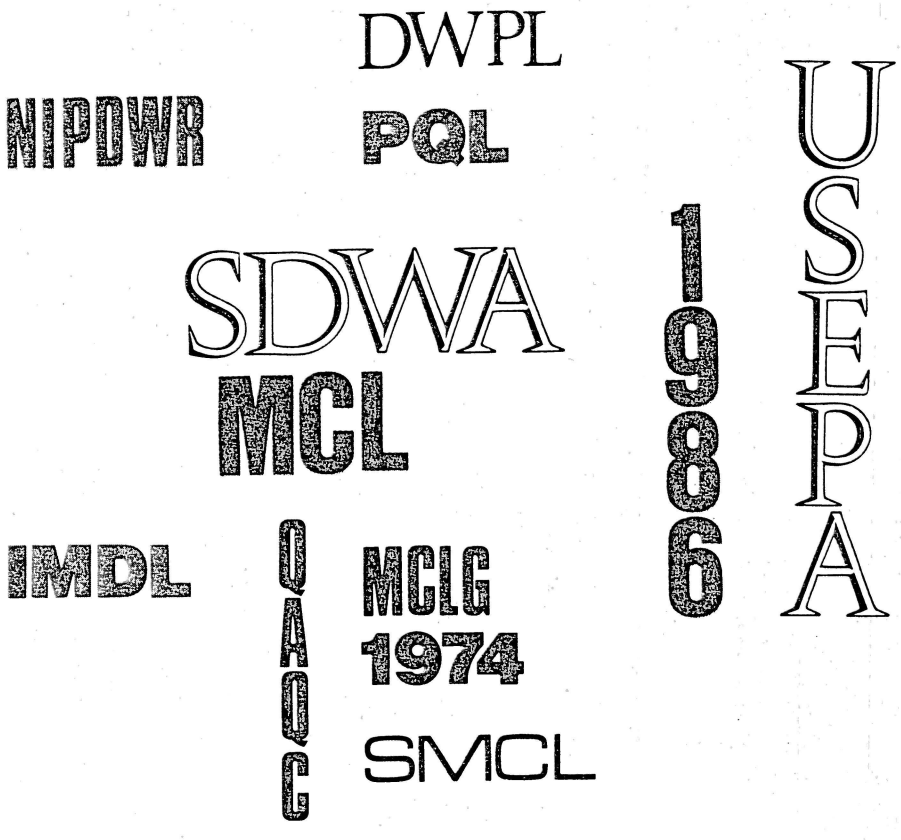
Complying With the New Drinking Water Quality Regulations

Frederick W. Pontius

The 1986 amendments to the Safe Drinking Water Act mandate the establishment of new drinking water quality and treatment regulations. In fulfilling this mandate, the US Environmental Protection Agency is in the process of developing, proposing, and promulgating drinking water quality regulations that will significantly change water treatment practice and water utility operations. New regulations for volatile organic chemicals, fluoride, surface water treatment, and total coliform bacteria have been promulgated. Regulations for synthetic organic and inorganic chemicals and lead and copper have been proposed. Regulations for radionuclides, additional synthetic organic and inorganic chemicals, and disinfectants and disinfection by-products are under development. The history, content, current status, and schedule of new or anticipated regulatory actions are reviewed.

New water quality regulations are causing a rapid change in the drinking water industry. Water suppliers, state regulatory agencies, and the US Environmental Protection Agency (USEPA) all face challenges associated with new regulations mandated by the 1986 amendments to the Safe Drinking Water Act (SDWA). The new regulations are complex and will place significant demands on water utility operation, engineering, and financial resources.

This article reviews water quality regulatory actions mandated by the 1986 SDWA amendments. Particular attention is given to explaining the history, content, current status, and schedule of recent or anticipated regulatory actions. In addition, suggestions for compliance are given where appropriate. Only highlights of selected regulatory actions and related compliance issues are discussed. Additional details concerning the content of new or proposed regulations can be found in the *Federal Register* citations referenced here or obtained from the USEPA Office of Drinking Water and state regulatory agencies. The object of this review is to serve as a guide to the current drinking water quality regulatory program* so that intelligent and timely decisions regarding long-term planning for compliance can be made.



SDWA requirements

The SDWA (PL 93-523), signed into law Dec. 16, 1974,[1] mandated the establishment of drinking water regulations that were the first to apply to all public water systems in the United States. The federal government, specifically the USEPA, was authorized to set national drinking water regulations, conduct special studies and research, and oversee implementation of the act. State governments, through their health departments and environmental agencies (referred to here as the state), were to accept the major responsibility (called primary enforcement responsibility or primacy) for implementation and enforcement of the act's provisions. Public water systems were obligated by law to

*The term "current regulatory program" refers to drinking water quality regulation status as of December 1989.

assume the day-to-day responsibility of meeting the regulations.

A "public water system" has 15 or more service connections or regularly serves at least 25 people 60 or more days per year. Public water systems can be publicly or privately owned and are subdivided for regulatory purposes into two major categories: community and noncommunity systems. A community system serves water to a resident population, whereas a noncommunity system serves water to a nonresident population. Noncommunity systems are further subdivided into nontransient noncommunity systems (serves the same nonresident population, such as schools and factories) and transient noncommunity systems (serves a different nonresident population, such as highway rest stops and motels).

A "public water system" has 15 or more service connections or regularly serves at least 25 people 60 or more days per year.

Interim regulations. Under the 1974 SDWA, the USEPA was charged with proposing enforceable National Interim Primary Drinking Water Regulations (NIPDWRs, Table 1) by March 1975. Revised Primary Drinking Water Regulations (RPDWRs) were to be adopted by September 1977. Congress severely underestimated the time required to develop credible regulations. As a result, development of the revised primary regulations slowed. Table 2 summarizes the actual development schedule for the NIPDWRs listed in Table 1.

In addition to health-related enforceable standards, the 1974 SDWA required USEPA to set nonenforceable federal guidelines for contaminants that may adversely affect the aesthetic quality of drinking water.[2] Secondary drinking water standards or secondary maximum contaminant levels (SMCLs) were initially set in 1979 (Table 3).[3] The SMCL for fluoride was revised in 1986.[4]

1986 SDWA amendments. To strengthen the SDWA, particularly the regulation-setting process and groundwater protection, Congress amended most of the 1974 SDWA and added six new sections in 1986. The 1986 amendments to the SDWA (PL 99-339), signed into law June 19, 1986,[5] mandated the establishment of a variety of new drinking water regulations according to specific timetables.

At the time of enactment, the significant effect of the 1986 SDWA amendments on water treatment practices was clear. In addition to other provisions, section 1412* mandates the establishment of several water-quality-related regulations.

- Maximum contaminant level goals (MCLGs) and MCLs must be established for 83 contaminants listed in the Advanced Notice for Proposed Rulemakings published Mar. 4, 1982,[6] and Oct. 5, 1983[7] (Table 4). That no provision was included in the act to allow the USEPA to refrain from regulating any of the 83 contaminants if they are not found in drinking water supplies or for any other reason is significant. USEPA must set MCLGs and MCLs for these contaminants, although up to seven substitutes were allowed.
- MCLGs and MCLs must be established for 25 contaminants selected from a priority list to be prepared by USEPA and updated every 3 years.
- Criteria must be established under which filtration is required for public systems using surface water sources.
- Disinfection is required of all public water supplies.

Specific time lines were given in the act for regulation development (Table 5). NIPDWRs and RPDWRs were renamed as National Primary Drinking Water Regulations (NPDWRs). In addition, section 1445 requires USEPA to establish monitoring regulations for additional unregulated contaminants to develop occurrence data for evaluating health risks.

Contaminant substitutes. SDWA section 1412(b)(2) allows USEPA to substitute up to seven contaminants on the list of 83 (Table 4) if regulation of the substitutes is more likely to be protective of public health. USEPA proposed[8] and adopted[9] the seven substitutes listed at the end of Table 4.

Drinking water priority list (DWPL). Section 1412(b)(3) requires USEPA to develop a list of contaminants, known or anticipated to occur in public water systems, that may require regulation under this act. In developing the DWPL, USEPA was required to consider hazardous substances, as defined in the Comprehensive Environmental Response, Compensation, and Liability Act, Section 101(14), and pesticides registered under the Federal Insecticide, Fungicide, and Rodenticide Act. In addition, the list includes the seven substitutes removed from the original list of 83.

The first DWPL was proposed July 8, 1987,[8] and finalized Jan. 22, 1988.[9] The initial list (Table 6) contains 53 contaminants and contaminant groups that

*Section citations refer to the amended SDWA.

Glossary

ANPRM—advance notice of proposed rulemaking
AOC—assimilable organic carbon
AWWARF—American Water Works Association Research Foundation
BAT—best available technology
CT—disinfectant concentration contact time
DBCP—dibromochloropropane
DBP—disinfection by-product
D-DBP—disinfection-disinfection by-product
DWPL—drinking water priority list
EDB—ethylene dibromide
GAC—granular activated carbon
GC—gas chromatography
GC-MS—gas chromatography-mass spectrometry
HPC—heterotrophic plate count
IOC—inorganic chemical
MCL—maximum contaminant level
MCLG—maximum contaminant level goal
MDL—method detection limit
MF—membrane filter
MTF—multiple tube fermentation
MX—3-chloro-4-(dichloromethyl)-5-hydroxy-2(5H)-furanone
NIPDWR—National Interim Primary Drinking Water Regulations
NPDWR—National Primary Drinking Water Regulations
NTIS—National Technical Information Service
P-A—presence-absence
PAH—polyaromatic hydrocarbon
PCB—polychlorinated biphenyl
POE—point of entry
POU—point of use
RMCL—recommended maximum contaminant level
RPDWR—Revised Primary Drinking Water Regulations
SDWA—Safe Drinking Water Act
SMCL—secondary maximum contaminant level
SOC—synthetic organic chemical
SWTR—Surface Water Treatment Rule
TTHM—total trihalomethane
TOC—total organic carbon
USEPA—US Environmental Protection Agency
VOC—volatile organic chemical

either occur in public water systems or have characteristics or use patterns such that the potential to occur in public water systems at levels of concern is strong.[8] By Jan. 22, 1990, proposed MCLGs and MCLs for a minimum of 25 contaminants or contaminant groups from the list given in Table 6 are to be published, and final MCLGs and MCLs are to be promulgated by Jan. 22, 1993. The initial DWPL is to be updated at 3-year intervals, with at least 25 contaminants on each list regulated.

MCLGs and MCLs. Section 1412(b)(3) authorizes the USEPA administrator to publish MCLGs and promulgate MCLs for each contaminant that, in the judgment of the USEPA administrator, may have any adverse effect on human health and that is known or anticipated to occur in public water systems. This statute is a primary driving force behind the establishment of new drinking water regulations. Note that, as in the 1974 SDWA, the adverse health effect of a contaminant need not be proved conclusively prior to regulation.

Section 1412(a)(2) redefines the previously established recommended maximum contaminant levels (RMCLs) as MCLGs. MCLGs are nonenforceable, health-based goals. Section 1412(b)(4) requires that MCLGs be set at a level at which no known or anticipated adverse effect on human health occurs and that allows for an adequate margin of safety, without regard to the cost of reaching these goals.

MCLs are enforceable standards. Sections 1412(b)(4) and (5) require that MCLs be set as close to the MCLGs as feasible, with the use of the best technology, treatment techniques, and other means that are available, taking cost into consideration.

Section 1412(a)(3) requires that an MCLG be proposed and promulgated simultaneously with the corresponding MCL. To accomplish this, USEPA assesses the available technical and scientific information on the contaminant(s) of concern and develops proposed regulations by means of an internal work group. Separate support documents for each contaminant are prepared on occurrence and human exposure, health effects and toxicology, analytical methods and monitoring, and treatment technologies and costs.

The process of setting MCLGs for noncarcinogens differs from the process used for carcinogens. For contaminants not considered to have a carcinogenic effect, MCLGs are based on "no effect" levels for chronic-lifetime periods of contaminant exposure that include a factor of safety. For noncarcinogenic toxicity, the assumption is made that an organism can tolerate and detoxify some amount of a toxic agent without ill effects up to a certain threshold. A

TABLE 1
National Interim Primary Drinking Water Regulations

Contaminant	MCL (enforceable)*
Organics	
2,4-D	0.1 mg/L
Endrin	0.0002 mg/L
Lindane	0.0004 mg/L
Methoxychlor	0.1 mg/L
Toxaphene	0.005 mg/L
2,4,5-TP (Silvex)	0.01 mg/L
Trihalomethanes (sum of chloroform, bromoform, bromodichloromethane, dibromochloromethane)	0.10 mg/L
Inorganics	
Arsenic	0.05 mg/L
Barium	1.0 mg/L
Cadmium	0.010 mg/L
Chromium	0.05 mg/L
Fluoride	1.4–2.4 mg/L† (ambient temperature)
Lead	0.05 mg/L
Mercury	0.002 mg/L
Nitrate (as N)	10 mg/L
Selenium	0.01 mg/L
Silver	0.05 mg/L
Sodium and corrosion	No MCL; monitoring and reporting only
Radionuclides	
Beta particle and photon radioactivity	4 mrem (annual dose equivalent)
Gross alpha particle activity	15 pCi/L
Radium-226 plus radium-228	5 pCi/L
Microbials	
Coliforms	<1/100 mL
Turbidity	1 ntu (up to 5 ntu)

*Monitoring and reporting for each contaminant are also required.
†Revised MCL and MCLG for fluoride is 4 mg/L.

TABLE 2
NIPDWR development schedule

Regulation	Promulgation Date	Effective Date	Coverage
NIPDWR	Dec. 24, 1975	June 24, 1977	Inorganic, organic, and microbiological contaminants and turbidity
First amendment	July 9, 1977	June 24, 1977	Radionuclides
Second amendment	Nov. 29, 1979	Varies depending on system size	THMs
Third amendment	Aug. 27, 1980	Feb. 27, 1982	Special monitoring requirements for corrosion and sodium
Fourth amendment	Feb. 28, 1983	Mar. 30, 1983	Identifies best generally available means with which to comply with THM regulations

TABLE 3
National Secondary Drinking Water Regulations

Contaminant	Current SMCLs	SMCLs Proposed Under Phase II*	SMCL Being Considered Under Phase V*
Chloride	250 mg/L		
Color	15 cu		
Copper	1 mg/L		
Corrosivity	Noncorrosive		
Fluoride	2 mg/L†		
Foaming agents	0.5 mg/L		
Iron	0.3 mg/L		
Manganese	0.05 mg/L		
Odor	3 Threshold odor number		
pH	6.5–8.5		
Sulfate	250 mg/L		
Total dissolved solids	500 mg/L		
Zinc	5 mg/L		
Aluminum		0.05 mg/L	
o-Dichlorobenzene		0.01 mg/L	
p-Dichlorobenzene		0.005 mg/L	
Ethylbenzene		0.03 mg/L	
Monochlorobenzene		0.1 mg/L	
Pentachlorophenol		0.03 mg/L	
Silver		0.09 mg/L	
Toluene		0.04 mg/L	
Xylene		0.02 mg/L	
Hexachlorocyclopentadiene			0.008 mg/L

*Phases are identified and defined in the text.
†The SMCL for fluoride was revised in 1986.[1]

TABLE 4

Contaminants required to be regulated under the 1986 SDWA amendments

Volatile organic chemicals
- Benzene
- Carbon tetrachloride
- Chlorobenzene
- Dichlorobenzene
- 1,2-Dichloroethane
- 1,1-Dichloroethylene
- *cis*-1,2-Dichloroethylene
- *trans*-1,2-Dichloroethylene
- Methylene chloride
- Tetrachloroethylene
- Trichlorobenzene
- 1,1,1-Trichloroethane
- Trichloroethylene
- Vinyl chloride

Microbiology and turbidity
- *Giardia lamblia*
- *Legionella*
- Standard plate count
- Total coliforms
- Turbidity
- Viruses

Inorganics
- Aluminum
- Antimony
- Arsenic
- Asbestos
- Barium
- Beryllium
- Cadmium
- Chromium
- Copper
- Cyanide
- Fluoride
- Lead
- Mercury
- Molybdenum
- Nickel
- Nitrate
- Selenium
- Silver
- Sodium
- Sulfate
- Thallium
- Vanadium
- Zinc

Organics
- Acrylamide
- Adipates
- Alachlor
- Aldicarb
- Atrazine

Organics, continued
- Carbofuran
- Chlordane
- Dalapon
- Dibromochloropropane (DBCP)
- Dibromomethane
- 1,2-Dichloropropane
- Dinoseb
- Diquat
- Endothall
- Endrin
- Epichlorohydrin
- Ethylene dibromide (EDB)
- Glyphosphate
- Hexachlorocyclopentadiene
- Lindane
- Methoxychlor
- Pentachlorophenol
- Phthalates
- Pichloram
- Polychlorinated biphenyls (PCBs)
- Polynuclear aromatic hydrocarbons (PAHs)
- Simazine
- 2,3,7,8-Tetrachlorodibenzodioxin (dioxin)
- Toluene
- Toxaphene
- 2,4,5-TP (Silvex)
- 1,1,2-Trichloroethane
- Vydate
- Xylene

Radionuclides
- Beta particle and photo radioactivity
- Gross alpha particle activity
- Radium-226 and -228
- Radon
- Uranium

Removed from SDWA List of 1983
- Aluminum
- Dibromomethane
- Molybdenum
- Silver
- Sodium
- Zinc

Substituted into SDWA List of 1983
- Aldicarb sulfone
- Aldicarb sulfoxide
- Ethylbenzene
- Heptachlor
- Heptachlor epoxide
- Nitrite
- Styrene

TABLE 5

*Water quality regulation development time frame specified by the amended SDWA**

Date	Action
June 1986	SDWA amendments enacted
June 1987	Publish MCLGs and promulgate NPDWRs for nine of the contaminants listed in the Mar. 4, 1982, and Oct. 5, 1983, *Federal Registers* (See Table 2)
	Publish proposed list of contaminants for substitution
August 1987	Publish final list of contaminants to be substituted
December 1987	Promulgate criteria under which filtration is required as a treatment technique for public water systems using surface sources
January 1988	Publish priority list of contaminants known or anticipated to occur in public water systems that may require regulation under the SDWA
June 1988	Publish MCLGs and promulgate NPDWRs for at least 40 of the contaminants listed in Table 2
June 1989	Publish MCLGs and promulgate NPDWRs for the remainder of the contaminants listed in Table 2
	States must have adopted regulations to implement filtration requirements
	Promulgate NPDWRs requiring disinfection as a treatment technique for all public water systems
January 1990	Publish proposed MCLGs and NPDWRs for at least 25 contaminants on the January 1988 priority list
January 1991	Publish MCLGs and promulgate NPDWRs for the 25 contaminants proposed in January 1990
	Publish updated priority list of contaminants known or anticipated to occur in public water systems

*Some actions have slipped beyond the dates specified in the amended SDWA.

threshold effect has not, however, been scientifically demonstrated for carcinogens. This means that any exposure to a carcinogen may theoretically represent some finite level of risk. Even though such a risk could be small at very low exposure levels, USEPA has adopted the policy that the MCLG for a known or probable human carcinogen will be set at zero, rather than at some *de minimus* risk level. Note that zero means none, as opposed to a measured value. Because current analytical methods have a finite detection limit, zero cannot be measured. Thus, zero is a concept, not a number.

Best available technology. Section 1412(a)(6) requires that for each MCL established, the technology, treatment technique, and other means feasible for purposes of meeting the MCL (referred to as best available technology, or BAT) be listed. Section 1412(a)(5) requires that the BAT be examined for efficacy under field conditions and not solely under laboratory conditions. In addition, granular activated carbon (GAC) adsorption is specified as BAT for treatment of synthetic organic chemicals (SOCs); other measures specified for SOC removal must be at least as effective as GAC adsorption. The amended SDWA does not, however, require the use of BAT. Systems may use any "appropriate technology" that is acceptable to the state and that results in compliance with an MCL. BAT designations are only recommendations.

Treatment technique allowance. Section 1412(b)(7) allows the USEPA to require the use of a treatment technique in lieu of establishing an MCL, if it is determined that monitoring for the contaminant is not economically or technologically feasible. The availability, accuracy, and practicality of available analytical methods for a contaminant significantly influence whether an MCL or a treatment technique will be established for that contaminant. This provision was retained essentially unchanged from the 1974 SDWA.

Variances. Section 1415 authorizes a state to grant one or more variances to water systems that cannot comply with an MCL because of characteristics of the water source(s). A variance may only be granted to those systems that have installed full-scale BAT for treatment of the MCL being violated. Before the state can grant a variance, it must find that the variance will not result in an unreasonable risk to health. Should a variance be granted, the state must prescribe a schedule for compliance and any additional control measures required of the public water system during the variance period. Even though a treatment plant is not achieving the desired degree of treatment, it must be kept in operation.

Exemptions. Section 1416 authorizes a state to exempt a water system from

TABLE 6
Drinking water priority list

Contaminant or Contaminant Group to be Regulated	
Aluminum	1,3-Dichloropropane
Ammonia	2,2-Dichloropropane
Boron	1,3-Dichloropropene
Bromobenzene	2,4-Dinitrotoluene
Bromochloroacetonitrile	ETU
Bromodichloromethane	Halogenated acids, alcohols, aldehydes, ketones, and other nitriles
Bromoform	
Chloramine	Hypochlorite ion
Chlorate	Isophorone
Chlorine	Methyltertbutylether
Chlorite	Metolachlor
Chloroethane	Metribuzin
Chloroform	Molybdenum
Chloromethane	Ozone by-products
Chloropicrin	Silver
o-Chlorotoluene	Sodium
p-Chlorotoluene	Strontium
Cryptosporidium	2,4,5-T
Cyanazine	1,1,1,2-Tetrachloroethane
Cyanogen chloride	1,1,2,2-Tetrachloroethane
Dibromoacetonitrile	Trichloroacetonitrile
Dibromochloromethane	1,2,3-Trichloropropane
Dibromomethane	Tribluralin
Dicamba	Vanadium
1,1-Dichloroethane	Zinc
Dichloroacetonitrile	

an MCL or treatment technique requirement if it finds that:

- the system is unable to comply with the requirement because of compelling factors (which may include economic factors),
- the exemptions will not result in an unreasonable risk to health, and
- the system was in operation as of Jan. 1, 1989, or, if it was not, no reasonable alternative source of drinking water is available to the new system.

The primary difference between an exemption and a variance is that treatment does not have to be installed before the system applies for an exemption. As a condition of granting the water system an exemption, the state may impose conditions such as increased monitoring or public notification or it may require that point-of-use (POU) devices or bottled water be used for the duration of the exemption. In general, an exemption cannot exceed three years; however, systems with fewer than 500 service connections (about 1,500 people) may be eligible for a renewable exemption every two years, with cause.

Public notification requirements. The 1974 SDWA required owners or operators of community water systems to notify customers they serve when drinking water standards were violated. The purpose of the public notification requirement was stated as part of the House of Representatives Report on the 1974 SDWA:

> The purpose of this notice requirement is to educate the public as to the extent to which public water systems serving them are performing inadequately in light of the objectives and requirements of this bill. Such public education is deemed essential by the Committee in order to develop public awareness of the problems facing public water systems . . . and to advise the public of potential or actual health hazards.

Public notification requirements were initially established by USEPA in 1975.[10] The 1986 SDWA amendments direct USEPA to revise the original public notification requirements to provide for different types and frequencies of notices based on the differences between violations. In addition, the revised requirements were to take into account the seriousness of any potential adverse health effects that may be involved. USEPA published final revised general public notification requirements Oct. 28, 1987.[11] Technical amendments to the revised requirements were published Apr. 17, 1989.[12] The new public notification requirements went into effect Apr. 28, 1989.[13]

The revised public notification regulations require public notification if any one of six conditions occurs:

(1) failure of the system to comply with an applicable MCL,

(2) failure to comply with a prescribed treatment technique,

(3) failure of the system to perform water quality monitoring as required by the regulations,

(4) failure to comply with testing procedures as prescribed by an NPDWR,

(5) issuance of a variance or an exemption, or

(6) failure to comply with the requirements of any schedule that has been set under a variance or exemption.

Because some violations are more serious than others, two tiers of public notification were established (Table 7). Tier 1 violations are considered more serious than tier 2 violations. Consequently, tier 1 violations have more extensive notification requirements than tier 2 violations. Tier 1 violations are further classified as acute or nonacute. Acute violations involve an acute risk to human health and have the most intensive public notification requirements, including television and radio announcements. Violations of state reporting requirements, however, do not require public notification.

Acute violations are listed in the general public notice regulations. Currently specified acute violations are as follows:[13]

- any violation specified by the state as posing an acute risk to human health;
- violation of the MCL for nitrate;
- violation of the MCL for total coliforms, when fecal coliforms or *E. coli* are present; and
- occurrence of a waterborne disease outbreak in an unfiltered system.

The general public notice requirements apply to all regulatory phases. Each new regulatory phase will specifically identify acute violations associated with the rule that will be added to the preceding list. In addition, mandatory language that must be used in public notices will also be specified in each new regulatory phase.

Current regulatory agenda

Prior to the 1986 SDWA amendments, USEPA was proceeding on an established regulatory agenda that involved development of new water quality regulations in four phases. The amendments added new tasks to the agenda and accelerated USEPA's timetable. To accomplish the mandate of the 1986 SDWA amendments, new requirements were incorporated into certain phases already under development at that time and new regulatory phases were added.

The regulatory agenda established by USEPA immediately following the 1986 SDWA amendments was based on the schedule established by Congress. The established development and review process for proposed and final USEPA regulations is extensive and involves public participation at several levels. Congress again underestimated the time required to develop sound regulations, and some actions have slipped past the schedule shown in Table 5.

The current schedule of development for new regulations is summarized in Table 8. All current regulatory phases and schedules are shown. In addition, *Federal Register* citations are listed for the Advance Notice for Proposed Rulemaking (ANPRM) notices and proposed and final rule notices. The specific content of each regulatory phase is summarized in the following sections. Promulgated regulations are discussed first; then proposed and anticipated regulations are discussed.

Volatile organic chemicals (VOCs) rule (Phase I)

MCLGs were proposed for eight VOCs (Table 9) June 12, 1984.[14] Final MCLGs and proposed MCLs for the eight VOCs were published Nov. 13, 1985.[15,16] Detailed discussions of the history of the regulation of VOCs in drinking water, occurrence, and health effects were presented in these notices. USEPA proposed to amend the MCLG for paradichlorobenzene and reproposed the MCL Apr. 17, 1987.[17] The final VOC rule was published July 8, 1987,[18] and corrections to the final rule were published July 1, 1988.[19]

Major provisions. The VOC regulation establishes MCLGs and MCLs for the eight VOCs listed in Table 9. Monitoring is a significant aspect of this rule and requirements are specified for the eight VOCs and fifty-one additional contaminants. The requirements pertain to both community water systems and nontransient, noncommunity water systems (such as factories and schools).

Monitoring requirements. The basic monitoring requirement is one sample per quarter at each entry point to the distribution system for groundwater and surface water sources. Composite samples of up to five sampling points are allowed. Initial monitoring requirements are phased in, based on the size of the population served (Table 10); small systems have the greatest time allowance for implementing the monitoring program.

Systems with groundwater sources

TABLE 7
Summary of public notification requirements

Violation Category Type	Mandatory Health Effects Information Required (All Public Water Supplies)	Notice to New Billing Units (Community Water Supplies Only)	Type of Public Water Supply	Time Frame Within Which Notice Must Be Given (Box indicates time frame for initial notice, and is followed by the frequency of repeat notice until the violation is resolved.)
				Violation: 72 hours / 7 days / 14 days / 45 days / 3 months / Annual
Tier 1			Community	Acute violations:
MCL	Yes	Yes		TV and radio: No repeat
Treatment technique	Yes	Yes		Newspaper*: No repeat
Variance or exemption schedule violation	Yes	Yes		Mail or hand delivery†: Quarterly repeat
				Nonacute violations:
				Newspaper*: No repeat
				Mail or hand delivery†: Quarterly repeat
			Noncommunity‡	Option 1: Notice as for Community Water Systems
				or
				Option 2:
				Acute violations:
				Posting or hand delivery: Continuous/quarterly repeat§
				Nonacute violations:
				Posting or hand delivery: Continuous/Quarterly repeat§
Tier 2			Community	Newspaper*: Quarterly repeat by mail or hand delivery
Monitoring**	No	No		
Testing procedure	No	No		
Variance or exemption issued	Yes	No	Noncommunity†	Option 1: Notice as for Community Water Systems
				Option 2:
				Posting or hand delivery: Continuous quarterly repeat§

*If no newspaper of general circulation is available, posting or hand delivery is required.
†May be waived
‡Includes both transient noncommunity public water systems and nontransient noncommunity public water systems
**Less frequent notice (but no less than annual) to be required
§Continuous repeat required if posting is used; quarterly repeat required if hand delivery is used

must sample at each entry point to the distribution system (after the application of any treatment). For example, if a system has four wells, each with unique points of entry to the distribution system, four separate samples would have to be taken. If a system has four wells that are combined before entry to the distribution system, only one sample is required. This approach was chosen as an economical means of assuring that the MCL is not exceeded at the tap, because it avoids dealing with mixing zones when multiple source waters exist.

Groundwater samples must be taken quarterly. The state may reduce the monitoring frequency depending on whether any of the regulated or additional VOCs (discussed later) are detected in the first sample (or any subsequent sample) and whether the system has been designated by the state as vulnerable to potential contamination.

Systems with surface water sources are required to sample at points in the distribution system representative of each water source or at entry points to the distribution system after any application of treatment. These points must be sampled quarterly for one year, regardless of whether any VOCs are detected. Repeat monitoring must be conducted based on judged vulnerability and previous monitoring results.

Monitoring for vinyl chloride is required only for groundwater systems and only if vinyl chloride precursors are detected. If the chemical is detected, the system must analyze for vinyl chloride at each distribution or entry point at which one or more of the chemicals was found. If the first analysis does not detect vinyl chloride, the state may reduce the frequency of vinyl chloride monitoring to once every three years. Systems using surface water sources must analyze for vinyl chloride at the discretion of the state.

Analytical requirements. Analytical methods approved by USEPA must be used and analyses must be performed by laboratories. Five methods are currently approved for compliance monitoring and are based on gas chromatography (GC) or GC-mass spectrometry (MS) techniques.[18] Note that USEPA-approved analytical methods are specified in the *Federal Register* notice for each regulatory phase. Information regarding USEPA-approved analytical methods may be obtained by contacting the USEPA Environmental Monitoring and Support Laboratory, 26 W. Martin Luther King Dr., Cincinnati, OH 45268.

Compliance requirements. Compliance with the MCLs is determined by a running annual average of quarterly samples for each sampling location. If the average is greater than the MCL, the system is out of compliance.

BAT. BAT for all VOCs except vinyl

TABLE 8

Schedule of USEPA drinking water quality regulations

Regulation	Action	Date*	*Federal Register* Citation
Promulgated regulations			
VOCs (Phase I)			
	ANPRM	Mar. 4, 1982	47 *FR* 9350
	Proposed rule (RMCLs)	June 12, 1984	49 *FR* 24330
	Final rule (RMCLs)	Nov. 13, 1985	50 *FR* 46880
	Proposed rule (MCLs)	Nov. 13, 1985	50 *FR* 46902
	Proposed rule (*para*-dichlorobenzene)	Apr. 17, 1987	52 *FR* 12876
	Final rule	July 8, 1987	52 *FR* 25690
	Final rule corrections	July 1, 1988	53 *FR* 25108
Fluoride (Phase IIA)			
	ANPRM	Oct. 5, 1983	48 *FR* 45502
	Proposed rule (RMCL)	May 14, 1985	50 *FR* 20164
	Final rule (RMCL)	Nov. 14, 1985	50 *FR* 47142
	Proposed rule (MCL, SMCL)	Nov. 14, 1985	50 *FR* 47156
	Final rule	Apr. 2, 1986	51 *FR* 11396
Surface Water Treatment Rule			
	ANPRM	Oct. 5, 1983	48 *FR* 45502
	Proposed rule	Nov. 13, 1985	50 *FR* 46936
	Proposed rule	Nov. 3, 1987	52 *FR* 42178
	Proposed rule (Extension)	Jan. 7, 1988	53 *FR* 1892
	Notice of options	May 6, 1988	53 *FR* 16348
	Final rule	June 29, 1989	54 *FR* 27488
Total Coliform Rule			
	Proposed rule	Nov. 3, 1987	52 *FR* 42224
	Notice of options	May 6, 1988	53 *FR* 16348
	Final rule	June 29, 1989	54 *FR* 27547
Proposed regulations			
Lead and copper			
	ANPRM	Oct. 5, 1983	48 *FR* 45502
	Proposed rule (MCLG)	Nov. 13, 1985	50 *FR* 46936
	Proposed rule (MCLGs/MCLs and treatment technique)	Aug. 18, 1988	53 *FR* 31516
	Final rule	(Nov. 1990)*	
SOCs & IOCs (Phase II)			
	ANPRM	Oct. 5, 1983	48 *FR* 45502
	Proposed rule	Nov. 13, 1985	50 *FR* 46936
	Proposed rule	May 22, 1989	54 *FR* 22062
	Final rule	(Dec. 1990)	
Anticipated regulations			
SOCs & IOCs (Phase V)			
	ANPRM	Oct. 5, 1983	48 *FR* 45502
	ANPRM	Nov. 13, 1985	50 *FR* 16936
	Proposed rule	(June 1990)	
	Final rule	(March 1992)	
Radionuclides (Phase III)			
	ANPRM	Oct. 5, 1983	48 *FR* 45502
	ANPRM	Sept. 30, 1986	51 *FR* 34836
	Proposed rule	(Sept. 1990)	
	Final rule	(June 1992)	
D-DBP (Phase VIa)			
	Proposed rule	(Late 1991)	
	Final rule	(1993)	

*Dates in parentheses are anticipated and subject to change.

TABLE 9

VOC (Phase I) regulations

Compound	MCLG *mg/L*	MCL *mg/L*
Benzene	zero	0.005
Carbon tetrachloride	zero	0.005
para-Dichlorobenzene	0.075	0.075
1,2-Dichloroethane	zero	0.005
1,1-Dichloroethylene	0.007	0.007
1,1,1-Trichloroethane	0.20	0.20
Trichloroethylene	zero	0.005
Vinyl chloride	zero	0.002

TABLE 10

Monitoring requirements for VOCs (Phase I)

Initial Monitoring*		
Size of Population Served	**Begin By**	**Complete By**
>10,000	Jan. 1, 1988	Dec. 31, 1988
3,300-10,000	Jan. 1, 1989	Dec. 31, 1989
<3,300	Jan. 1, 1991	Dec. 31, 1991

Repeat Monitoring		
Status†	**Groundwater**	**Surface Water**
VOCs not detected; source judged not vulnerable to possible contamination	Repeat every five years	State discretion
VOCs not detected; source judged vulnerable to possible contamination		
More than 500 system connections	Repeat every three years	Repeat every three years
Less than 500 system connections	Repeat every five years	Repeat every five years
VOCs detected	Sample quarterly	Sample quarterly

*Sampling site and monitoring frequency depend on the type of source water.
†States must recertify vulnerability status every three years for systems serving >500 connections, every five years for systems serving <500 connections. States may, however, change the vulnerability status at any time.

TABLE 11

Additional contaminants for which monitoring is required under the VOC (Phase I) rule

List 1	List 2	List 3
Bromobenzene	Ethylene dibromide (EDB)	Bromochloromethane
Bromodichloromethane	1,2-Dibromo-3-chloropropane (DBCP)	*n*-Butylbenzene
Bromoform		Dichlorodifluoromethane
Bromomethane		Fluorotrichloromethane
Chlorobenzene		Hexachlorobutadiene
Chlorodibromomethane		Isopropylbenzene
Chloroethane		*p*-Isopropyltoluene
Chloroform		Naphthalene
Chloromethane		*n*-Propylbenzene
o-Chlorotoluene		sec-Butylbenzene
p-Chlorotoluene		tert-Butylbenzene
Dibromomethane		1,2,3-Trichlorobenzene
m-Dichlorobenzene		1,2,4-Trichlorobenzene
o-Dichlorobenzene		1,2,4-Trimethylbenzene
trans-1,2-Dichloroethylene		1,3,5-Trimethylbenzene
cis-1,2-Dichloroethylene		
Dichloromethane		
1,1-Dichloroethane		
1,2-Dichloropropane		
1,3-Dichloropropane		
2,2-Dichloropropane		
1,1-Dichloropropene		
1,3-Dichloropropene		
Ethylbenzene		
Styrene		
1,1,1,2-Tetrachloroethane		
1,1,2,2-Tetrachloroethane		
Tetrachloroethylene		
1,1,2-Trichloroethane		
1,2,3-Trichloropropane		
Toluene		
p-Xylene		
o-Xylene		
m-Xylene		

TABLE 12

Monitoring requirements for additional contaminants under the VOC (Phase I) rule

Initial Monitoring		
Size of Population Served	**Begin By**	**Complete By**
>10,000	Jan. 1, 1988	Dec. 31, 1988
3,300-10,000	Jan. 1, 1989	Dec. 31, 1989
<3,300	Jan. 1, 1991	Dec. 31, 1991

Sampling Conditions	**Groundwater**	**Surface Water**
Sample locations	At each entry point to the distribution system representative of each well	In distribution system representative of each source
Number of samples	One sample; confirmation sample at the discretion of the state	One sample each quarter per source for one year; confirmation samples at the discretion of the state

Repeat Monitoring—Every five years

chloride is packed-tower stripping or GAC adsorption. Packed-tower stripping is the only BAT for vinyl chloride. Point of entry (POE) devices, although not designated BAT, are also an acceptable means of compliance, with state approval, if certain criteria are met. POU devices and bottled water are considered acceptable, at state discretion, only as interim measures to avoid unreasonable risks to health until full compliance can be achieved.

Additional contaminant monitoring. To satisfy the requirements of section 1445(a)(1), monitoring requirements for 51 additional contaminants were included in the VOC rule. The contaminants to be monitored are grouped into three lists (Table 11):

- List 1—thirty-four compounds that must be monitored by all systems.
- List 2—two compounds that must be monitored by systems whose water supply is determined to be vulnerable to possible contamination.
- List 3—fifteen compounds that may be monitored by systems at the discretion of the state.

The general monitoring schedule for the additional contaminants is given in Table 12. Repeat monitoring is required every five years. USEPA, however, expects to specify a new list for unregulated contaminants every five years, so the list will change over time. MCLs are also being developed for many of the additional contaminants to be dealt with in future regulations.

As in VOC monitoring, analyses must be performed by certified laboratories using USEPA-approved methods specified in the *Federal Register* notice, and composite samples of up to five sources are allowed.[18] Systems serving fewer than 150 connections are considered to be in compliance with the additional contaminant monitoring requirements if they provide water samples or the opportunity for sampling to the state.

Public notification. All general public notice requirements apply to the VOC rule. Mandatory language to be included in public notices for violations of VOC MCLs is specified.

Variances and exemptions. A water system may apply for a variance or exemption from any VOC MCL requirement if the appropriate criteria are met. As a condition of granting a variance or exemption, the state may impose conditions on the system, such as increased monitoring or public notification or it may require the use of POU devices or bottled water if either is needed to avoid an unreasonable risk to health.

Compliance issues. The VOC rule became effective Jan. 9, 1989. Deadlines have expired for initial VOC and additional contaminant monitoring by systems serving populations of >3,300 people. The monitoring deadline for

systems serving populations of <3,300 people is Dec. 31, 1991. State implementation of this rule is well under way, and water utilities are expected to comply with its requirements.

Vulnerability. Vulnerability assessments affect repeat monitoring requirements. The vulnerability of each water system is determined by the state based on an assessment of several factors, including previous monitoring results; number of people served by the water system; proximity of the system to commercial or industrial use, disposal, or storage of VOCs; and level of protection given to the water source, such as a watershed management or wellhead protection program.

A system is considered vulnerable for a period of three years after any positive sample of one or more VOCs. Conversely, sampling requirements can be reduced from quarterly to no less than annually after no VOCs are detected for a three-year period.

Composite sampling. Compositing of samples is intended to reduce costs, especially for small systems. It is viewed as a screening test to determine whether samples from multiple sampling sites may be contaminated by VOCs. Composite samples must be analyzed within 14 days of collection. If any VOC is detected in a composite sample, followup analysis is required for each source within 14 days of receipt of laboratory results.

Fluoride (Phase IIA)

The NIPDWR for fluoride (Table 2) was based on ambient air temperature to account for assumed differences in water consumption between cold and warm climates. An RMCL was proposed May 14, 1985,[20] and finalized Nov. 14, 1985.[21] The proposed MCL and SMCL were published Nov. 14, 1985,[22] and finalized Apr. 2, 1986.[23] The fluoride rule, along with the VOC rule, satisfied the statutory requirement under the amended SDWA that USEPA regulate nine substances by June 1987.

Major provisions. Based on review of health effects information available at the time, USEPA set both the MCLG and MCL at 4.0 mg/L to protect against crippling skeletal fluorosis. The SMCL was set at 2.0 mg/L to protect against objectionable dental fluorosis, not considered by USEPA to be an adverse health effect.

Monitoring requirements. Monitoring is required yearly for systems using surface water sources and every three years for systems using groundwater sources. A state may reduce monitoring to once every 10 years if it determines that the system is not likely to exceed the MCL. A state also may require monitoring more frequently than the minimum. Note that the Centers for Disease Control recommends daily fluoride monitoring for systems that practice fluoridation.[24]

Sampling is required at points in the distribution system that are representative of household taps. At a minimum, separate distribution system samples are required for each source water the utility uses. Because multiple source waters in a single system can have different fluoride levels, systems must sample at an entry point to the distribution system representative of the maximum fluoride levels occurring under normal operating conditions.

Analytical requirements. Four analytical methods are USEPA-approved for compliance monitoring: (1) ion selective electrode, (2) automated ion selective electrode, (3) colorimetric SPADNS, and (4) complexone.[23] Analyses for compliance monitoring must be conducted by certified laboratories.

All public water systems using any surface water or groundwater that is under the direct influence of surface water are required to disinfect.

BAT. Central treatment using activated alumina adsorption or reverse osmosis is specified as BAT for fluoride removal.

Compliance requirements. Compliance with the fluoride MCL is based on each sampling point. If any sampling point is determined to be out of compliance, the system is deemed out of compliance.

Public notification. The general public notice requirements apply to this rule. In addition, community water systems that exceed the SMCL, but not the MCL, are required to give special notice annually (or at the time service begins in the case of new billing units) using mandatory language that informs customers of the significance of exceeding the SMCL.

Variances and exemptions. A system may apply for a variance or exemption from the fluoride MCL. As a condition of a variance, a schedule of compliance will be specified by the state that may require the system to examine the following methods to determine their effectiveness for reducing fluoride levels:

- modification of lime softening,
- alum coagulation,
- electrodialysis,
- anion exchange resins,
- well-field management,
- alternative sources, and
- regionalization.

The state may require the use of one of these or of other treatment methods in connection with the variance compliance schedule if the treatment method is found to be technically feasible, economically reasonable, and achieves fluoride reductions commensurate with the costs incurred for installation and use.

Compliance issues. The MCL for fluoride became effective Oct. 2, 1987. The provisions of the rule are in effect and community water systems are expected to comply with its requirements. USEPA estimates that about 300 community water systems currently exceed the 4.0-mg/L fluoride MCL. The rule does not apply to noncommunity systems.

SDWA section 1412(b)(9) requires USEPA to review all primary drinking water regulations at least once every three years, and USEPA has initiated a review of the current fluoride standard. Following review of health effects information that has become available since the rule was established, USEPA will determine whether or not the MCLG, MCL, or both should be changed. Included in this review will be the results of a bioassay from the National Toxicology Program on the incidence of cancer in animals exposed to high doses of fluoride. USEPA's review is expected to take at least a year and results will not be published until 1991.

Surface water treatment regulations

Regulations for filtration, disinfection, turbidity, *Giardia lamblia*, viruses, *Legionella*, and heterotrophic bacteria were proposed Nov. 3, 1987,[25] and promulgated June 29, 1989.[26] Known as the Surface Water Treatment Rule (SWTR), the regulations apply to all public community and noncommunity water systems that use surface water sources or groundwater sources under the direct influence of surface water. The basis for this rule is the assumption that all surface waters and groundwaters under the direct influence of surface water are at risk, at least to some degree, from contamination by *Giardia lamblia* and other protozoa, viruses, and pathogenic bacteria. Public water systems using these source waters must provide minimum levels of treatment to ensure protection from illnesses caused by these contaminants.

Major provisions. All public water systems using any surface water or groundwater under the direct influence of surface water are required to disinfect and may be required by the state to install filtration, unless certain water quality source requirements and site-specific requirements are met. An MCLG of zero is established for *Giardia lamblia*,

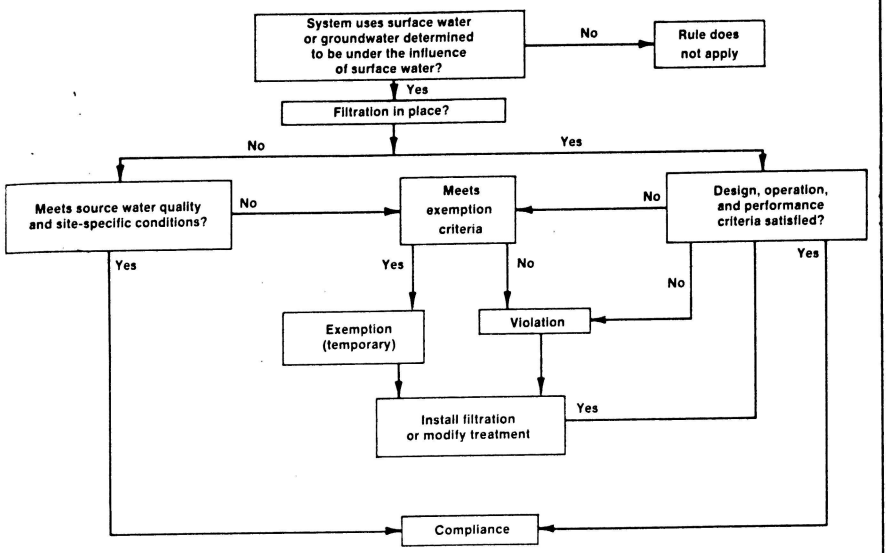


Figure 1. Simplified compliance decision tree for the Surface Water Treatment Rule[25]

viruses, and *Legionella*. USEPA recommends levels as close to zero as possible for turbidity and heterotrophic plate count (HPC) bacteria, although MCLGs have not been formally established.

Treatment technique requirements are established in place of MCLs for *Giardia*, viruses, HPC bacteria, *Legionella*, and turbidity. Treatment (disinfection with or without filtration) must achieve at least 99.9 percent (frequently called 3-log) removal or inactivation of *Giardia lamblia* cysts and 99.99 percent (frequently called 4-log) removal or inactivation of viruses.

Operating criteria are established for systems that currently have filtration or that must install filtration because of this rule. Filtered water turbidity must at no time exceed 5 ntu and must meet the following turbidity limits in 95 percent of the measurements taken:

- conventional treatment or direct filtration—0.5 ntu,
- slow sand filtration—1 ntu,
- diatomaceous earth filtration—1 ntu, and
- other technologies approved by the state—1 ntu.

Turbidity measurements must be made every 4 hours by grab sampling or continuous monitoring.

The residual disinfectant in treated water entering the distribution system cannot be less than 0.2 mg/L for more than 4 hours. The residual disinfectant in treated water anywhere in the distribution system cannot be undetectable in more than 5 percent of the samples taken in a month, for any two consecutive months. A system may measure for HPC in lieu of disinfectant residual. If the HPC measurement is less than 500 colonies/mL, the site is considered to have a "detectable" residual for compliance purposes.

Requirements to avoid filtration. A public water system using surface water or groundwater under the influence of surface water must use filtration unless it meets criteria related to source water quality and site-specific conditions. The criteria are divided into eight areas, described in general as follows:

(1) Coliform limits—to avoid filtration, the fecal coliform level prior to disinfection must be less than or equal to 20/100 mL in at least 90 percent of samples taken, or the total coliform level prior to disinfection must be less than or equal to 100/100 mL in at least 90 percent of samples taken. Sampling frequency is based on system size. The calculation is based on the previous six months of monitoring results.

(2) Turbidity limits—to avoid filtration, the turbidity level prior to disinfection must not exceed 5 ntu, based on measurements taken every 4 hours. A system may occasionally exceed 5 ntu and still avoid filtration if the state determines that this turbidity level occurred because of unusual circumstances and not more than two such violations have occurred in the past 12-month period or more than five violations in the past 120 months.

(3) Disinfection—to avoid filtration, a system must practice disinfection and achieve 99.9 and 99.99 percent inactivation of *Giardia* cysts and viruses, respectively. This must be demonstrated by the system each day it delivers water to consumers by meeting minimum *CT* values in the rule. (See reference 26 for specific *CT* values.) *CT* is the product of disinfectant residual *C* (mg/L) times contact time *T* (minutes), measured at peak hourly flow determined at or prior to the first customer tap. As stated previously, the disinfectant residual in water entering the distribution system must not be less than 0.2 mg/L. The disinfectant residual in the distribution system cannot be undetectable in more than 5 percent of the samples in a month, for any two consecutive months. A system may measure for HPC in lieu of disinfectant residual in the distribution system.

(4) Watershed control—to avoid filtration, systems must establish and maintain an effective watershed control program.

(5) On-site inspection requirements—to avoid filtration, a system must have an annual on-site inspection conducted by the state (or third party approved by the state) to demonstrate that the system is maintaining an adequate watershed control program and reliable disinfection treatment.

(6) Absence of waterborne disease outbreaks—to avoid filtration, a system cannot have been identified as a source of waterborne disease outbreak, or, if it has been, the system must have been modified sufficiently to prevent another outbreak.

(7) Compliance with the total coliform MCL—to avoid filtration, a system must comply with the total coliform rule requirements.

(8) Compliance with the total trihalomethane (TTHM) MCL—to avoid filtration, a system must comply with the TTHM regulation.

Analytical requirements. Except for ozone analyses, testing and sampling must be in accordance with *Standard Methods* (sixteenth edition) or methods approved by the USEPA for total coliforms, fecal coliform, turbidity, disinfectant residuals, temperature, and pH.[26] Residual disinfectant concentrations for ozone must be measured by the Indigo Method or automated methods that are calibrated in reference to the results obtained by the Indigo Method. Note that the comparable method in the seventeenth edition of *Standard Methods* should not be used for compliance monitoring unless the method is unchanged from the sixteenth edition or until the seventeenth edition version of the method is approved by USEPA.

Operator requirements. All systems using surface water or groundwater under the direct influence of surface water must have operators that meet qualifications specified by the state.

Compliance requirements. The rule establishes compliance requirements for all systems. A simplified compliance decision tree is shown in Figure 1.

TABLE 13

Routine sampling requirements under the total coliform rule

Population Served	Minimum Number of Routine Samples per Month	Population Served	Minimum Number of Routine Samples per Month
25-1,000*	1	59,001-70,000	70
1,001-2,500	2	70,001-83,000	80
2,501-3,300	3	83,001-96,000	90
3,301-4,100	4	96,001-130,000	100
4,101-4,900	5	130,001-220,000	120
4,901-5,800	6	220,001-320,000	150
5,801-6,700	7	320,001-450,000	180
6,701-7,600	8	450,001-600,000	210
7,601-8,500	9	600,001-780,000	240
8,501-12,900	10	780,001-970,000	270
12,901-17,200	15	970,001-1,230,000	300
17,201-21,500	20	1,230,001-1,520,000	330
21,501-25,000	25	1,520,001-1,850,000	360
25,001-33,000	30	1,850,001-2,270,000	390
33,001-41,000	40	2,270,001-3,020,000	420
41,001-50,000	50	3,020,001-3,960,000	450
50,001-59,000	60	3,960,001 or more	480

*Includes public water systems that have at least 15 service connections but serve fewer than 25 people

TABLE 14

Monitoring and repeat-sample frequency after a total-coliform-positive routine sample

Number of Routine Samples per Month	Number of Repeat Samples*	Number of Routine Samples Next Month†
1 or less	4	5/month
2	3	5/month
3	3	5/month
4	3	5/month
5 or more	3	Table 13

*Number of repeat samples in the same month for each total-coliform-positive routine sample
†Except when state invalidates the original routine sample, substitutes an on-site evaluation of the problem, or waives the requirement on a case-by-case basis

The existing interim standard for turbidity will continue in effect for unfiltered systems until Dec. 30, 1991, and for filtered systems until June 29, 1993. If the state determines before Dec. 30, 1991, that an unfiltered system must filter, the system must comply with the interim standard for turbidity until June 29, 1993, or until filtration is installed, whichever is later.

States must set regulations necessary to implement this rule by Dec. 30, 1990. State rules must be at least as stringent as those set by USEPA. Before Dec. 30, 1991, each state must determine which systems will be required to filter. If filtration is required, it must be installed before June 29, 1993, unless the system is allowed an exemption by the state. If an exemption is granted, filtration must be installed by the date specified in the terms of the exemption. Monitoring and reporting requirements go into effect Dec. 30, 1990, for unfiltered systems, unless the state determines by then that filtration is required. All systems with filtration in place must meet the filtration criteria, disinfection criteria, and the monitoring and reporting requirements beginning June 29, 1993.

States must adopt procedures for determining whether a groundwater source is under the direct influence of surface water by Dec. 30, 1990. For each system served by a groundwater source, the state must determine whether that source is under the direct influence of surface water. This determination must be made for community water systems by June 29, 1994, and for noncommunity systems by June 29, 1999.

A system using a groundwater under the direct influence of surface water must comply with the monitoring and reporting requirements of this rule beginning Dec. 30, 1991, or six months after the state determines that the groundwater is under the direct influence of surface water, whichever is later. Within 18 months of determining that a groundwater source is under the direct influence of surface water, the state must determine whether filtration is required.

Beginning Dec. 30, 1991, or 18 months after the state determines that a groundwater source is under the direct influence of surface water, whichever is later, the criteria for avoiding filtration and the requirements for unfiltered systems go into effect, unless the state has determined that filtration is required.

This means that a system using a groundwater source under the direct influence of surface water that fails to meet any one of the criteria for avoiding filtration after the relevant date must install filtration and comply with the requirements for filtered systems by June 29, 1993, or within 18 months of failure to meet any one of the criteria for avoiding filtration, whichever is later.

Public notification. All general public notification requirements, including the manner and frequency of notification, apply to violation of this rule. Mandatory language to be included in public notices for violations of the filtration and disinfection requirements of the rule is specified. Violations of treatment technique requirements are classified as tier 1 violations. Violations of testing procedures and monitoring requirements are classified as tier 2 violations. A waterborne disease outbreak in an unfiltered supply is designated as a tier 1, acute violation.

Variances and exemptions. No variances from the filtration and disinfection requirements of the rule are allowed. Exemptions are allowed for all requirements except disinfection residual requirements at the point of entry to the distribution system.

State flexibility. The SWTR allows some state flexibility in interpreting and implementing the provisions of the rule. State primacy agencies must be consulted to determine how the rule will be implemented. Particular areas in which state agencies have discretion include:

Determination of groundwater under the influence of surface water. As discussed in the preceding sections, states must establish criteria to be used to determine whether a groundwater source is under the direct influence of surface water. The state must make this determination for each groundwater source.

Turbidity monitoring. For systems using slow sand filtration or filtration technologies other than conventional treatment, direct filtration, or diatomaceous earth filtration, the state may reduce turbidity sampling frequency to once a day. The state may reduce monitoring to one grab sample a day for all systems serving fewer than 500 people.

Turbidity removal for conventional or direct filtration. The state may increase the 0.5-ntu turbidity limit up to less than 1 ntu in ≥95 percent of the measurements, without any demonstration by the system, if the state determines that overall treatment with disinfection achieves at least 99.9 and 99.99 percent removal and inactivation of *Giardia* cysts and viruses, respectively.

Turbidity removal for slow sand filtration. The state may increase the 1-ntu turbidity limit (but at no time to exceed 5 ntu) if it determines that no significant interference with disinfection exists.

Turbidity limits for alternative filtration technologies. The state may increase the 1-ntu turbidity limit (but at no time to exceed 5 ntu) if it determines that there is no significant interference with disinfection.

Disinfection requirements for filtered systems. The state defines the level of disinfection required, depending on technology and source water quality.

Alternative technology approval. States may approve alternative filtration and disinfection technologies demonstrated to achieve at least 99.9 percent and 99.99 percent removal or inactivation of *Giardia lamblia* cysts and viruses, respectively.

Criteria to avoid filtration. Some flexibility in interpreting the criteria to be met to avoid filtration is allowed. If the state determines that certain of the criteria established to avoid filtration were exceeded because of particular circumstances defined in the rule, the state may waive the requirement to install filtration.

Compliance issues. Compliance with the requirements of the SWTR will be affected by state flexibility allowed in the rule and by each utility's situation. To assist water utilities and states in implementing the SWTR, USEPA has prepared a guidance manual[27] (available from the National Technical Information Service [NTIS], 5285 Port Royal Rd., Springfield, VA 22161; 1-800-336-4700).

Systems that use a surface wate

*AWWA has obtained permission to reprint the guidance manual, which should be available in mid-1990.

TABLE 15

Proposed lead and copper regulation

I. Source Water Requirements

A. Sampling

1. Lead and copper concentrations to meet the following MCLs—
   Lead: 0.005 mg/L
   Copper: 1.3 mg/L
2. Monitoring requirements are based on system size and water source

Population Served by System	Water Source	Number of Samples	Monitoring (Number of Months After Publication of Final Regulation)	
			Begin By	Complete By
Less than 500	Ground, surface	1 per year	27	39
500-3,300	Ground	1 per year	15	27
	Surface	1 per quarter	15	27
More than 3,300	Ground	1 per year	3	15
	Surface	1 per quarter	3	15

3. Samples must be taken at entry points to the distribution system from each source and after any treatment. Individual states will have discretion to allow composite samples or use of a representative well in a well field.
4. Compliance is based on the results of each analysis. If one result exceeds the MCL, the system is out of compliance.

B. Treatment

1. Achieving compliance may mean using costly treatment processes, such as reverse osmosis, or changing sources.

II. Corrosion of Pipes and Household Plumbing

A. Sampling

1. Identify pool of residences most likely to have high lead levels for sampling. Residences must be at the ends of the distribution system. Each residence must have
   - lead solder less than five years old in the plumbing or
   - lead service connections or lead plumbing.
2. Sampling pool must have at least 50 percent more sites than required for monitoring. For example, if 50 samples are required, 75 homes would have to be identified.
3. Monitoring requirements are based on system size.

Population Served by System	Number of Samples	Monitoring (Number of Months After Publication of Final Regulation)	
		Begin By	Complete By
Less than 500	10 in 1 year every 5 years*	27	39
500-3,300	10 in 1 year every 2 years*	15	27
3,301-10,000	20 per quarter†	3	15
10,001-100,000	30 per quarter†	3	15
More than 100,000	50 per quarter†	3	15

*Must be taken during June, July, and August
†Can be reduced to one sample set each year; taken during June, July, and August if no-action levels are achieved

4. Samples must be at least one litre in volume and collected from a cold-water kitchen tap. Samples must represent water that has stood in the service lin and plumbing for 8-18 hours.
5. No-action levels
   a. Based on the sample results for one year, a water system is in compliance and will take no action if
      - the average lead level is less than or equal to 0.010 mg/L,
      - no more than 5 percent of the samples contain more than 1.3 mg/L of copper, and
      - no more than 5 percent of the samples have a pH less than 8.

B. Treatment

1. Some form of treatment would be required to control corrosion in pipes and household plumbing if any of the no-action levels are not achieved.
2. A water system that fails to meet any of the no-action levels must submit a treatment plan to the state within one year. This plan must outline the step the utility will take and a schedule it will follow to provide corrosion control treatment, including pilot studies and final installation of equipment.

C. Public education

1. As part of the treatment plan, a water system must also develop a public education program to inform its customers about lead in drinking water if
   - the average lead level exceeds 0.010 mg/L or
   - more than 5 percent of the samples have more than 0.020 mg/L of lead.
2. The public education program must be approved by the state for content and for the way in which the program will be delivered.
3. Systems serving more than 10,000 people are required to conduct an evaluation of the public education program.

TABLE 16

Proposed MCLGs and MCLs for SOCs and IOCs (Phase II)

Contaminant	Drinking Water Health Effects	Proposed MCLG mg/L	Current MCL mg/L	Proposed MCL mg/L	Sources
Inorganics					
Asbestos	Benign tumors	7 million fibers/L*		7 million fibers/L*	Geological, asbestos-cement
Barium	Circulatory system effects	5	1	5	Geological
Cadmium	Kidney effects	0.005	0.01	0.005	Geological, mining, smelting, and corrosion of galvanized pipe
Chromium	Gastrointestinal effects	0.1	0.05	0.1	Geological
Mercury	Kidney effects	0.002	0.002	0.002	Used in manufacture of paint, paper, vinyl chloride; used in fungicides; geological
Nitrate†	Methemoglobinemia ("blue baby" syndrome)	10 (as Nitrogen)	10 (as Nitrogen)	10 (as Nitrogen)	Fertilizer, sewage, feedlots
Nitrite†	Methemoglobinemia ("blue baby" syndrome)	1 (as Nitrogen)		1 (as Nitrogen)	Fertilizer, sewage, feedlots
Selenium	Neurological effects	0.05	0.01	0.05	Geological, mining
Volatile organics (solvents)					
cis-1,2-Dichloroethylene	Nervous system, liver, kidney	0.07		0.07	Extraction solvent, dyes, perfumes, pharmaceuticals, lacquers
1,2-Dichloropropane	Liver, toxin, lung, and kidney effects	0		0.005	Pesticide, solvent
Ethylbenzene	Liver, kidney effects	0.7		0.7	Manufacture of styrene
Monochlorobenzene	Respiratory, nervous system, liver, kidney effects	0.1		0.1	Solvent, pesticide
o-Dichlorobenzene	Nervous system, lung, liver, kidney effects	0.6		0.6	Industrial solvent, pesticide
Styrene	Possible cancer, liver, central nervous system effects	0/0.1‡		0.005/0.1‡	Manufacture of polystyrene plastic
Tetrachloroethylene	Probable cancer	0		0.005	Dry-cleaning solvent
Toluene	Nervous system, lung, liver effects	2		2	Solvent, gasoline additive
trans-1,2-Dichloroethylene	Nervous system liver, kidney effects	0.1		0.1	Extraction solvent, dyes, perfumes pharmaceuticals, lacquers
Xylenes (total)	Central nervous system effects	10		10	Solvent; used to manufacture paint, dyes, adhesives, detergents, fuel additive

*Longer than 10 μm
†Total nitrate plus nitrate MCLG and MCL = 10 mg/L (as nitrogen).
‡USEPA proposes a dual MCLG-MCL for styrene. After public comment, a single MCLG and MCL will be set.
§Treatment technique requirement limits the amount of the chemical used to treat drinking water.

source or groundwater source under the direct influence of surface water and that do not currently disinfect must install disinfection treatment. These systems may also be required to install filtration unless the criteria for avoiding filtration are met following installation of disinfection treatment. During evaluation of a system to determine what type of treatment is required, the state may determine that interim measures are needed to reduce health risks. Interim measures might include a boil-water notice or the use of bottled water.

Systems that practice only disinfection could attempt to meet the requirements for avoiding filtration. Systems that do not meet one or more of the requirements for avoiding filtration must filter. During the period prior to installation of filtration, the state may require interim measures to reduce health risks, such as maintaining more stringent disinfection conditions until filtration is installed.

Water distribution systems that currently filter and disinfect must meet the treatment criteria in the rule. If the criteria cannot be met using current treatment practice, an upgrade in water treatment will be necessary.

Total coliform rule

The 1986 SDWA amendments included total coliform on the list of 83 contaminants that USEPA must regulate. USEPA developed a proposed rule for total coliform, which was published Nov. 3, 1987.[28] Additional regulatory options were published in the *Federal Register* May 6, 1988,[29] and the final rule was promulgated June 29, 1989.[30]

Major provisions. The revised rule set an MCLG for total coliforms (including fecal coliform and *E. coli*) at zero and an MCL based on the presence-absence (P-A) of total coliforms. The basis of the new MCL represents a major change in approach from the current rule, which estimates coliform density.

The MCL for water distribution systems analyzing at least 40 samples per month is that no more than 5.0 percent of the monthly samples may be positive for total coliform. The MCL for water distribution systems analyzing less than 40 samples per month is that no more than 1 sample per month may be positive for total coliform.

Under the current rule, no one positive sample can cause a violation. Because the new rule is based on presence or absence, one positive sample can cause a system to be in violation, if that positive sample is followed by a positive sample or if that sample brings the total percent positive to greater than the MCL. In

TABLE 16, continued
Proposed MCLGs and MCLs for SOCs and IOCs (Phase II)

Contaminant	Drinking Water Health Effects	Proposed MCLG *mg/L*	Current MCL *mg/L*	Proposed MCL *mg/L*	Sources
Pesticides, herbicides, PCBs					
Alachlor	Probable cancer	0		0.002	Herbicide
Aldicarb	Nervous system toxicity	0.01		0.01	Pesticide, herbicide; restricted in some areas
Aldicarb sulfone	Nervous system toxicity	0.01		0.01	Pesticide, herbicide; restricted in some areas
Aldicarb sulfoxide	Nervous system toxicity	0.04		0.04	Pesticide, herbicide; restricted in some areas
Atrazine	Nervous system, liver, heart effects	0.003		0.003	Herbicide
Carbofuran	Nervous system, reproductive effects	0.04		0.04	Pesticide, herbicide
Chlordane	Nervous system, liver effects	0		0.002	Pesticide, herbicide; most uses banned in 1980
Dibromochloropropane (DBCP)	Probable cancer	0		0.0002	Pesticide; canceled in 1977
2,4-D	Liver, kidney effects	0.07	0.1	0.07	Herbicide
Ethylene dibromide (EDB)	Probable cancer	0		0.0005	Gasoline additive, soil fumigant, solvent; most pesticide uses restricted in 1984
Heptachlor	Probable cancer	0		0.0004	Insecticide; most uses restricted in 1983
Heptachlor epoxide	Probable cancer	0		0.0002	Insecticide; most uses restricted in 1983
Lindane	Neurological, liver, kidney effects	0.0002	0.004	0.0002	Insecticide to control fleas, lice, ticks; some uses restricted in 1983
Methoxychlor	Central nervous system effects	0.4	0.1	0.4	Insecticide
PCBs	Probable cancer, reproductive effects	0		0.0005	Transformers, capacitors; production banned in 1977
Pentachlorophenol	Organ, central nervous system, fetal effects	0.2		0.2	Wood preservative; nonwood uses banned in 1987
Toxaphene	Probable cancer	0	0.005	0.005	Pesticide, herbicide; most uses canceled in 1977
2,4,5-TP (Silvex)	Liver, kidney effects	0.05	0.01	0.05	Herbicide; canceled in 1983
Drinking water treatment chemicals					
Acrylamide	Probable cancer	0		Treatment technique§	Water treatment chemicals (polymers)
Epichlorohydrin	Probable cancer	0		Treatment technique§	Water treatment chemicals (polymers)

addition, the new rule does not allow substitution of chlorine residual monitoring as does the current rule.

Monitoring requirements. All public water systems must sample according to a written sample-siting plan. The plan is subject to review and revision by the state, according to a process to be established by the state that ensures the adequacy of the plan.

Monthly routine monitoring requirements are based on population served (Table 13). States may specify a sampling frequency of less than one per month for noncommunity water systems using groundwater and serving 1,000 people or less until a sanitary survey is conducted. Thereafter, noncommunity water systems using groundwater and serving 1,000 people or less must monitor in each calendar quarter during which the system provides water to the public, unless the state determines that another frequency is more appropriate. After June 29, 1994, noncommunity water systems using groundwater and serving 1,000 people or less must monitor at least once a year.

Noncommunity water systems using surface water or groundwater under the direct influence of surface water, regardless of the number of people served, must monitor at the same frequency as a like-sized community water system. A noncommunity water system using groundwater and serving more than 1,000 people during any month must monitor at the same frequency as a like-sized community water system. The state may, however, reduce the monitoring frequency for any month the system serves 1,000 people or less.

For a community water system serving 25 to 1,000 people, the state may reduce the sampling frequency if a sanitary survey conducted within the last five years indicates that the system is supplied solely by a protected groundwater source and is free of sanitary defects. The sampling frequency, however, may not be reduced to less than once a quarter.

Repeat sample monitoring requirements under the new rule are extensive (Table 14). For each routine sample that tests positive for total coliform, a set of three or four repeat samples must be analyzed for total coliforms. At least one repeat sample in the set must be from the same tap as the original sample. Two repeat samples in the set must be collected from within five service connections of the original sample, one upstream and one downstream. Repeat samples must be collected within 24 hours of notification of the original result, except when the state waives this

requirement on a case-by-case basis. The purpose of repeat sampling is to determine whether the original positive sample is indicative of system contamination or a domestic or nondistribution system problem. If the problem is domestic or nondistribution system in nature, the state can invalidate the sample for compliance calculation purposes.

If total coliforms are detected in any repeat sample, the utility must collect another set of repeat samples, as before, unless the MCL has been violated and the utility has notified the state. In these cases, the state may reduce or eliminate the repeat-sampling requirement for the remainder of the month because the utility has already incurred a violation.

If a utility that routinely collects less than five routine samples per month detects total coliforms in any routine or repeat sample and the sample is not invalidated by the state, it must collect a set of five routine samples the next month the system provides water to the public, as shown in Table 14. The state may waive this requirement if either of two state actions occurs. The state can (1) perform a site visit to evaluate the contamination problem or (2) the state can determine why the sample was positive, explain this conclusion in writing, obtain the signature of the supervisor of the state official who draws this conclusion, make the documentation available to USEPA and the public, and

TABLE 17

Proposed (SOC-IOC) monitoring requirements for community systems

Contaminant	Vulnerability Assessment Required	Nonvulnerable Source		Vulnerable Source	
		Surface Water	Groundwater	Surface Water	Groundwater
Inorganics					
Barium	No	Initial: annually	Initial: every three years	Not applicable	Not applicable
Cadmium	No	Repeat: minimum of every 10 years after three rounds completed	Repeat: minimum of every 10 years after three rounds completed and all results <50 percent of MCL		
Chromium	No				
Mercury	No				
Selenium	No				
Asbestos	Yes, for initial sampling	No monitoring required if initial result is ≥50 percent of MCL	No monitoring required	Initial: one time Repeat: annually if initial result is ≥50 percent of MCL	Initial: one time Repeat: every three years if initial result is ≥50 percent of MCL
Nitrate-Nitrite	No	Quarterly (reduced to annually if concentration is <50 percent of MCL)	Annually (quarterly if concentration is ≥50 percent of MCL)	Not applicable	Not applicable
Synthetic organics					
VOCs					
cis-1,2-Dichloroethylene	Yes, for repeat frequency	Initial: quarterly for one year	Initial: quarterly for one year	Initial: quarterly for one year	Initial: quarterly for one year
trans-1,2-Dichloroethylene					
1,2-Dichloropropane		Repeat: *VOCs detected*†—quarterly *VOCs not detected*—state discretion	Repeat: *VOCs detected*†—quarterly *VOCs not detected*—five years	Repeat: *VOCs detected*†—quarterly *VOCs not detected*—>500 connections—every three years; ≤500 connections—every five years	Repeat: *VOCs detected*†—quarterly *VOCs not detected*—>500 connections—every three years; ≤500 connections—every five years
o-Dichlorobenzene					
Ethylbenzene					
Monochlorobenzene					
Styrene					
Tetrachloroethylene					
Toluene					
Xylenes (total)					
Pesticides, herbicides, PCBs					
Alachlor	Yes, for initial sampling	No monitoring required	No monitoring required	Initial: quarterly for one year	Initial: quarterly for one year
Aldicarb					
Aldicarb sulfone					
Aldicarb sulfoxide					
Atrazine				Repeat: *Detected*‡—>500 connections—quarterly; ≤500 connections—annually *Not detected*—>500 connections—four quarterly samples every three years; ≤500 connections—four quarterly samples every five years	Repeat: *Detected*‡—>500 connections—quarterly; ≤500 connections—annually *Not detected*—>500 connections—four quarterly samples every three years; ≤500 connections—four quarterly samples every five years
Carbofuran					
Chlordane					
Dibromochloropropane					
2,4-D					
Ethylene dibromide					
Heptachlor					
Heptachlor epoxide					
Lindane					
Methoxychlor					
PCBs					
Pentachlorophenol					
Toxaphene					
2,4,5-TP (Silvex)					
Additional contaminants					
6 IOCs	Yes	No requirement	No requirement	One time only	One time only
23 SOCs	Yes	No requirement	No requirement	Four quarterly samples for one year	Four quarterly samples for one year
84 SOCs	No	No requirement	No requirement	State discretion	State discretion

NOTE: This table is a summary of the proposed monitoring requirements. Consult the proposed rule for a full description of requirements.
*Based on vulnerability assessment
†Detected = 0.0005 mg/L
‡Detected = method detection limit (MDL) as defined by USEPA

require the system to collect at least one sample as described in the rule.

Unfiltered surface water systems or systems using unfiltered groundwater under the direct influence of surface water must analyze one coliform sample each day the turbidity source water exceeds 1 ntu.

Analytical requirements. A 100-mL standard sample volume must be used in analyzing for total coliforms, regardless of the analytical method. Total coliform analyses may be conducted using the 10-tube multiple tube fermentation (MTF) technique, the membrane filter (MF) technique, the P-A coliform test, or the minimal media ONPG-MUG test (known commercially as the Colilert test).[30,31] The five-tube MTF technique (20-mL sample portions) or a single culture bottle containing MTF medium may also be used if a 100-mL water sample is used in the analysis.

Invalidation of positive samples. All positive total coliform samples count in compliance calculations, except for samples that are invalidated by the state. Invalidated samples, however, do not count toward the minimum monitoring frequency. States may invalidate samples only under three conditions:

(1) the analytical laboratory acknowledges that improper sample analysis caused the positive result,

(2) the system determines that the contamination is a domestic or other nondistribution system plumbing problem on the basis that any repeat sample taken at the same tap as the original positive sample is positive but all repeat samples at nearby sampling locations are negative, or

(3) the state has substantial grounds to believe that the positive result is because of some circumstance or condition not related to the quality of drinking water in the distribution system.

Because the distribution of coliform bacteria in the distribution system is not uniform, repeat samples alone are not adequate to determine the validity of a total-coliform-positive sample. States may not invalidate a total-coliform sample solely because a subsequent sample taken at the same site or nearby taps or service connections is total-coliform negative. The preceding condition 2 requires the state to determine whether or not the problem is in the distribution system as the basis of sample invalidation. States cannot invalidate a total-coliform-positive sample solely on the grounds that all repeat samples are coliform-negative. Whenever a total-coliform-positive sample is invalidated, the state must provide written documentation that includes the specific cause of the total-coliform-positive sample and that outlines what action the system has taken or will take in order to correct the problem.

Variances and exemptions. The total coliform rule does not allow for variances or exemptions.

Sanitary surveys. Periodic sanitary surveys are required for all systems that collect less than five samples per month. Initial sanitary surveys must be completed for community and noncommunity water systems by June 29, 1994, and June 29, 1999, respectively. Following the initial survey, subsequent surveys are required every five years for all

TABLE 18

Initial sampling requirements under the proposed SOC-IOC rule (Phase II)

Contaminant	Population Served	Sampling Completed *(Months after regulation is published in final form)*
IOCs (except asbestos)	All sizes	18
Asbestos	All sizes (if vulnerable)	60
VOCs	>10,000 people	18
	3,300-10,000 people	30
	<3,300 people	54
Pesticides, herbicides, and PCBs	All sizes (if vulnerable)	48
Additional (see Table 16)	All sizes (if vulnerable)	48

TABLE 19

BATs specified under the proposed SOC-IOC (Phase II) rule

Organics

Chemical	Treatment Technique: Granular Activated Carbon	Packed-Tower Aeration	Polymer Addition Practices
Acrylamide			X
Alachlor	X		
Aldicarb	X		
Aldicarb sulfone	X		
Aldicarb sulfoxide	X		
Atrazine	X		
Carbofuran	X		
Chlordane	X		
2,4-D	X		
Dibromochloropropane (DBCP)	X	X	
o-Dichlorobenzene	X	X	
cis-1,2-Dichloroethylene	X	X	
trans-1,2-Dichloroethylene	X	X	
1,2-Dichloropropane	X	X	
Epichlorohydrin			X
Ethylene dibromide (EDB)	X	X	
Ethylbenzene	X	X	
Heptachlor	X		
Heptachlor epoxide	X		
Lindane	X		
Methoxychlor	X		
Monochlorobenzene	X	X	
PCBs	X		
Pentachlorophenol	X		
Styrene	X	X	
2,4,5-TP (Silvex)	X		
Tetrachloroethylene	X	X	
Toluene	X	X	
Toxaphene	X		
Xylenes (total)	X	X	

Inorganics

Chemical	Treatment Technique	Chemical	Treatment Technique
Asbestos	Coagulation-filtration Direct and diatomite filtration Corrosion control	Mercury	Granular activated carbon Coagulation-filtration* Lime softening Reverse osmosis*
Barium	Ion exchange Lime softening Reverse osmosis	Nitrate-nitrite	Ion exchange Reverse osmosis
Cadmium	Ion exchange Reverse osmosis Coagulation-filtration	Selenium	Activated alumina Lime softening Coagulation-filtration (selenium IV only) Reverse osmosis
Chromium	Lime softening Coagulation-filtration Ion exchange Lime softening (chromium III only) Reverse osmosis		

*Mercury influent concentrations ≤10 μg/L

TABLE 20

Additional contaminants required to be monitored under the proposed SOC-IOC rule (Phase II)

Priority I Contaminants	Priority II Contaminants	
Organics	Ametryn	Ethion
Aldrin	Aspon	Ethoprop
Butachlor	Atraton	Ethylparathion
Carbaryl	Azinphos methyl	Etridiazole
2,4-DB	BCH-alpha	Famphur
Dalapon	BCH-beta	Fenamiphos
Dicamba	BCH-delta	Fenarimol
Dieldrin	BCH-gamma	Fenitrothion
Dinoseb	Bolstar	Fensulfothion
Hexachlorobenzene	Bromacil	Fenthion
Glyphosphate	Butylate	Fluridone
Hexachlorocyclopentadiene	Carboxin	Fonofos
3-Hydroxybarbofuran	Chlorneb	Hexazinone
Methomyl	Chlorobenzilate	Malathion
Metribuzin	Chloropropham	Merphos
Oxamyl (vydate)	Chloropropylate	Methyl paraoxon
PAHs	Chlorothalonil	Methyl parathion
Phthalates	Chloropyrifos	Mevinphos
Picloram	Coumophas	MGK 264
Simazine	Cycloate	MGK 326
2,3,7,8-TCDD (Dioxin)	DCPA	Molinate
2,4,5-T	4,4'-DDD	Napropamide
	4,4'-DDE	Norflurazon
Inorganics	4,4'-DDT	Pebulate
Antimony	Demeton-O	*cis*-Permethrin
Beryllium	Demeton-S	*trans*-Permethrin
Cyanide	Diazinon	Phorate
Nickel	Dichlofenthion	Phosmet
Sulfate	Dichloran	Prometon
Thallium	Dichlorvos	Prometryn
	Diphenamid	Pronamide
	Diquat	Propazine
	Disulfoton	Simetryn
	Disulfoton sulfone	Stirofos
	Disulfoton sulfoxide	Tebuthiuron
	EPN	Terbacil
	EPTC	Terbufos
	Endosulfan I	Terbutryn
	Endosulfan II	Triademefon
	Endosulfan sulfate	Tricyclazole
	Endothall	Trifluralin
	Endrin aldehyde	Vernolate

TABLE 21

Tentative MCLGs and MCLs for Phase V SOCs and IOCs (released by USEPA prior to proposal)

Contaminants	MCLG *mg/L*	MCL *mg/L*
Organics		
Dalapon	0.2	0.2
Di(ethylhexyl)adipate	0.5	0.5
Di(ethylhexpy)phthalate	zero	0.004
Dichloromethane (methylene chloride)	zero	0.005
Dinoseb	0.007	0.007
Diquat	0.02	0.02
Endothall	0.1	0.1
Endrin	0.002	0.002
Glyphosate	0.7	0.7
Hexachlorobenzene	zero	0.001
Hexachlorocyclopentadiene	0.05	0.05
Oxamyl (vydate)	0.2	0.2
PAHs [Benzo(a)pyrene]*	zero	0.0002
Picloram	0.5	0.5
Simazine	0.001	0.001
1,2,4-Trichlorobenzene	0.009	0.009
1,1,2-Trichloroethane	0.003	0.005
2,3,7,8-TCDD (Dioxin)	zero	5×10^{-8}
Inorganics		
Antimony	0.003	0.01/0.005†
Beryllium	zero	0.001
Cyanide	0.2	0.2
Nickel	0.1	0.1
Sulfate	400	400
Thallium	0.0005	0.002/0.001†

*USEPA is considering establishment of MCLGs and MCLs for six additional PAHs classified as probable human carcinogens: benz(a)anthracene, benzo(b)fluoranthene, benzo(k)-fluoranthene, chrysene, dibenz(a,h)anthracene, and indenopyrene.

†USEPA is considering proposing two MCLs based on five or 10 times the minimum detection limit.

systems except noncommunity water systems that use protected and disinfected groundwater, in which case sanitary surveys are required every 10 years.

Fecal coliforms, E. coli, and heterotrophic plate count. A fecal coliform analysis is required on each total-coliform-positive routine or repeat sample culture. Analysis for *E. coli* may be done in place of fecal coliform. If fecal coliform or *E. coli* is detected, notification of the state is required.

States may allow water systems, on a case-by-case basis, to forego fecal coliform or *E. coli* testing on samples positive for total coliform if the system treats every sample positive for total coliform as if it contained fecal coliforms. Also, state invalidation of the routine total-coliform-positive sample automatically invalidates a subsequent positive fecal coliform or *E. coli* result on that sample.

Heterotrophic bacteria can interfere with total coliform analyses. If any one of the following three situations occurs and total coliforms are not detected, the sample is invalid:

(1) a turbid culture with no gas production using the MTF technique,

(2) a turbid culture in the absence of an acid reaction using the P-A test, or

(3) confluent growth or a colony number that is "too numerous to count" using the MF technique.

For each invalid sample, a system must take a replacement sample from the same location as the invalid sample within 24 hours of being notified of the result. If a sample has evidence of interference by heterotrophic bacteria (any one of the preceding three situations) but is positive for total coliform, the sample is considered valid.

Compliance requirements. If more than 5 percent of the monthly samples (routine plus repeats) test positive for total coliform for systems analyzing at least 40 samples per month, the system is out of compliance. If more than one sample per month tests positive for total coliform for systems analyzing less than forty samples per month, the system is out of compliance.

If a routine total-coliform-positive sample tests positive for fecal coliform or *E. coli*, the repeat sample is positive for total coliforms, and the original sample is not invalidated, the system is in violation of the MCL. In addition, if a routine total-coliform-positive sample tests negative for fecal coliform or *E. coli* and any repeat sample is negative for fecal coliform or *E. coli*, the system is in violation of the MCL. Both of these situations represent a tier 1, acute MCL violation that would trigger appropriate public notification (Table 7).

Compliance issues. All public water systems must meet the revised final coliform MCL and monitoring requirements 18 months after promulgation,

i.e., Dec. 31, 1990. Current rules remain in force until that date. (Utilities are encouraged, however, to begin now to evaluate the effects of the rule on their operations and transition to P-A testing.)

Some water utilities have a concern that violation of the total coliform rule does not necessarily correspond to a demonstrable public health risk. AWWA filed a petition to review the rule in the US Court of Appeals for the District of Columbia and also requested USEPA to reconsider the rule.[32] As of press time (December 1989), AWWA was negotiating with USEPA to ascertain whether a refinement of the rule that satisfies the industry's concerns while providing public health protection and appropriate public notification is feasible.

Lead and copper rule

Requirements to minimize lead and copper in drinking water were proposed Aug. 18, 1988.[33] When finalized, these regulations will affect all community water systems and nontransient, noncommunity water systems, regardless of size. The USEPA held three public hearings and received approximately 3,000 comments on the proposed rule, including numerous inquiries from members of Congress. Publication of the final rule is scheduled for November 1990.

Major provisions. Key provisions of the proposed rule are summarized in Table 15.[32] The proposal includes a 0.005-mg/L lead MCL at the entry point to the distribution system. In addition, the proposal contains a treatment technique requirement that would mandate optimal corrosion control to minimize lead and copper as corrosion by-products as well as public education so consumers can reduce exposure. The treatment technique would be triggered by various no-action levels. If these levels are met, no action would be required.

Compliance issues. Compliance issues surrounding this rule include the location at which monitoring should be required (i.e., tap or plant), the level at which the MCL should be set, and whether the rule should include mandatory lead-service-line replacement. The potential economic and legal effects of this rule on water utilities are significant.

A significant issue surrounding this rule is whether an MCL should be established at the consumer's tap. USEPA included in the proposed rule a lengthy discussion of why an MCL at the tap could not be proposed. The agency requested and received comments on the MCL-at-the-tap option—both for and against. A final decision on the regulatory approach has not been made, although USEPA is considering an MCL for lead at the tap. A lead level of 0.015 mg/L has been suggested as achievable, but the specific level has not yet been established. Because this issue was discussed in the proposed rule, USEPA does not plan to repropose the rule if the MCL-at-the-tap option is adopted.

To assist utilities in implementation of this rule, USEPA is developing guidance manuals for corrosion control,[34] public education, and monitoring. In addition, the AWWA Research Foundation (AWWARF) has prepared a guidance manual on lead control strategies.[35] This manual, scheduled to be available in 1990, includes specific strategies and case studies to assist water utilities in controlling lead.

Synthetic organic and inorganic chemicals rule (Phase II)

USEPA proposed regulations for 30 SOCs and 8 inorganic chemicals (IOCs) May 22, 1989.[36] Most of the RMCLs for SOCs and IOCs proposed Nov. 13, 1985,[37] were reproposed as MCLGs May 22, 1989,[36] along with corresponding MCLs. Some changes to the RMCLs proposed in 1985, however, have been made in the current proposal based on updated health effects information. Public comment closed Aug. 21, 1989, and the final rule is scheduled for December 1990.

Major provisions. Table 16 lists the proposed MCLGs and MCLs for the 30 SOCs and 8 IOCs. An MCLG and MCL for total nitrate plus nitrite of 10 mg/L is proposed, plus individual MCLGs and MCLs for them. Questions about the carcinogenic potential of styrene resulted in the proposal of two alternative MCLGs and MCLs. A single MCLG and MCL

TABLE 22

Candidate disinfectants and by-products for regulation under the D-DBP rule

- **Chlorination by-products**
  - Chlorophenols
    - 2-Chlorophenol
    - 2,4-Dichlorophenol
    - 2,4,6-Trichlorophenol
  - Cyanogen chloride
  - Haloacetic acids
    - Dibromoacetic acid
    - Dichloroacetic acid
    - Monobromoacetic acid
    - Monochloroacetic acid
    - Trichloroacetic acid
  - Haloacetonitriles
    - Bromochloroacetonitrile
    - Dibromoacetonitrile
    - Dichloroacetonitrile
    - Trichloroacetonitrile
  - Haloketones
    - 1,1-Dichloropropanone
    - 1,1,1-Trichloropropanone
  - MX [3-chloro-4-(Dichloromethyl)-5-hydroxy-2(5H)furanone]
  - N-Organochloramines
  - Other
    - Chloral hydrate
    - Chloropicrin
  - Trihalomethanes
    - Bromodichloromethane
    - Bromoform
    - Chloroform
    - Dibromochloromethane
- **Disinfectants**
  - Chloramine
    - Ammonia
  - Chlorine
    - Hypochlorite ion
    - Hypochlorous acid
  - Chlorine dioxide
    - Chlorate
    - Chlorite
- **Ozonation by-products**
  - Inorganics
    - Bromate
    - Chlorate
    - Hydrogen peroxide
    - Iodate
  - Organics (major groups)
    - Aldehydes (formaldehyde, acetaldehyde, hexanol, and heptanal)
    - Bromine-substituted compounds
    - Epoxides
    - Ketones
    - N-Oxy compounds
    - Nitrosamines
    - Organic acids
    - Peroxides
    - Quinones (polyhydroxyphenols)

will be selected based on further review of health effects data and information received during the comment period.

The proposal includes revisions to existing NIPDWR MCLs for several contaminants. MCLs for barium, chromium, selenium methoxychlor, and 2,4,5-TP (Silvex) are proposed to be increased. The MCLs for cadmium, 2,4-D, and lindane are proposed to be decreased. In addition, removing silver from the primary regulations and placing it on the list of secondary regulations has been proposed.

Treatment techniques are proposed for acrylamide and epichlorohydrin because of the lack of reliable analytical methods. These compounds are impurities found in certain water treatment chemicals, such as coagulant aids. Each public water system would have to certify annually that the chemicals it uses do not exceed specified levels based on dosage and percentage of the compound in the coagulant aid or other chemical.

TABLE 23
Key points of the D-DBP strawman rule

A. MCLGs and MCLs to be set for selected contaminants and disinfectants:
  1. Most likely
    a. Total trihalomethanes (TTHMs)
    b. Haloacetic acids
    c. Chloride dioxide, chlorite, chlorate
    d. Chlorine and chloramine
  2. Potential additional contaminants
    a. Chloropicrin
    b. Cyanogen chloride
    c. Hydrogen peroxide, bromate, iodate
    d. Formaldehyde
  3. MCL for TTHM of 50 or 25 μg/L
  4. Other MCLs based on analyses of feasibility similar to those conducted for TTHMs
B. Treatment technique requirements or guidance provided for selected surrogate parameters:
  1. MX (as a surrogate for mutagenicity)
  2. Total oxidizing substances (as a surrogate for organic peroxides and epoxides)
  3. Assimilable organic carbon (AOC) (as a surrogate for microbiological quality of oxidized waters)
C. Monitoring required based on treatment:

Treatment Process	Monitoring Parameters Under Consideration
Chlorination	TTHMs Haloacetic acids Total organic halides Total oxidizing substances Chloropicrin Cyanogen chloride Total chlorine residual
Chloramination	TTHMs Chloropicrin Cyanogen chloride Total chloramine residual
Chlorine dioxide	Total oxidizing substances Chlorine dioxide Chlorite Chlorate
Ozonation	Formaldehyde Total oxidizing substances Bromate Iodate Hydrogen peroxide

NOTE: Consideration is being given to possibly reducing monitoring requirements to one sample per quarter at system discretion or one per year at state discretion based on system history.

D. BAT established
  1. Precursor removal techniques (50 percent removal of TTHM formation potential)
    a. Conventional treatment modifications
    b. GAC adsorption with up to 30 minutes' empty bed contact time and regeneration every 3 months
    c. GAC adsorption is not universally feasible because of water quality conditions.
    d. Membrane processes may not be BAT because of lack of full-scale experiences.
  2. Alternative oxidants
    a. MCL values for disinfectants must be met.
    b. Chlorine dioxide with chlorite residual removal and chloramines
    c. Ozone plus chloramines
    d. Initial estimate is that a TTHM MCL of 25 μg/L is the lowest that allows continued use of free chlorine.
  3. By-product removal
    a. Stripping (possible for some contaminants)
    b. GAC adsorption (not for most chlorination by-products; effectiveness for ozone by-products unknown)
    c. Reducing agents for MX, total oxidizing substances, possible chloropicrin and cyanogen chloride
    d. Reducing agents or free chlorine for hydrogen peroxide
    e. Caveat regarding ozone use with possible future need for post-GAC adsorption treatment for controlling AOC or removal of other by-products.

Monitoring requirements. Proposed monitoring requirements for community systems are summarized in Table 17. Vulnerability assessments, conducted by the state, play a key role in determining the frequency of monitoring for SOCs and asbestos. Assessments are intended to determine the likelihood that a water system might be subject to contamination from SOCs or asbestos. Vulnerability analyses are to be completed by the states within 18 months after the final regulation is published.

Monitoring frequency varies depending on system size and whether contaminants are detected during initial sampling. For asbestos, nitrate, and nitrite, monitoring frequency depends on the percentage of contaminant detected compared with the MCL. Samples for nitrate, nitrite, herbicides, pesticides, and polychlorinated biphenyls (PCBs) must be taken during periods when the likelihood of contamination is highest. Initial sampling must be completed according to the schedule proposed in Table 18.

BAT. Specified BATs for the contaminants included in the proposed rule are listed in Table 19. GAC adsorption and packed-tower stripping are designated in the rule as BAT for SOCs. As mentioned earlier, GAC adsorption was specified as BAT for SOCs in the 1986 SDWA amendments.

Compliance requirements. Compliance is based on an annual running average for each sample point for systems monitoring quarterly or more frequently. For systems monitoring annually or less frequently, compliance is based on a single sample unless the state requests a confirmation sample. For nitrate and nitrite, if the first sample exceeds the MCL, another sample is required within 24 hours. Compliance is based on the average of the two samples.

Additional contaminant monitoring. Monitoring for 113 additional contaminants is proposed by USEPA (Table 20). Monitoring for 29 contaminants (designated priority 1 contaminants) would be determined by a vulnerability analysis conducted by the state. Monitoring for the remaining 84 priority 2 contaminants is at the discretion of the state. Water systems required to monitor must complete monitoring within four years after publication of the final rule.

SMCLs. Proposed SMCLs are included in Table 3. The proposed SMCLs for the organic chemicals are lower than the

respective MCLs because the contaminants cause tastes or odors in water at the lower levels. This point is significant because in some states SMCLs are enforceable regulations.

Compliance issues. The proposed SOC-IOC (Phase II) rule becomes effective 18 months after the regulation is published in its final form. The final rule is currently scheduled for January 1991.

The proposed rule gives states flexibility to determine whether a public water system is vulnerable to pesticide contamination. USEPA solicited comments on an alternative approach that would assume all utilities to be vulnerable until sufficient monitoring by the supplier proves otherwise. The alternative approach would lessen the work load for state programs because vulnerability assessments would not be required, but monitoring requirements for water suppliers would be greater. In either case, the rule will place an increased burden on laboratory capabilities.

SOCs and IOCs (Phase V)

The Phase V rule will set regulations for 24 of the last 25 contaminants of the 83 mandated for regulation by the SDWA. The final statutory deadline for this regulation was June 19, 1989, but the current schedule calls for publishing of the proposed rule by June 1990. The final rule is scheduled for March 1992.

Major provisions. USEPA has released tentative MCLGs and MCLs for the 18 SOCs and 6 IOCs currently scheduled for inclusion in the rule (Table 21).[38] An SMCL for hexachlorocyclopentadiene is also being considered (Table 3). Arsenic, originally included on the Phase V list, was removed because of unresolved issues concerning its carcinogenicity classification, and it will be regulated separately.

Compliance issues. Compliance issues for the Phase V SOCs-IOCs will parallel the Phase II SOC-IOC rule issues. Of particular concern with Phase V is the lack of occurrence data for many of these contaminants. USEPA is constrained by the language of the SDWA as amended to regulate the contaminants listed, regardless of occurrence. Compliance monitoring will likely be required at some minimum frequency. Note that many of the organic contaminants listed are included as additional contaminants for monitoring under the VOC rule (Phase I) and SOC-IOC rule (Phase II).

Radionuclide rule (Phase III)

An ANPRM for radionuclides was originally published Oct. 5, 1983,[7] and a second ANPRM was published Sept. 30, 1986.[39] A proposed rule is scheduled for September 1990 and the final rule for June 1992.

Major provisions. The radionuclide rule will establish MCLGs and MCLs for radon-222, radium-226, radium-228, natural uranium, and beta particle and photon emitters. All of the radionuclides are classified as known human carcinogens, and MCLGs will be set at zero. Noncancerous effects of natural uranium are also of concern and an MCLG between 20 and 40 pCi/L is being considered.[40] MCLs currently (December 1989) being considered are[40]

- radon—200 to 2,000 pCi/L,
- radium-226—5 pCi/L,
- radium-228—5 pCi/L,
- uranium—20 to 40 pCi/L, and
- beta particle and photon emitters—4 mrem.

As with other rules, the proposed regulation will include monitoring requirements, designation of BAT, public notification requirements, and variance and exemption criteria, if allowed. Public education will likely be included in the proposed rule.

Compliance issues. A variety of compliance issues will be raised once MCLGs and MCLs are officially proposed. The radon rule will be particularly significant because it could affect up to 30,000 groundwater supplies, depending on the MCL level that is determined. Monitoring, BAT, and particularly waste disposal will be addressed for all of the radionuclides included in the rule.

Disinfection-disinfection by-products rule (Phase VIa)

The disinfection-disinfection by-product (D-DBP) rule satisfies several requirements of the 1986 SDWA amendments. The amendments require USEPA to regulate 25 additional contaminants, beyond the original 83, every three years beginning in 1991. Candidate contaminants for regulation are to be taken from the DWPL, which includes disinfectants and a variety of DBPs. Contaminants regulated under the D-DBP rule will satisfy a portion of the regulatory requirement. The balance of the 25 contaminants required to be regulated will be covered in a separate rule, to be known as Phase VI.

Section 1412(b)(8) requires USEPA to set mandatory disinfection regulations for all public water systems. Disinfection of surface water is covered in the SWTR. The agency will include mandatory disinfection requirements for groundwater in the D-DBP rule.

Agency activity on this rule began in the spring of 1989. USEPA developed a strawman proposal outlining its initial thinking on the rule. The strawman proposal,[41] dated Sept. 22, 1989, was first presented to the Science Advisory Board October 11 and was the subject of a public workshop December 4. The D-DBP rule is expected to be proposed in late 1991 and promulgated in 1993.

Strawman D-DBP rule. USEPA developed the strawman rule to serve as a basis for discussion and to seek input from the affected parties early in the rule-making process. A working list of disinfectants, chlorination by-products, and ozonation by-products has been developed (Table 22). MCLs or treatment technique requirements could be established for some or all of the contaminants listed. USEPA has tentatively determined that the most cost-effective regulatory approach would be to set MCLs for a few contaminants that would serve as surrogates of the overall chemical safety of the water, similar to the existing TTHM standard methodology.

Key elements of the D-DBP strawman rule are summarized in Table 23. Because full support documentation is not available, the information in the rule is limited. For example, draft MCLGs have been calculated for most contaminants, but health effects information for some is incomplete. MCLG numbers were not available for discussion. A number of health, occurrence, analytical, and treatment issues are unresolved.[41]

The major thrust of the D-DBP rule will be monitoring requirements and MCLs designed to reduce human exposure to disinfectants and their by-products. This will be done by changing water treatment practice. Although not included in USEPA's strawman proposal, regulations governing disinfection of groundwater will also be included in the rule, with variances allowed for good-quality source waters.

Compliance issues. The D-DBP rule will likely be the most complex regulation. USEPA is welcoming participation in formulation of the rule and AWWA's D-DBP Technical Advisory Workgroup is actively involved.[42]

An important compliance consideration with the D-DBP rule will be how it interfaces with other rules. For example, the SWTR includes *CT* values, turbidity requirements, and minimum disinfectant residual requirements. The proposed lead and copper rule included pH adjustment to >8, which favors TTHM formation. For free chlorine, higher *CT* values are required at higher pH values to achieve equivalent disinfection. In addition, water utilities will be required to meet the mandatory disinfection requirements and the total coliform rule while at the same time meeting restrictions placed on disinfectant application by the D-DBP rule.

Planning for compliance

The stream of new drinking water quality regulations necessitates short- and long-term planning by water utilities for compliance. Some rules are in effect now, whereas others have tentative schedules. Schedules for future rules are subject to change but all will have a significant effect on utility operations. A variety of resources are being developed

to assist water utilities in complying with new regulations.

The 1986 SDWA amendments gave USEPA the authority to enforce regulations by administrative orders. In addition, USEPA was granted authority to collect administrative penalties. USEPA has placed a high emphasis on enforcement activities, and enforcement actions will be taken against significantly noncompliant facilities and facilities that cause a public health threat. Further, the 1986 SDWA amendments authorized any person to sue an alleged violator of any requirement of the SDWA or its regulations, and regulations governing citizen suit notices have been promulgated.[43] Water utilities must work with their state primacy agencies to ensure that actions taken to meet current and future regulations coincide with actual effective dates for new regulations.

The new regulations will place a particularly heavy burden on state drinking water programs, which have the major responsibility for implementation and enforcement. States must adopt regulations no less stringent than federal regulations to retain primacy;[44] some states will have more stringent requirements. A study by the Association of State Drinking Water Administrators and USEPA identified a current annual shortfall in funding for state programs of $32 million nationally.[45] The report also estimated that implementing the 1986 SDWA amendments will require an additional $131 million. The states and USEPA are now beginning to confront the magnitude of the problem of inadequate state resources. In addition to addressing their own resource needs for meeting SDWA regulations, water utilities must be sensitive to the needs of their state primacy agencies and actively support adequate funding mechanisms for state drinking water programs.

New water quality regulations will require drinking water suppliers to carefully evaluate, optimize, and perhaps change current water treatment practices. Drinking water suppliers must stay informed about proposed and anticipated regulations and plan accordingly for compliance with promulgated regulations, so that the public they serve may benefit from drinking tap water of unquestionable quality.

Acknowledgment

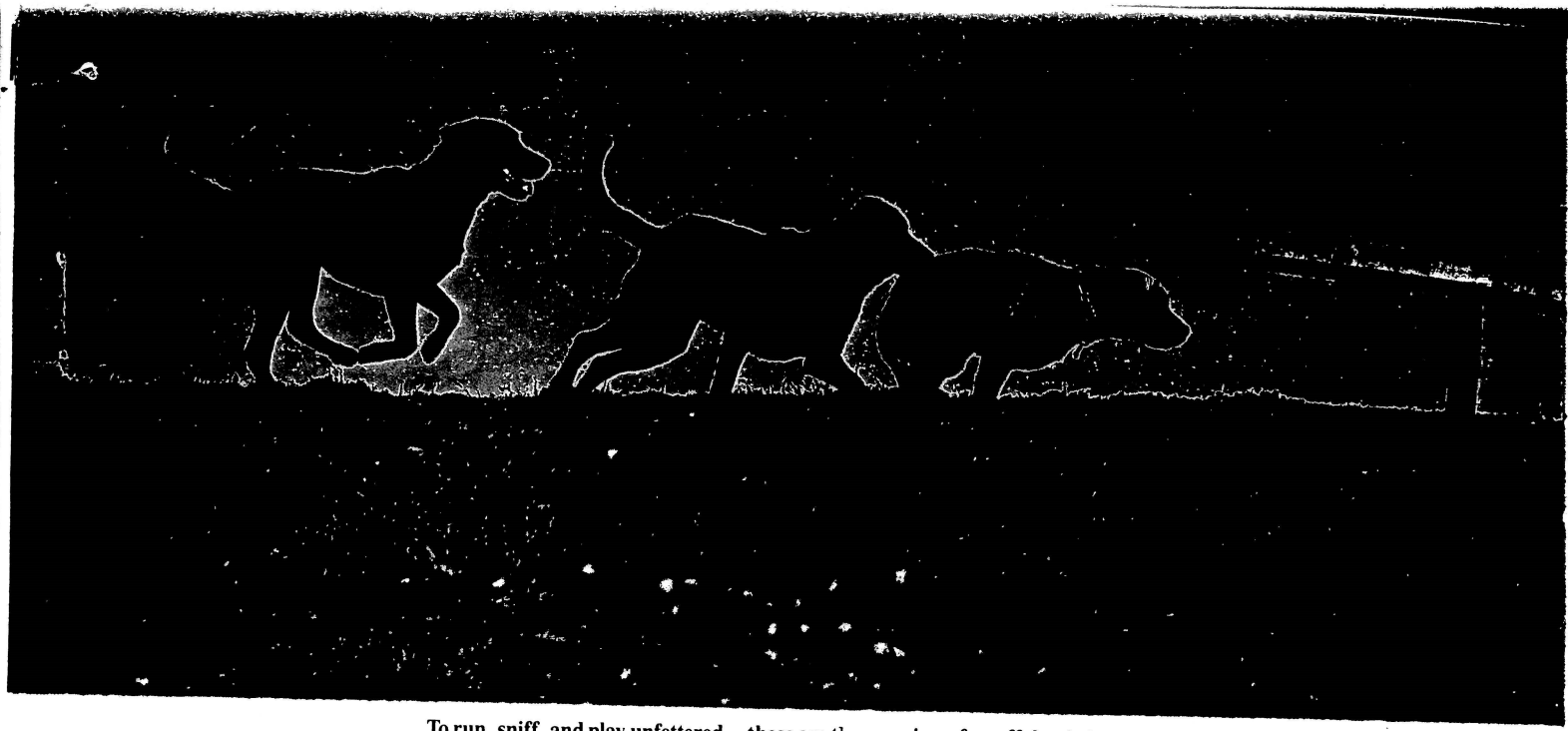
The author thanks James M. Symons, University of Houston, and Joseph A. Cotruvo and the staff of the Criteria and Standards Division, USEPA Office of Drinking Water, for their reviews and helpful suggestions.

References

1. Public Law 93-523. Safe Drinking Water Act. (Dec. 16, 1974).
2. National Secondary Drinking Water Regulations. Proposed Rule. *Fed. Reg.*, 42:62:17143 (Mar. 31, 1977).
3. National Secondary Drinking Water Regulations. Final Rule. *Fed. Reg.*, 44:140:42195 (July 19, 1979).
4. Fluoride. Final Rule. *Fed. Reg.*, 51:63: 11396 (Apr. 2, 1986).
5. Public Law 99-339. Safe Drinking Water Act Amendments of 1986. (June 19, 1986).
6. Advanced Notice of Proposed Rulemaking. Volatile Synthetic Organic Chemicals. *Fed. Reg.*, 47:43:9350 (Mar. 4, 1982).
7. Advanced Notice of Proposed Rulemaking. Synthetic Organic Chemicals, Inorganic Chemicals, Microbials. *Fed. Reg.*, 48:45502 (Oct. 5, 1983).
8. Proposed Substitution of Contaminants and Proposed List of Additional Substances Which May Require Regulation Under the Safe Drinking Water Act. *Fed. Reg.*, 52:130:25720 (July 8, 1987).
9. Substitution of Contaminants and Drinking Water Priority List. *Fed. Reg.*, 53:14: 1892 (Jan. 22, 1988).
10. Public Notification. Final Rule. *Fed. Reg.*, 40:59570 (Dec. 24, 1975).
11. Public Notification. Final Rule. *Fed. Reg.*, 52:208:41534 (Oct. 28, 1987).
12. Public Notification. Technical Amendments. *Fed. Reg.*, 54:72:15185 (Apr. 17, 1989).
13. Public Notification Handbook for Public Water Systems. USEPA Ofce. of Drinking Water. EPA-570/9-89-002. Washington, D.C. (Sept. 1989).
14. Volatile Synthetic Organic Chemicals. Proposed Rulemaking. *Fed. Reg.*, 49:114: 24330 (June 12, 1984).
15. Volatile Synthetic Organic Chemicals. Final Rule. *Fed. Reg.*, 50:219:46880 (Nov. 13, 1985).
16. Volatile Synthetic Organic Chemicals Proposed Rule. *Fed. Reg.*, 50:219:46902 (Nov. 13, 1985).
17. Volatile Synthetic Organic Chemicals; Para-Dichlorobenzene. Proposed Rule. *Fed. Reg.*, 52:74:12876 (Apr. 17, 1987).
18. Volatile Synthetic Organic Chemicals. Final Rule. *Fed. Reg.*, 52:130:23690 (July 8, 1987).
19. Volatile Synthetic Organic Chemicals. Final Rule Correction. *Fed. Reg.*, 53:127: 25108 (July 1, 1988).
20. Fluoride. Proposed Rulemaking. *Fed. Reg.*, 50:93:20164 (May 14, 1985).
21. Fluoride. Final Rule. *Fed. Reg.*, 50:220: 47142 (Nov. 14, 1985).
22. Fluoride. Proposed Rulemaking. *Fed. Reg.*, 50:220:47156 (Nov. 14, 1985).
23. Fluoride. Final Rule. *Fed. Reg.*, 51:63: 11396 (Apr. 2, 1986).
24. *Water Fluoridation—A Training Course Manual for Engineers and Technicians* (Thomas G. Reeves, editor). Centers for Disease Control, Atlanta, Ga. (Sept. 1986).
25. Filtration and Disinfection; Turbidity, *Giardia lamblia*, Viruses, *Legionella*, and Heterotrophic Bacteria. Proposed Rule. *Fed. Reg.*, 52:212:42178 (Nov. 3, 1987).
26. Filtration and Disinfection; Turbidity, *Giardia lamblia*, Viruses, *Legionella*, and Heterotrophic Bacteria. Final Rule. *Fed. Reg.*, 54:124:27486 (June 29, 1989).
27. Guidance Manual for Compliance with the Surface Water Treatment Requirements for Public Water Systems. Criteria and Standards Div., USEPA Ofce. of Drinking Water, Washington, D.C. (Nov. 1989; available from NTIS).
28. Total Coliforms. Proposed Rule. *Fed. Reg.*, 52:212:42224 (Nov. 3, 1987).
29. Notice of Availability. Total Coliforms. *Fed. Reg.*, 53:88:16348 (May 6, 1988).
30. Total Coliforms. Final Rule. *Fed. Reg.*, 54:124:27544 (June 29, 1989).
31. Analytical Techniques: Coliform Bacteria. Final Rule. *Fed. Reg.*, 54:135:29998 (July 17, 1989).
32. Update. *Jour. AWWA*, 81:10:15 (1989).
33. Lead and Copper. Proposed Rule. *Fed. Reg.*, 53:160:31516 (Aug. 18, 1988).
34. Draft Corrosion Control Guidance Manual for Lead and Copper for Public Water Systems. Science and Technology Branch, Criteria and Standards Div., USEPA Ofce. of Drinking Water, Washington, D.C. (Mar. 24, 1989).
35. *Lead Control Strategies Guidance Manual.* AWWA Res. Fdn., Denver, Colo. (in press).
36. National Primary and Secondary Drinking Water Regulations. *Fed. Reg.*, 54:97: 22062 (May 22, 1989).
37. Synthetic Organic Chemicals and Inorganic Chemicals. Proposed Rule. *Fed. Reg.*, 50:219:46936 (Nov. 13, 1985).
38. Phase V Status Report. USEPA Ofce. of Drinking Water, Washington, D.C. (Oct. 10, 1989).
39. Radionuclides. Advance Notice of Proposed Rulemaking. *Fed. Reg.*, 51:189: 34836 (Sept. 30, 1986).
40. Status of the Radionuclides Proposal. USEPA Ofce. of Drinking Water, Washington, D.C. (June 1989).
41. Discussion of Strawman Rule for Disinfectant and Disinfection By-Products. Criteria and Standards Div., USEPA Ofce. of Drinking Water, Washington, D.C. (Sept. 22, 1989).
42. McGuire, M.J. Preparing for the Disinfection By-Product Rule: A Water Industry Status Report. *Jour. AWWA*, 81:8:35 (Aug. 1989).
43. Notice Requirements for Citizen Suits Under the Safe Drinking Water Act. Final Rule. *Fed. Reg.*, 54:91:20770 (May 12, 1989).
44. Primacy Requirements. Final Rule. *Fed. Reg.*, 54:243:52126 (Dec. 1989).
45. State Costs of Implementing the 1986 SDWA Amendments. Assn. of State Drinking Water Administrators and USEPA Ofce. of Drinking Water, Washington, D.C. (Feb. 1989).



About the author: *Frederick W. Pontius is regulatory engineer at AWWA, 6666 W. Quincy Ave., Denver, CO 80235. A graduate of the University of Colorado (Boulder) with BS (civil engineering) and MS (sanitary engineering) degrees, Pontius has been with AWWA since 1982. In his current position, Pontius monitors and evaluates legislation and regulations that affect the water industry. He prepares official AWWA statements on drinking water issues and represents the association at meetings, workshops, and study groups. His work has been published previously by* JOURNAL AWWA *and* Journal WPCF.



To run, sniff, and play unfettered—these are the promises of an off-leash dog park.

Off-Leash Havens, Canine Heavens

By Candace Crane Photographs by Robert F. Campbell

"MARCH "ANIMALS" MARCH/APRIL

Off-leash dog parks—where canines (and their owners) are free to frolic.

On any given Sunday morning, it is truly a dog heaven. Forty or 50 dogs, all shapes and sizes, romp happily off-leash but under their owners' voice control. Some chase each other in games of tag over the grassy hillocks. Others amble with their owners down a path, stopping on occasion to greet a canine friend or climb on the rocks that lead down to a canal. There, the retrievers are in the swim of things, jumping and diving and fetching sticks. Everywhere clumps of people are socializing while their dogs do likewise. Two four-month-old pups wrestle in childlike exuberance, and Artie, a basenji mix who's one of the regulars here, tries to entice her play-tired owner to throw her super-deluxe frisbee for the hundredth time.

The place is Point Isabel, a park that hugs the eastern shore of San Francisco Bay. Since 1984 the leash law has been formally suspended here, and while the point's expansive 21 acres makes it the single largest off-leash pet playground, it's only one of many springing up. From Los Angeles to Boston, communities are increasingly being asked to provide places for dog owners to exercise their pets off-leash.

The trend began in the mid-1970s. As urban populations increased, the open space available to dog owners began to dwindle, and, as it did, conflicts with the general public became more frequent. Owners who let pets chase joggers or didn't clean up their animals' droppings gave rise to increasing anticanine sentiment and stiffer leash laws. Some places banned dogs entirely.

This was no answer for a sizeable number of people; 17 to 40 percent of an average community's households have dogs, many of whose owners feel strongly about exercising their pets off-leash. The San Francisco Bay Area city of Palo Alto recognized the need for a better answer, and when it toughened its leash law in 1974, it also went looking for places to establish dog-exercise areas. Palo Alto animal-control director Greg Betts says, "It's one thing to come down heavily on dog owners, but you have to have a humane alternative."

Thus were born the first four off-leash areas. Since then, 25 others have sprung up in the San Francisco area, with 3 more in the works. Los Angeles; Austin, Texas; Toledo, Ohio; and Arlington and Alexandria, Virginia, have also sprouted dog parks; and Bloomington, Indiana, will soon burst forth with its first. These areas have been the answer for everyone—dogs, dog owners, *and* their communities. Everywhere they're being tried they're working well and are so heavily used that several cities say they need more.

Veterinarian and behaviorist Ian Dunbar, who takes his pets to the Berkeley, California, off-leash dog park, says there are both physical and mental aspects to exercise and that while most dogs need more aerobic exercise, the biggest benefit of off-leash play to dogs lies in the mental exercise it provides. "Saying dogs can get enough exercise on-leash is like saying humans can get enough exercise walking to work," insists Dunbar. "It's nice to occasionally have a game of squash." As for humans, so for dogs. "It's a quality-of-life issue," he continues. "If all the dog is used to is being walked on-leash, it doesn't know anything else and is perfectly happy. But if it has ever had the chance to play off-leash with other dogs or even to sniff another dog, it's definitely going to miss the mental exercise of running around and interacting with other animals

and people."

Dog parks are one way to socialize dogs so they *can* have healthy interactions, according to Dunbar, who developed the first temperament-training course for puppies done entirely off-leash. His Sirius Puppy Training philosophy, emphasizing socialization, has spread to many puppy classes across the country. "Owners must realize," Dunbar says, "their dogs will not automatically grow up to be like Lassie." Dogs learn not to bite, not to fight, and not to be fearful by playing, and these lessons are learned between three and a half and six months of age. After that it's too late, stresses Dunbar. Taking a puppy to a dog park to play with other dogs and meet a variety of people in a positive situation can be the foundation of good social skills for life.

Dog parks provide a recreational and social outlet for dog owners, too. Doris Richards, Berkeley dog park association president, sums it up, "They're as good for people as they are for dogs." Many dog owners feel like second-class citizens in their communities, unwelcome anywhere with what may be, especially for single and older people who are alone, their closest friend. In a dog park, owners feel not only welcome, but well-liked by people with similar interests. Friendships form easily as people chat about everything.

New dog owners can find guidance and gain confidence here because it's responsible, usually veteran, dog owners who use dog parks. As Betts says, "The irresponsible owners, with their unmanageable dogs, are more commonly found on the city streets." People such as Richards are always eager to help spot and solve a behavior or health problem, recommend a veterinarian or trainer, or put a special brand of self-policing action on those who don't follow the rules.

Some people, for example, simply will not clean up after their dogs. Richards says the reasons are as diverse as being inconsiderate, ashamed, not knowing how, or, as one man even admitted, getting sick to his stomach from it. A few bring in aggressive dogs, also against the rules. "We really can't tell them to leave," says Richards, "because it's a public park. But we can all leave so they're alone." If a fight starts, which it rarely does, Richards says it can be stopped by both owners pulling their dogs by the tail, by swinging a leash between them, or by dousing the dogs with water.

Prevention, of course, is best. Veterinarian Amy Marder, consulting behaviorist for the Massachusetts Society for the Prevention of Cruelty to Animals (MSPCA), points out that people should know how their dogs behave around other dogs before trying an off-leash park. If a dog wasn't trained or socialized as a puppy, she recommends taking it to an obedience class first. "Get the advice of a good dog trainer," she counsels, and adds that spaying and neutering also help skirt trouble.

Encouraging such responsible pet ownership is one way dog parks are proving to be assets to their communities. They also increase public health and safety by containing dogs and their droppings, which can transmit certain diseases,

Carol Burnett, Bear, and Muffie enjoy time-out from an afternoon's activities at a table in California's Point Isabel dog park.



Dog Parks

and they make animal-control officers' jobs much easier by giving them an alternative to offer dog owners who exercise pets illegally off-leash. Animal-control directors Sandy Smith of Arlington and Jim Lang of Bloomington spearheaded their cities' dog parks for just this reason. Smith says since Arlington's three dog parks started, "The problem of people walking their dogs through neighborhoods off-leash has definitely decreased."

Sometimes dog parks benefit cities in unexpected ways. San Leandro, California, parks director Dennis Smith says his city was skeptical at first and challenged dog owners to prove themselves. They not only proved to be "very well organized, very well behaved, and good users of our parks," according to Smith, but they also brought national dog shows, with their publicity and revenue, to town. San Leandro is now in favor of dogs.

The biggest requirement for a successful dog park is that dogs and owners are safe and separated from the public. Size and location are also important. Betts says an area needs to be at least 100 by 200 feet to allow for activities like frisbee. He and others also believe it should be easily accessible.

"Going to a dog exercise area should not be a special event like taking the dog to the beach," says Betts. "It needs to be the daily alternative to opening the back door and turning the dog loose. If people have to get in the car and schlep the dog somewhere, they're not going to do it." Thus, Palo Alto and other cities have scattered their areas, tennis-court style, in neighborhood parks. Within the parks, the dog areas should be in out-of-the-way locations. San Francisco parks superintendent Ron DeLeon adds that he looks for areas that aren't heavily used for other special interests and never for those directly conflicting with dogs, such as baseball.

Beyond this and a few basics like water faucets and trash cans for the inevitable bags of dog droppings, dog parks are as diverse as their communities. Some are as large as four acres, others less than an acre. Some are fenced; others are unfenced areas marked with signs. Some are scattered; some—such as the one Bloomington is creating on property owned by B.F. Goodrich near the city's central park—are one special place for dogs and owners. Some are left *au naturel*; others, such as Canine Commons—which will open next spring in Larkspur, California—are being carefully landscaped.

The cost of establishing a dog park can range from the few hundred dollars Alexandria spent on signs for its 26 unfenced areas to the $2,500 dog owners in Brookline, Massachusetts, near Boston, requested for fencing to the $18,000 the Marin Humane Society helped Larkspur raise to develop Canine Commons from scratch. Some parks are run by structured dog-owner groups, such as Berkeley's, where 150 dues-paying members have a newsletter and meetings with guest speakers. In others, coalitions are informal.

The only snafu in dog parks seems to be getting them started. While some of the non-dog-owning public always raise some objections, the real resistance comes from city officials. One fear is that liability will increase. Lang says attorneys envisioned "dog packs ... and the worst scenario possible." But the facts are that 80 dog visits per day in Palo Alto—almost half a million since 1974—have not produced a single liability claim, while the city's swing sets account for about 168 cases annually. Further, a national computer search conducted by Brookline dog owners revealed no liability claims from dog parks anywhere. Lang says when Bloomington officials saw these statistics "they were shocked."

The biggest obstacle is often the attitude of parks officials. Some simply see dog owners as irresponsible people, and many think having a dog on-leash in a park makes an owner more likely to clean up droppings (actually the reverse is true). Another widespread view is that the problem of dogs belongs to animal control, not parks. However, it's people who want dog parks, and, as one city's planning commissioner notes, "This is a human-services issue. People have dogs, and their needs must be accommodated."

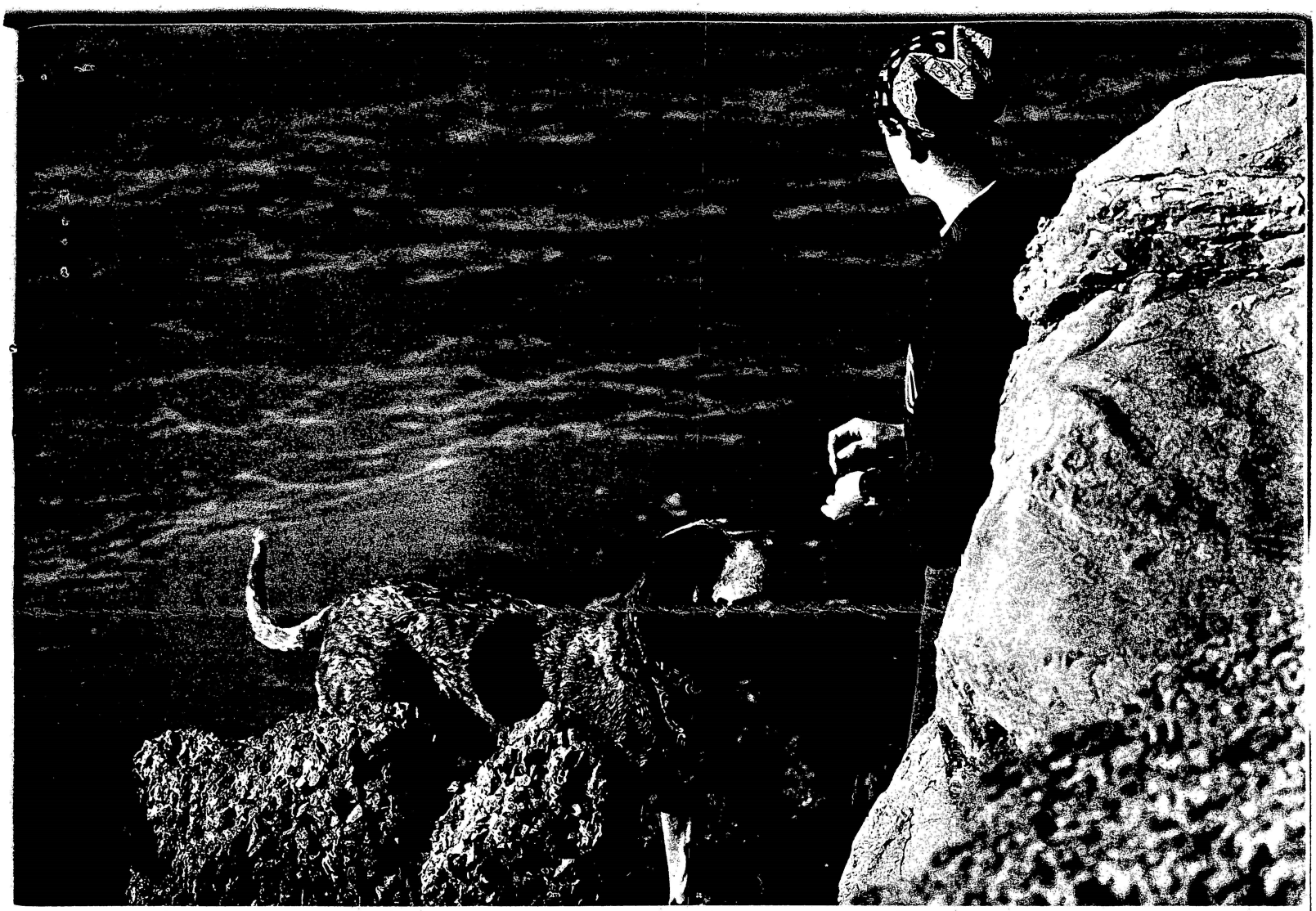
Dog owners are, in fact, often a larger special-interest group than some traditionally served by park districts. Elected officials often see this light, because while dogs don't pay taxes or vote, dog owners do. When the Bloomington parks board turned Lang down, the mayor caught him in the hall and said, "Let's assign a task force."

Animal-related issues are also often seen as unimportant. Berkeley animal-control director Kathy Flood says in a 1980 survey the nation's mayors revealed that animal problems accounted for their greatest number of complaints, but they rated animal control last among 50 budget priorities.

Such attitudes and the underfunded, sometimes inadequate, animal control that results can stop a dog park cold. In fact, it is where animal control is strong—well-funded,

Two dogs get acquainted at Point Isabel. Off-leash parks seem to attract responsible owners and well-behaved dogs and work best in communities with strong animal control.





A woman calls her dog back from a swim in an off-leash park.

adequately staffed, humane—that dog parks are succeeding. Where animal control is weak, such as in New York City and throughout Massachusetts, or where it is unsympathetic, as in the case of Los Angeles, dog-park efforts have had trouble. Boston, for example, has only two animal-control officers for 650,000 people. The MSPCA has worked for years to strengthen animal control statewide, but local policies and massive budget cuts have worked against it. Martha Armstrong, MSPCA director of animal-welfare and legislative issues, explains, "Dog parks combine the ideas of responsible pet ownership and animal control, and animal control is woefully underfunded in this state."

In Los Angeles, on the other hand, city reaction to dog-park efforts has been heavy-handed. Dog-owner association leader Jane Purse and four other dog owners set out in 1982 to restore, at their own expense, a 4.4-acre park in the Hollywood Hills that had become a hangout for drug dealers and gangs. Purse says the community never went near it. The fence was knocked down and trees were uprooted when the dog owners began work. In two years they had the grass growing and the vandals gone. Suddenly the city decided to develop the park. When dog owners continued to exercise their pets there, they were arrested and jailed for leash-law infractions. Growing to ranks of 1,000, they finally charged animal control with harassment and brutality. In the end, Purse says, they fought city hall and won, but had "one horrible time."

Sometimes dog owners add to the problem. In Brookline, Martha Bradford organized 50 dog owners and, with the help of the MSPCA, won the town's approval for a fenced area in one of the parks. However, the dog owners already using that park opposed the idea because they did not want to be restricted to one area. In New York City, organizer Corinne Standish says dog owners were unwilling to agree on a location and deserted the effort when they discovered the parks commissioner was already allowing off-leash hours in the park in lieu of fencing special areas. Standish says the situation now is unacceptable: unleashed dogs are fouling areas used for sunbathing and children's play; dog owners are demanding more off-leash hours; and an irate public feels it has lost its rights to the parks.

Where efforts to establish dog parks fail, dog owners often opt for continuing to break the leash law, a situation good for no one, least of all the dogs. The MSPCA's Armstrong says leash laws, like dog parks, perform an important humane function—that of keeping animals controlled, and therefore safer, than if they are roaming free among the public. The laws may be humane for dog owners, too; Bradford notes that without parks "we end up not only criminals, but broke." One woman she knows paid $300 in fines in a year.

Hopefully as the idea of dog parks is accepted, they can help solve the problems caused on all sides by off-leash pets and bring a bit more quality of life to everyone—including dogs.

Regular contributor Candace Crane drives her dogs to "dog heaven" on Sundays. She was also involved in an unsuccessful dog park effort in her Northern California community.

FRANK DUEHAY

Please continue to allow dogs to run off leash in the Fresh Pond Reservation. Our dogs are important to us and this place where they can be free to get the exercise and socialization they need is essential to our well-being as well as theirs. We are more than willing to work with you and the Water Board to try to solve the problem of dog waste in the Reservation and to resolve the conflicts between dog walkers and other users; and we feel sure that these problems can be solved without resorting to a ban on unleashed dogs.

DATE	NAME	ADDRESS
3/3/90	Abigail [illegible]	109 Grozier Rd
	Stephen [illegible]	" " "
3/3/90	[illegible]	48 BRASTON AVE SOMERVILLE
3/3/90	Gary Swift	Topanga, California
3/3 90	Maureen Hanlon	121 Appleton St Cambridge
3/3/90	Barbara Minges	103 Raymond Ave Somerville
3/4/90	[illegible]	324 [illegible] Street Cambridge
3/4/90	[illegible]	20 [illegible] Camb. 02139
3/4/90	[illegible]	3½ [illegible] St. Camb. 02138
3.4.90	Melissa Weber	87 Washington Ave 02140.
3/4/90	Rebecca Folliman	100 Larch Rd Camb.
3/4/90	Leslie Heerman	98 Larch Rd Camb
3/4/90	Jeffrey Freyman	98 LARCH RD, CAMB.
3/4/90	Jonathan Aaron	100 Larch Road, Camb.
3/4/90	David MAZIERES	100 Larch Road, Camb
3/4/90	Estelle Disch	528 Franklin St. Camb

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DATE	NAME	ADDRESS
3/3/90	Ellen P. Duehay	130 Mt. Auburn St., Cambr.

FRANK DUEHAY

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DATE	NAME	ADDRESS
3/5/90	MR & MRS PETER STANDISH	107A LAKE VIEW CAMBRIDGE
3/6/90	MR. + MRS. [illegible]	109 Lakeview Ave Cambridge
3/14/90	Ellen + Gordon Tully	112 Lake View Ave
3/14/90	Ellen D.B. Tully	112 Lakeview Ave.

6

CITY OF CAMBRIDGE

CAMBRIDGE, MASSACHUSETTS 02139
TEL. 498-9011

EXECUTIVE DEPARTMENT
ROBERT W. HEALY
City Manager

RICHARD C. ROSSI
Deputy City Manager

February 2, 1990

To The Honorable, The City Council:

Attached is a recommendation from the Cambridge Water Board to request that City Ordinance No. 998, Ch. 4, Article 1, Section 4-8 be eliminated so that dog management at the Fresh Pond Reservation would conform with dog control requirements throughout the City.

Very truly yours,

Robert W. Healy
City Manager

Attachment

ORDINANCE NO. 998.
Final Publication No. 2209.
First publication in the Chronicle on May 26, 1983.
CITY OF CAMBRIDGE
In the Year One Thousand, Nine Hundred Eighty-Three
AN ORDINANCE

In amendment to an ordinance formerly entitled: "The General Ordinances of the City of Cambridge" as revised in 1972 and now designated as "The Code of the City of Cambridge."

Be it ordained by the City Council of the City of Cambridge as follows:

Chapter Four, entitled "Animals," is hereby amended by striking out the present Chapter Four and substituting in place thereof the following new Chapter Four, which reads as follows:

Chapter 4. Animals

Article I. In General

§4-1. Definitions.
§4-2. Dogs.
§4-3. Running at large; permits for exhibitions.
§4-4. Fast driving.
§4-5. Frightening horses.
§4-6. Penalty.
§4-7. Licensing of dogs.
§4-8. Control of dogs - Fresh Pond Reservation.
§4-9. Leashing of dogs.
§4-10. Removal of canine wastes.
§4-11. Enforcement.
§4-12. Appointment of Dog Officer.

Article II. Inspector of Animals

§4-13. Nominees for Inspector.
§4-14. Duties of Inspector.
§4-15. Report to City Manager.

Article III. Cambridge Animal Commission

§4-16. Establishment.
§4-17. Function and purpose.
§4-18. Membership, Appointment, Term.
§4-19. Appointment of a Director.

Article I. In General

Sec. 4-1. **Definitions.**

As used herein:

(a) **Animals** shall mean all mammals, fowl and reptiles, except man.

(b) **At large** shall mean off the premises of the owner or custodian and not under the control of the owner or custodian either by leash, cord, chain or otherwise.

(c) **Keep** shall mean possessing, controlling, exercising or allowing to run at large.

(d) **Owner** shall mean any person possessing, keeping, harboring or having custody of an animal.

Sec. 4-2. **Dogs.**

No person shall own or keep in the City any dog which by barking, biting, howling or in any other manner, disturbs the quiet of any person.

(G.O. 1943, Ch. 3, §1.)

Sec. 4-3. **Running at large; permits for exhibitions.**

No owner or person having the care of any domestic fowls, or any goats, sheep, swine, horses, oxen, cows, or other grazing animals, shall permit or suffer the same to go at large, or to graze on any street; and no person shall publicly exhibit any animal in the streets or public places of the City except in accordance with a permit from the Superintendent of Streets.

(G.O. 1943, Ch. 3, §2.)

Sec. 4-4. **Fast driving.**

No person having the care or use of a horse or other beast of burden, carriage, or draught, shall ride, drive or permit such horse or other beast to go at a rate of speed greater than is reasonable and proper, having regard to traffic and the use of the way and the safety of the public.

(G.O. 1943, Ch. 3, §3.)

Sec. 4-5. **Frightening horses.**

No person shall, by any noise, gestures, words or other means, wantonly and designedly frighten or drive any horse in any street.

(G.O. 1943, Ch. 3, §4.)

Sec. 4-6. **Penalty.**

Any person who violates any of the provisions of Sections 4-2, 4-3, 4-4 or 4-5 shall be subject to a fine not exceeding fifty dollars ($50.00) for each offense.

(Ord. No. 765, §6, par. 6, 4-22-68 and part of G.O. 1943, Ch. 3, §1.)

Sec. 4-7. **Licensing of dogs.**

Every dog three months old or over shall be licensed pursuant to G.L. c. 140, §137. The fee for such license shall, except as otherwise provided, be two dollars ($2.00) for a spayed or neutered dog and ten dollars ($10.00) for an unspayed or unneutered dog. As proof that the dog has been spayed or neutered, the owner or keeper shall present to the Director of the Animal Commission or his designee a certificate of the registered veterinarian who performed the operation. If the Director is satisfied that the certificate of the veterinarian who performed the operation cannot be obtained, he may accept in lieu thereof a sworn statement of a veterinarian registered and practicing in the Commonwealth, describing the dog, and stating that he has examined the dog and that, in his opinion, it has been spayed or neutered. No fee shall be charged for a license for a dog specially trained to lead or serve a blind person, if the Division of the Blind certifies that such dog is so trained and actually in the service of a blind person. No part of the fee shall be refunded because of the subsequent death, loss, spaying, castration, removal from the Commonwealth or other disposal of the dog. Nor shall any part of the fee paid by mistake be refunded.

Sec. 4-8. **Control of dogs - Fresh Pond Reservation.**

Dogs may go unleashed on the Fresh Pond Reservation provided they have been trained by their masters to follow oral commands and provided further that they are not allowed to romp in mowed, grassy areas and provided further that their owners are Cambridge residents who have received Resident Sticker Parking Permits approved by the Water Board and issued by the Traffic Department.

Provided further, that the Water Board post appropriate signs in conspicious locations throughout the Reservation relative to the control of dogs.

Sec. 4-9. **Leashing of dogs.**

(a) No person owning or keeping a dog shall permit it to be at large other than on his own premises; if it be on the premises of another person, it shall be with the knowledge and permission of such other person. The owner, keeper or person having custody of a dog which is not on the premises of the owner or upon the premises of another person with the knowledge and permission of such person shall keep the dog under control by means of a chain, rope or cord not exceeding six (6') feet in length of sufficient strength to control the actions of said dog.

(b) In any prosecution hereunder, the presence of such dog at large upon premises other than the premises of the owner or keeper of such dog shall be prima facie evidence that such knowledge and permission was not had.

Sec. 4-10. **Removal of canine wastes.**

It shall be the duty of each person who owns, possesses, or controls a dog to remove and dispose of any feces left by his dog on any sidewalk, gutter, street or other public area, or on any private property neither owned nor occupied by said person. No such person shall appear with a dog on any sidewalk, gutter, street or other public area, or on any private property neither owned nor occupied by said person without the means of removal of any feces left by such dog.

Sec. 4-11. **Enforcement.**

(a) For the purpose of enforcing the provisions of Section 4-9 and Section 4-10, NOTICES OF VIOLATION (appearance tickets) may be issued by Sanitation Inspectors and Code Enforcement Inspectors detailed within the Department of Health and Hospital, by persons appointed as Parking Control Officers detailed within the Department of Traffic and Parking, by any police officer, and by the dog officer, and employees of the Water Department recommended by the Water Board and approved by the Chief of Police in those areas under the jurisdiction of the Water Board.

Any owner or keeper of a dog, who has been observed by a police officer to have violated any provisions of Sections 4-7, 4-8, 4-9 or 4-10 of this Chapter, and who refuses to give proper personal identification of his or her person to said police officer upon request, shall be subject to arrest.

(b) **Disposition of complaints.** All NOTICES OF VIOLATION (appearance tickets) shall be returnable to the Clerk of the Cambridge Division, District Court Department of the Trial Court, Middlesex County. Unless the person named on said NOTICE OF VIOLATION appears before said Clerk within twenty-one days of said violation either personally or through an agent duly authorized in writing, or by mailing to such Clerk, with the NOTICE, the fine provided therein, a complaint will be sought against the person named in said NOTICE. If the violation is the first offense under Sections 4-9 or 4-10 of this Chapter committed by such person within a calendar year, the payment to the Clerk of a fine of ten dollars ($10.00) shall operate as a final disposition of the case. If it is the second offense in a calendar year, payment to the Clerk of a fine of twenty-five dollars ($25.00) shall operate as a final disposition of the case. If it is the third or subsequent offense in a calendar year, payment of a fine of fifty dollars ($50.00) shall operate as a final disposition of the case. A violation of Section 4-7 of this Chapter shall be punishable by a fine of not more than fifteen dollars ($15.00) for each offense.

Sec. 4-12. **Appointment of Dog Officer.**

A full time Dog Officer and an Assistant shall be appointed by the City Manager and shall have the responsibility of enforcing this Article.

Article II. Inspector of Animals

Sec. 4-13. **Nominees for Inspector.**

The City Manager shall annually, in March, nominate one (1) or more Inspectors of Animals, and before April 1 send to the Director of Livestock Disease Control the name, address and occupation of each nominee. Such nominee shall not be appointed until approved by the Director.

(G.O. 1943, Ch. 2, §168.)

Sec. 4-14. **Duties of Inspector.**

In addition to the duties required of him by the statutes, and acts in amendment thereof, Inspector of Animals shall professionally visit, attend and treat, whenever necessary or requested by the City Manager, any and all of the horses owned by the City and shall physically examine and report upon all horses offered for sale to the City.

(G.O. 1943, Ch. 2, §169.)

Sec. 4-15. **Report to City Manager.**

He shall annually, in January, and whenever requested by the City Manager, make a full and detailed report of all matters pertaining to his department, with such suggestions as he may deem proper.

(G.O. 1943, Ch. 2, §170.)

Article III. Cambridge Animal Commission

Sec. 4-16. **Establishment.**

There shall be and hereby is established a Cambridge Animal Commission.

Sec. 4-17. **Function and purpose.**

It shall be the function of the Commission to facilitate and promote programs affecting animal control within the City of Cambridge. Such programs shall include:

(a) A low cost spaying and neutering program.
(b) A euthanasia program.
(c) A dog pound and adoption program.
(d) An animal census program.
(e) A citizen education program.
(f) Such other activities which, by and with the approval of the City Manager, are considered necessary and appropriate to insure effective animal control within the City of Cambridge.

Sec. 4-18. **Membership, Appointment, Term.**

(a) The Commission shall consist of seven members. The Chief of the Cambridge Police Department and the Commissioner of Health and Hospital shall be permanent members of the Commission. The remaining five members shall be appointed initially by the City Manager to serve for the following terms:

(1) One member shall serve for a one year term.
(2) Two members shall serve for a two year term.
(3) Two members shall serve for a three year term.

After the initial terms all Commissioners shall be appointed for a term of three years.

(b) Members of the Commission shall have demonstrated ability in the animal welfare field with related experience in any of the following:

(1) Public information programs.
(2) Animal shelter operations.
(3) Spaying and neutering programs.
(4) Affiliations with national and local animal protection societies.
(5) Knowledge of animal health care and diseases.

Sec. 4-19. **Appointment of a Director.**

The City Manager shall appoint a Director from a list of names recommended by the Commission. The Director shall have general charge of all animal control activities in the City.

It shall be the function of the Director to coordinate activities of all departments and divisions of City government which affect the control of animals within the City of Cambridge, and to provide such other related services as are deemed necessary and proper by the Commission, subject to the approval of the City Manager.

The Director shall serve a term of employment to be determined by the

C. C. 106

City of Cambridge

PUBLIC HEARING

The Committee on Ordinances, comprised of the entire membership of the City Council, will conduct a public hearing on Wednesday, April 4, 1990 at 5:30 p. m. in the Sullivan Chamber, City Hall, Cambridge, Massachusetts.

The hearing has been scheduled for the purpose of reviewing the recommendations of the Cambridge Water Board to amend Ordinance #988 by deleting Section 4-8 entitled **"Control of Dogs - Fresh Pond Reservation".**

All persons interested are requested to attend and be heard at this time.

For the Committee,

Councillor Francis H. Duehay
Chairman.

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OFFICE OF THE CITY CLERK

CITY OF CAMBRIDGE

CITY HALL, CAMBRIDGE, MASSACHUSETTS 02139

(617) 498-9017

JOSEPH E. CONNARTON
CITY CLERK

JOHN E. FLYNN
DEPUTY CITY CLERK

February 26, 1990

Mr. Russell B. Higley
City Solicitor
City Hall
Cambridge, MA 02139

Dear Sir:

Enclosed you will find a communication from the Water Board requesting a proposed amendment to Ordinance Number 988, Chapter Four, Article One, Section 4-8 be deleted so that dog management at the Fresh Pond Reservation would conform with dog control requirements throughout the city. Would you kindly incorporate this amendment into the new Municipal Code format.

Please be advised that Councillor Duehay, Chairman of the Ordinance Committee, has scheduled a public hearing on this matter for Wednesday, April 4, 1990 at 5:30 p. m.

Your kind attention in this matter will be greatly appreciated.

Sincerely yours,

Joseph E. Connarton
City Clerk

JEC/dl

Enc.

6

CITY OF CAMBRIDGE

CAMBRIDGE, MASSACHUSETTS 02139
TEL. 498-9011

EXECUTIVE DEPARTMENT
ROBERT W. HEALY
City Manager

RICHARD C. ROSSI
Deputy City Manager

February 2, 1990

To The Honorable, The City Council:

Attached is a recommendation from the Cambridge Water Board to request that City Ordinance No. 998, Ch. 4, Article 1, Section 4-8 be eliminated so that dog management at the Fresh Pond Reservation would conform with dog control requirements throughout the City.

Very truly yours,

Robert W. Healy
City Manager

Attachment

CITY OF CAMBRIDGE

250 FRESH POND PKY., CAMBRIDGE, MASSACHUSETTS 02138• TEL. 498-9070

OFFICE OF THE WATER BOARD

Donald F. Hornig
President
Thomas J. Begley
Ruth C. Birkhoff
Walter N. Conlon
A. Paul Flynn

February 1, 1990

Mr. Robert W. Healy
City Manager
City of Cambridge
Cambridge, MA 02138

Dear Mr. Healy:

Attached is a statement by the Cambridge Water Board concerning dogs at Fresh Pond Reservation which was voted unanimously at its meeting of January 4, 1990.

Dogs have been a concern of the Board for several years and from time to time we have discussed the problem with Mr. Rossi and others. The Water Department has tried to control the situation in various ways. Until now we have had little success in bringing the problem under control. The City Council, for the most part, has opposed restrictions on dogs in the past.

We need help from all of the City Departments which are involved -- police, dog officer, etc.

Sincerely,

Donald F. Hornig

Donald F. Hornig
President

cc: Mr. Richard Rossi

RECEIVED
90 JAN 32 PM 4:37
OFFICE OF THE CITY MANAGER

CITY OF CAMBRIDGE

250 FRESH POND PKY., CAMBRIDGE, MASSACHUSETTS 02138• TEL. 498-9070

OFFICE OF THE WATER BOARD

Donald F. Hornig
President

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Walter N. Conlon

A. Paul Flynn

The Water Board has felt strongly for some time that allowing dogs to roam freely on the Fresh Pond Reservation is incompatible with its primary purpose, which is the provision of a potable water supply to the City of Cambridge. Until now we have had little support for this position and have been limited to putting up more signs and passing out leaflets to dog owners. There has been some support from animal control but it has been inadequate.

Violations of the dog regulations continue on a large scale. There are deposits of animal waste along the paths, in the grass and even inside the fence, as a result of dogs passing through cuts in the fence. Since a number of parasitic diseases such as Giardia or Cryptospiridium can be introduced into the water supply by contact with feces, these deposits pose a constant health hazard. Outbreaks of these diseases have occurred in other communities. Furthermore, dogs run loose in Kingsley Park and other grassy areas throughout the day and pose a potential hazard to children and other users of the Reservation. Many of the dogs are not there to accompany citizens using the park but are brought to the reservoir in groups for exercise, often by people who are not residents of Cambridge. Lastly, the feces left around the pond by the dogs provide food for a large number of rats.

The large numbers of dogs who run free in the Reservation constitute both a hazard and a public nuisance. However, the Water Board recognizes that dogs contribute to the security of people walking or running around the pond so that their presence is justified if they are kept under control. To protect the water supply (and other citizens) dogs should be leashed at all times and owners should be required to carry means for removing solid waste. The waste must be deposited in the barrels which are provided at intervals along the pond road.

Bearing all of these things in mind the Water Board has voted unanimously to request that Ordinance No. 998, Ch. 4, Article 1, Section 4-8, be eliminated so that dog management at Fresh Pond Reservation would conform with dog control requirements throughout the City.

6

CITY OF CAMBRIDGE

CAMBRIDGE, MASSACHUSETTS 02139
TEL. 498-9011

EXECUTIVE DEPARTMENT
ROBERT W. HEALY
City Manager

RICHARD C. ROSSI
Deputy City Manager

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250 FRESH POND PKY., CAMBRIDGE, MASSACHUSETTS 02138• TEL. 498-9070

OFFICE OF THE WATER BOARD

Donald F. Hornig
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The large numbers of dogs who run free in the Reservation constitute both a hazard and a public nuisance. However, the Water Board recognizes that dogs contribute to the security of people walking or running around the pond so that their presence is justified if they are kept under control. To protect the water supply (and other citizens) dogs should be leashed at all times and owners should be required to carry means for removing solid waste. The waste must be deposited in the barrels which are provided at intervals along the pond road.

Bearing all of these things in mind the Water Board has voted unanimously to request that Ordinance No. 998, Ch. 4, Article 1, Section 4-8, be eliminated so that dog management at Fresh Pond Reservation would conform with dog control requirements throughout the City.

CITY OF CAMBRIDGE

250 FRESH POND PKY., CAMBRIDGE, MASSACHUSETTS 02138• TEL. 498-9070

OFFICE OF THE WATER BOARD

Donald F. Hornig
President
Thomas J. Begley
Ruth C. Birkhoff
Walter N. Conlon
A. Paul Flynn

The Water Board has felt strongly for some time that allowing dogs to roam freely on the Fresh Pond Reservation is incompatible with its primary purpose, which is the provision of a potable water supply to the City of Cambridge. Until now we have had little support for this position and have been limited to putting up more signs and passing out leaflets to dog owners. There has been some support from animal control but it has been inadequate.

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February 1, 1990

Mr. Robert W. Healy
City Manager
City of Cambridge
Cambridge, MA 02138

Dear Mr. Healy:

Attached is a statement by the Cambridge Water Board concerning dogs at Fresh Pond Reservation which was voted unanimously at its meeting of January 4, 1990.

Dogs have been a concern of the Board for several years and from time to time we have discussed the problem with Mr. Rossi and others. The Water Department has tried to control the situation in various ways. Until now we have had little success in bringing the problem under control. The City Council, for the most part, has opposed restrictions on dogs in the past.

We need help from all of the City Departments which are involved -- police, dog officer, etc.

Sincerely,

Donald F. Hornig

Donald F. Hornig
President

cc: Mr. Richard Rossi

OFFICE OF THE CITY MANAGER
90 JAN 32 PM 4:37
RECEIVED

CITY OF CAMBRIDGE

CAMBRIDGE, MASSACHUSETTS 02139
TEL. 498-9011

EXECUTIVE DEPARTMENT
ROBERT W. HEALY
City Manager

RICHARD C. ROSSI
Deputy City Manager

February 2, 1990

To The Honorable, The City Council:

Attached is a recommendation from the Cambridge Water Board to request that City Ordinance No. 998, Ch. 4, Article 1, Section 4-8 be eliminated so that dog management at the Fresh Pond Reservation would conform with dog control requirements throughout the City.

Very truly yours,

Robert W. Healy
City Manager

Attachment

Agenda # 6 Cal #2.

Recommendation from the Water Board that section 4-8 of Chapter 4 be striken to allow dogs at Fresh Pond.

In City Council,

February 5, 1990

Charter Right
Exercised by
Councillor Walsh
2/12/90 Referred to the
Ordinance Committee
Copy sent to Ordinance
Committee 2/13/90 (a)

CITY OF CAMBRIDGE

250 FRESH POND PKY., CAMBRIDGE, MASSACHUSETTS 02138• TEL. 498-9070

OFFICE OF THE WATER BOARD

Donald F. Hornig
President
Thomas J. Begley
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OFFICE OF THE CITY MANAGER
90 JAN 32 PM 4:37
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CITY OF CAMBRIDGE

250 FRESH POND PKY., CAMBRIDGE, MASSACHUSETTS 02138• TEL. 498-9070

OFFICE OF THE WATER BOARD

Donald F. Hornig
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Bearing all of these things in mind the Water Board has voted unanimously to request that Ordinance No. 998, Ch. 4, Article 1, Section 4-8, be eliminated so that dog management at Fresh Pond Reservation would conform with dog control requirements throughout the City.

The Committee on Ordinances conducted a public hearing on Wednesday, April 4, 1990 beginning at 5:45 P. M. in the Sullivan Chamber, City Hall

The purpose of the hearing was to review a proposed amendment to the Municipal Code relative to prohibiting dogs from running free throughout the Fresh Pond Reservoir and requesting dog owners to conform with the current dog control ordinance.

Members present were: Councillor Francis Duehay, Councillor Ed Cyr, Councillor Sheila Russell, Councillor Jonathan Myers, Vice Mayor Reeves, Mayor Wolf and Councillor Toomey.

Councillor Duehay opened the hearing by outlining the procedure for which testimony will be received by members of the City Council and the general public. He further stated that proponents of the amendment will speak first and opponents will speak last.

At this time the committee heard from Dr. Donald F. Hornig, President of the Cambridge Water Board, 16 Longfellow Park, Cambridge, who provided the committee with an overview of the board's responsibilities relative to the quality of water and the public health. He further stated that the board has had a continuing problem with dogs running free throughout the Fresh Pond Reservoir. He further stated that the board has given careful consideration to the problem and has come to the conclusion that Ordinance Number 998 needs to be amended in order to restrict dogs from running free in this area. Dr. Hornig stated one of the primary reasons for this request is the board's concern with potential outbreak of Giardia. This disease is caused from loose feces around the pond to which humans may come in contact. In the State of Pennsylvania such an outbreak occurred in which over 300 people were affected.

At this time Councillor Toomey stated that he strongly believed the city should enforce the existing regulations in and around the Fresh Pond Reservoir and help dog owners by placing additional barrels around Fresh Pond to allow dog owners to dispose of waste.

Councillor Walsh questioned whether or not chlorination would clear up the issue at Fresh Pond.

Dr. Hornig responded by stating that if all measures were working effectively chlorine would help.

At this time Councillor Myers asked what was the primary reason which caused the Water Board to submit this proposal?

Dr. Hornig responded that the Water Board wants to have all dogs leashed to prevent any cases of Giardia and has cause for concern or a hazard to youngsters who may be fearful of dogs running towards them.

At this time Councillor Duehay requested that the City Clerk obtain a report from the Public Health Commissioner, Dr. Chalfen, on the issue of Giardia and on his position on this ordinance.

coming onto the grounds and letting their dogs run free.

Vice Mayor Reeves questioned if the City Council were not to adopt the proposal as submitted what would be the response of the Water Board to take action.

Mr. Cusask stated that he would attempt to provide further public information and seek stronger enforcement measures. He stated that he believed that most of the present this evening were responsible dog owners but the problem rests with those individuals who refuse to clean up after their dogs.

The committee heard from Timothy McDonald, Water Resource Manager of the Water Department, 151 Grove Street, Reading who stated he supported the proposal as offered by the Water Board and he believed this is the only way to preserve the water quality.

The committee heard from Mark McCabe, Animal Control Director, 4 Dorothy Road, Arlington, who stated that his department has been working with the dog owners in an effort to resolve this problem and he has attempted to utilize "peer pressure philosophy" whereby responsible dog owners are influencing other people to be more aware of the existing problem and to address it.

Responding to a question by Councillor Toomey, Mark McCabe outlined the fines for K-9 waste are as follows: $10 fine for the first offense; $25 for the second offense; $50 fine for the third offense and $50 fine thereafter.

At this time Jack Martinelli, 171 Auburn Street, stated that he was very concerned with Giardia and the possibility of placing the same within the community and he supported the proposal.

After his oral tesimony he submitted written documentation relative to the Giardia issue.

The committee heard from Norma Weinberg of Mt. Auburn Street who stated she was concerned with the quality of the water.

Speaking in opposition to the proposal were the following:

Elizabeth Homans
Barbara Norfleet, 79 Raymond Street, Cambridge
Ellen Tully
Ester Puel, Ash Street Place, Cambridge
Sharon Ward, Esquire, 9 Potter Park, Cambridge
Tom Erenfeld, 100 Larch Road, Cambridge
Phoebe Morse, 663 Green Street, Cambridge
Anita McLellan, Stearns Street, Cambridge
Elizabeth Dungar, Fenno Street, Cambridge
Jane Myers, 165 Charles Street, Cambridge
Dorothea Cross, 111 Magazine Street, Cambridge

At this time Mayor Wolf stated that thus far she is unclear that a public heairng hazard exists and is uncertain whether adoption of this amendment is necessary at this time.

Councillor Walsh asked a series of question relative to the bathroom facilities at the Fresh Pond Reservoir.

Mr. Rossi stated that there was a facility at the main plant building and further informed the committee that a public health hazard does exist; that the Water Board has done extremely well in attempting to find other measures to prevent this problem and urged the City Council to adopt this proposal.

Councillor Cyr questioned the specific areas of concern by the Water Board.

Mr. Rossi responded that the board's concern with deposits of animal waste along the walkways of the pond and throughout the Kingsley Park and below the soccer field area.

Councillor Myers questioned whether the feces problem was prevalent throughout the city or whether it was concentrated at the Fresh Pond Reservoir.

Mr. Rossi responded that the problem permeates the city.

At this time Vice Mayor Reeves stated that he had concern over the current proposal and that the general public has a certain expectation that this area should be available but he does have great concern over the quality of the water and does believe more intense enforcement should be initiated.

Following up on Vice Mayor Reeves comment Councillor Cyr questioned the feasibility and cost of adding two additional animal control officers.

Mr. Rossi stated that the cost would be approximately $90,000 which includes salaries and benefits and such a proposal would only be effective if these officers were permanently assigned to this location.

At this time Councillor Duehay stated that this was extremely important for the committee to understand that this proposal is an attempt to protect the water quality which is the primary concern of the Water Board. He asked Mr. Rossi to contact other people who may have particular expertise in this area in an effort to obtain additional information on ways to solve this problem.

The committee then heard from John Cusack, Superintendent of the Water Board, 45 Hickory Road, Braintree, who stated that given the EPA guidelines and new water treatment rules that the multiple barrier water protection concept must be implemented and that restricting the Fresh Pond Reservoir to dog owners who have their dogs unleashed would be the next step. He further informed the committee that he observed kennel trucks

Abigail Winston, 30 Kelly Road, Cambridge ~~Street~~ Avenue
Melissa Weber, 87 Washington ~~Street~~, Cambridge
Lois Lamson, 180 Lexington Avenue, Cambridge
Mary Ahern, 75 Upham Street, Lowell

At this time Councillor Russell requested that the Superintendent of the Water Board take the appropriate steps to improve the signs throughout the park making all dog owners aware of the dog ordinance.

At this time Councillor Walsh moved that the proposal be referred to the full City Council with an unfavorable recommendation.

The motion -

Carried.

The hearing adjourned at eight o'clock and thirty-four minutes p.m.

For the Committee,

s/ Francis H. Duehay
Councillor Francis Duehay
Chairman.

Cal # 5

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1.

COMMITTEE REPORTS

Report from Councillor Duehay, Chairman of the Ordinance Committee, for a hearing held on April 4, 1990 relative to a proposed amendment to the Municipal Code relative to prohibiting dogs from running free throughout the Fresh Pond Reservoir.

In City Council,

May 7, 1990

Tabled by Councillor Duehay
2/11/91 Placed on file

Agenda # 6 Ca C #2 0-61

Recommendation from the Water Board that section 4-8 of Chapter 4 be striken to allow dogs at Fresh Pond.

12/9/91 Placed on file without prejudice

In City Council,

February 5, 1990

Charter Right exercised by Councillor Walsh

2/12/90 Referred to the Ordinance Committee