CITY OF CAMBRIDGE
MASSACHUSETTS

WATER DEPARTMENT
250 FRESH POND PARKWAY
CAMBRIDGE, MASS. 02138

Nancy E. Barnes
Managing Director

617-349-4770

DATE: November 12, 1992

TO: Robert W. Healy

FROM: Nancy E. Barnes

RE: Council Order #5, dated 11/2/92, RE: Discolored Tap Water

CC: Richard C. Rossi
Cambridge Water Board

The following Attachments are provided in this report:

Attachment A: Our internal Incident Report
Attachment B: Our action plan to control manganese now and in the future
Attachment C: American Water Works Association "Waternet" report on documented manganese outbreaks nationally and around the world
Attachment D: Similar Situations in Local Water Systems

Following is a summary of the information contained in the Attachments:

We believe that the October manganese outbreak in the water system was caused by several phenomena: 1) Last summer we drew down the Stony Brook Reservoir to allow for repairs to the travelling screen. When any reservoir is drawn down, groundwater is able to seep into the reservoir. Groundwater often contains manganese so manganese is added to the reservoir. We suspect that this happened at Stony Brook this summer because Stony Brook contains the highest levels of manganese of any of our reservoirs; 2) In the Fall, as temperatures drop, the top layer of water in the reservoirs cools down. The warmer bottom water rises and tends to stir up matter in

the raw water. This phenomenon is referred to as reservoir turnover. We suspect that this happened at Fresh Pond, stirring up manganese in the Fresh Pond raw water and 3) The aerator that normally controls the manganese level at Fresh Pond was not working effectively throughout the Pond.

When we realized that the manganese levels were elevated, we took immediate action to draw water into the treatment plant only from Fresh Pond where the manganese levels were much lower than Stony Brook. We managed our water filters to ensure the removal of the maximum amounts of manganese. We increased our water sampling to analyze the problem and gauge the effectiveness of our remedial measures.

Ours is not the only water system that experiences manganese outbreaks. We contacted the American Water Works Association and found a number of documented cases of water discoloration due to manganese around the country and the world: Normandy, France; Acton, Ontario; Queensland, Australia; Wimbleball Reservoir, Great Britain; Iowa; Fairfax County, Virginia; and Haverhill, MA. These cases are limited to those that have been documented and entered to the AWWA Waternet system. We are certain that there have been many more instances that have not been documented. In most of these cases, aeration and oxidation were found effective in controlling the seasonal manganese problem.

We have also contacted 6 local water systems: Andover, Haverhill, Ipswich, North Andover, Peabody and Portsmouth, NH. They have experienced either seasonal or drought related manganese outbreaks similar to the one we experienced. They have found aeration, potassium permanganate, and/or pre-ozonation to be effective in controlling the manganese.

In addition, we have discussed the manganese breakout with Camp Dresser & McKee. They concur that the following measures should be effective at manganese control 1) Aeration of Fresh Pond and Stony Brook, 2) Drawing raw water into the treatment plant only from Fresh Pond with additional pumping capacity and 3) A potassium permanganate feed system.

Our plan to prevent further outbreaks of manganese discoloration includes aeration of Fresh Pond and Stony Brook reservoirs, a potassium permanganate feed system and additional pumping to allow a 100% Fresh Pond raw water draw. Half of the aerator in Fresh Pond was replaced on November 6, 1992 - the balance will be replaced within the next two weeks. The other projects will take more time, either because they are not budgeted (Stony Brook Aerator, potassium permanganate feed) or because they involve design and bidding (pumping replacements).

ATTACHMENT A

Attachment A

CAMBRIDGE WATER DEPARTMENT

Incident Reporting Form

Describe the events leading to the incident:

Dirty/discolored water from October 3 to the week of October 19, 1992 caused by elevated manganese levels in the distribution system.

List people involved:

1) Treatment plant operating staff adjusted operational procedures during the incident and handled incoming phone calls after normal Department working hours.
2) Laboratory staff performed additional analysis and jar tests during the incident. The laboratory staff also handled incoming phone calls during the incident and helped to deliver Red-B-Gone to customers with stained laundry.
3) The Distribution Division of the Department was involved in flushing hydrants in areas badly impacted by dirty water complaints.
4) The business office staff also handled many incoming calls during the incident.

Describe the actual incident:

Elevated levels of dissolved manganese are not efficiently removed by the existing treatment plant. During this incident manganese came to the plant by two routes, directly from Stony Brook Reservoir and from raw water pumped from Fresh Pond. At the time of the incident, operating practice was to supplement the raw water flow from Fresh Pond with water directly from Stony Brook Reservoir to recover from low Payson Park levels after plant shut-downs. Manganese levels in Stony Brook Reservoir were high enough so that levels above the secondary standard of 0.05 mg/l went through the plant and into the distribution system.

The levels of manganese in Fresh Pond were lower, but still elevated. These levels were aggravated by transfers of water from Stony Brook Reservoir to Fresh Pond following repair work at Stony Brook Reservoir during the summer. There are also indications that the aeration system in Fresh Pond was not working efficiently to remove manganese or to de-stratify Fresh Pond. Sampling after the initial incident indicated that Fresh Pond had de-stratified or turned during the incident.

At the outset of the incident, the supply to the treatment plant was switched to just Fresh Pond water. This controlled the manganese leaving the treatment plant to the secondary standard level. The duration of the incident reflected the time needed to stabilize the initial manganese levels in the clearwell, in Payson Park, and in the distribution system.

What was our response:

1) Operating staff eliminated the direct use of Stony Brook Water to reduced the Manganese level in the raw water. The laboratory staff monitored total and dissolved manganese levels through the treatment process to evaluate the level of removal.
2) Jar tests where run to evaluate the feasibility of Potassium Permanganate feed to actively control/eliminate Manganese during the incident.
3) Area water departments were contacted to locate available tanks to allow for a temporary Potassium Permanganate feed.
4) A press release was issued on October 5, 1992 to notify customers of the nature of the problem and to direct their inquiries to the lab staff (copy attached).
5) Staff met with the Water Board's Water Quality Committee to evaluate the status of the incident and the corrective actions taken.
6) Red-B-Gone was made available to customers experiencing stained laundry.
7) Localized fire hydrant flush was conducted in areas experiencing particularly severe problems. This occurred both during the day and on the evening shifts.
8) Response to the City Council Order attached.
9) Statistics of the incident:

1) Customer calls: - 872 (based on laboratory logs and daily estimates from office staff)
2) Expenses for Red-B-Gone: $600 (estimate)
3) Manganese levels leaving the treatment plant .1 to .03 mg/l
4) Approximate raw water Manganese levels:
Stony Brook Reservoir - .24 mg/l
Fresh Pond - .13 mg/l

What did we learn:

1) An improved water quality incident notification system is needed. This should include: internal Water Department notice and a standardized list of major customer and institution contacts and phone numbers. Improved methods need to be developed to notify our residential customers. The press release was not seen by all our customers.
2) We should improve supply monitoring so that we can predict future occurrences and take action early enough.
3) At the bench scale level, controlled Potassium Permanganate feed is effective at Manganese removal in the treatment plant.

Future recommendations to prevent reoccurrences:

Monitor water quality to predict re-occurrences and take early action.

Operational alternatives include:

1) Rehabilitate the aeration system in Fresh Pond.
2) Install an aeration system in Stony Brook.
3) Consider a Potassium Permanganate feed system at the plant.
4) Provide raw water pumping to facilitate 100 % Fresh Pond intake.

Schedule maintenance/improvement projects on reservoir system to minimize disruption of water quality.

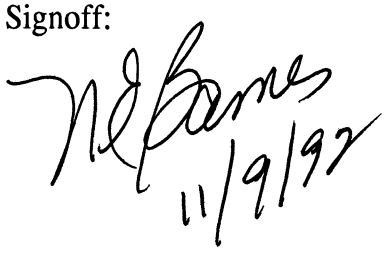
Further action required (if any):

1) Initiate recommendations immediately with existing materials and currently appropriated funds.
2) Evaluate historical data and monitor manganese levels at Stony Brook to assess the effectiveness of aeration of Stony Brook Reservoir.
3) Conduct additional laboratory testing to provide the basis for a design proposal for a Potassium Permanganate feed system.

Prepared by:

Timothy W.D. MacDonald

Signoff:



PRESS RELEASE

Fall Water Conditions

In the Fall, the character of our reservoir water changes because of natural conditions. The temperature of the water changes, falling leaves get into the water and seasonal rains begin to fill the reservoirs back up.

When the temperature of the upper water layer in the reservoirs drop, the water "turns" as the lower warmer water rises. When this happens, organic matter is stirred up in the reservoir. This contributes to rising manganese levels in the raw water.

The fall leaves and the organic matter from the reservoir "turn" add color to the raw water in much the same way as a tea bag works when tea is brewed.

In the Fall, we adjust the treatment process to control the impact of these changes on water quality in the home. Even still, customers may notice a darker color in the water. Occasionally, laundry may be stained. While manganese levels may rise to a small extent, they are not a health hazard.

If you experience a change in water quality with which you are not comfortable, please call Ed Dowling at 349-4780 for assistance.

ATTACHMENT B

1992 Manganese Incident
Cambridge Water Department
Action Plan: November 4, 1992

1) Rehabilitate the aeration system in Fresh Pond.
    Tubing in stock.
        -Installation planned for week of November 2.
    Backup air compressor on site.
        -Installation will be part of FY94 improvements to Low Level Pump Station.

2) Install an aeration system in Stony Brook.
    FY94 project, will require:
        -compressors(2)
        -tubing
        -cooling water pump/system
        -installation
    Estimated cost: $40,000, less engineering.

3) Install a Potassium Permanganate feed system at the treatment plant
    FY93 funds available for similar polymer feed project.
        -design proposal
        -design
        -bid
        -installation
    Estimated cost: $20,000, less engineering.
    Estimated time frame: complete by fall of 1993.

4) Increase Fresh Pond Pumping capacity.
    FY93 funds available.
        -design proposal requested.
        -design
        -bid(CWD)
        installation
    Estimated time frame: addition pumping capacity by summer of 1993.

5) Water quality monitoring.
    -CWD staff is in the process of reorganizing duties of watershed personnel and has a proposal pending to re-organize the laboratory. These changes will allow for improved efficiency in the current monitoring.
    -CWD staff will work with the Water Quality Committee to implement a monitoring program specific to manganese.

6) Develop a more formalized customer notification system.
    -CWD is currently preparing a computerized list of commercial, institutional, and industrial customers. This list will be used to notify customer about the start-up of the aqua ammonia system. This will establish a procedure for direct contact of customers in the future.

ATTACHMENT C

1/5/1
028509 QTC90014
Improving the Water Quality of a Shallow Eutrophicated Reservoir: The Case of Visance Reservoir (Normandy, France)
Laverty, John ; Morin, Denis
Aqua Technique, Nanterre, France ; Aqua Technique, Randolph, New Jersey
Proceedings Water Quality Technology Conference; Advances in Water Analysis and Treatment San Diego, California
November 11-15, 1990
p 211-225, 1991
Publ: AWWA
CODEN: PWQCD2 ISBN: 0-89867-565-0 ISSN: 0164-0755
Availability: AWWA
tables, figures
Language: English
Document Type: Conf Proc
In recent years, the Visance reservoir has had significant problems with algae. Problems include filter clogging, taste and odor, excessive levels of ammonia, iron and manganese in both raw and treated water, and poor oxygenation or anoxic conditions in deep layers of the reservoir. Study of the problem led to the use of diffuse aeration combined with dephosphatation, which proved very efficient in solving the problem. "Before and after" descriptions of the reservoir's water quality are offered, with emphasis on oxygen, pH, temperature, nutrients (nitrogen and phosphorus), organic compounds, iron and manganese, and chlorophyll and algae. Nutrient inputs were identified and their annual inputs quantified. The feasibility of various proposed control solutions is discussed, and the method used is described. Improvements in treatment followed improvement in the reservoir's water quality; filter operation and chemical consumption and costs are discussed.
Descriptors: Eutrophication ; Reservoirs ; Aeration ; Phosphates ; Algae ; Treatment Plants ; Costs ; Management ; Filters ; Fouling ; France ; Water Quality ; Taste and Odor ; Oxygen ; pH ; Temperature ; Nitrogen ; Phosphorus ; Organics ; Iron ; Manganese ; Chlorophyll ; Destratification
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Waternet(tm) 1971-
** 28 ** records for DISPLAY
Enter HALT to exit DISPLAY

Option No.	TITLE
1	Improving the Water Quality of a Shallow Eutrophicated Reservoir: The Cas
2	Water Treatment Plant Design, Second Edition
3	Immunological Examinations in Patients With Chronic Conditions Under Admi
4	Removal of Organics From Leachate by the Combined Process of a Facultativ
5	Iron and Manganese Removal, Prospect Park Halton Hills (Acton), Ontario R
6	Experiences with Manganese in Queensland Water Supplies
7	Iron and Manganese Oxides in Finnish Ground Water Treatment Plants
8	Description of the New Parkersburg Water Treatment Plant
9	Certification Corner
10	Confluence -- Removing Iron and Manganese from Groundwater

Enter option number(s), HALT, /H for help, or press ENTER for next screen:
?5

1/5/5

022314 SN000687
Iron and Manganese Removal, Prospect Park Halton Hills (Acton), Ontario
Regional Municipality of Halton
Laughton, Richard V.
Pollutech Limited, Oakville, Ontario, Canada
1987 Joint Annual Conference, Ontario Section, American Water Works Association, and Ontario Municipal Water Association Ottawa, Ontario, Canada
May 3-6, 1987
43 p, 1987
Availability: AWWA
tables
Language: English
Document Type: Sect Pap
Continually high manganese and iron levels were found in the water supply feeding the Prospect Park pumping station in Halton Hills, Ontario. Although the iron and manganese levels were not high enough to be a health hazard, they caused several aesthetic problems, particularly in households, where staining of toilet bowls and staining of clothing were noticed. Because of this the Ontario Ministry of Environment undertook tests to determine the best chemical treatment for this water supply. Among the treatment processes examined were: aeration and filtration; pH adjustment followed by aeration and filtration; lime soda softening; ozone oxidation and filtration; chlorine dioxide oxidation and filtration; potassium permanganate oxidation and filtration; hypochlorite oxidation and filtration; and hydrogen peroxide oxidation and filtration. On the basis of performance and cost the treatments decided upon were potassium permanganate or chlorine dioxide followed by filtration.
Descriptors: Iron Removal ; Iron ; Manganese Removal ; Manganese ; Water Treatment ; Filtration ; Aeration ; Sodium Carbonate ; Chlorine Dioxide ; Ozone ; Potassium Permanganate ; Hydrogen Peroxide ; Hypochlorites
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Waternet(tm) 1971-
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Option No.	TITLE
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Enter option number(s), HALT, /H for help, or press ENTER for next screen:
?6

1/5/6
020928 WAT86024
Experiences with Manganese in Queensland Water Supplies
Loos, E.T.
Department of Local Government, Brisbane, Queensland, Australia

Water, vol.14, no.1, p 28-31, 37, March 1987
Publ: Australian Water and Wastewater Association
ISSN: 0310-0367
Availability: AWWA
11 references
Language: English
Document Type: Jnl Article

Manganese-related dirty water problems have been causing increasing concern to Queensland Local Authorities in recent year and have been generating many consumer complaints. The problems have received much publicity particularly in relation to the Gold Coast water supply scheme. At the request of the Local Authorities involved, a steering committee organized by the Department of Local Government has been coordinating and directing research into the problems. This paper describes the activities of the Committee, the projects undertaken and some initial results of the research up to December 1986.

Descriptors: Manganese ; Water Quality ; Surveys ; Water Systems ; Water Treatment ; Potassium Permanganate ; Aeration ; Destratification ; Research ; Biofilms ; Queensland ; Treatment Plants ; Australia

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Enter option number(s), HALT, /H for help, or press ENTER for next screen:
?9

1/5/9
017486 OPF85047
Certification Corner
OpFlow, p 3, 8, August 1985
Publ: AWWA
CODEN: OPFLDG ISSN: 0149-8029
Availability: AWWA
Language: English
Document Type: Newsletter

Questions in this month's Certification Corner deal with the selection of pipe sizes so the velocity of the water from the basin to the filters will not exceed a requirement of 2 fps; cross connections; aeration; chlorine leaks; the use of M-endo agar; groundwater; reservoir water levels; chlorine dosage; manganese; dry-barrel fire hydrants; the most probable number (MPN) test for total coliform bacteria; and filter rates.

Descriptors: Certification

1/5/25
005081 RFWQ0020
Benefits of Reservoir Destratification in England
Battersby, D. ;
AWWA Research Foundation Water Quality Research News , No. Five , p 3-4 , February 1980
CODEN: WQRND7
Availability: AWWA-RF
Sec Jnl Source: Journal of The Institution of Water Engineers and Scientists, September 1979, p 399
Language: English
Document Type: Newsletter
The value of a destratification system has been demonstrated at a number of sites in Great Britain, such as the Wimbleball reservoir completed in early 1979 after five years of construction. Aeration, thermal stratification, perforated pipe, iron, manganese, anaerobic conditions, dissolved oxygen, ammonia, and sulfide are discussed.
Descriptors: Reservoirs ;
Subject Codes: 1510 ;
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Waternet(tm) 1971-
** 28 ** records for DISPLAY
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Option No.	TITLE
21	Water Treatment Plant Design
22	The Quest For Pure Water - Iron and Manganese Removal
23	The Quest For Pure Water - Iron and Manganese Removal
24	Iron-Bacteria and Sulfide Problems in Wells
25	Benefits of Reservoir Destratification in England
26	Water Quality and Treatment A Handbook of Public Water Supplies 3rd Editi
27	Iron and Manganese Removal - A Case Study
28	Control of Reservoir Eutrophication

Enter option number(s), HALT, or /H for help:
?27

1/5/27
000693 JAW75042
Iron and Manganese Removal - A Case Study
Cleasby, John L.;
Journal American Water Works Association , p 147-149 , March 1975
Publ: AWWA
CODEN: JAWWA5 ISSN: 0003-150X
Availability: AWWA
4 references, tables, figure
Language: English
Document Type: Jnl Article
This article discusses the problem of attempting to remove iron and manganese from groundwater by means of precipitation and filtration. A case study of a

water treatment plant in Iowa which experienced severe red water problems illustrates the difficulties associated with iron-manganese removal. Generally, simple aeration and filtration will not succeed in removing manganese. Chemical oxidation with chlorine or potassium permanganate, addition of base to raise the pH, addition of coagulants, or provision of detention or flocculation may improve the flow scheme.
Descriptors: Iron Removal; Manganese Removal;
Subject Codes: 4250;
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Waternet(tm) 1971-
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26	Water Quality and Treatment A Handbook of Public Water Supplies 3rd Editi
27	Iron and Manganese Removal - A Case Study
28	Control of Reservoir Eutrophication

Enter option number(s), HALT, or /H for help:
?28

1/5/28
000330 JAW73045
Control of Reservoir Eutrophication
Eunpu, Floyd F.;
Journal American Water Works Association , p 268-274 , April 1973
Publ: AWWA
CODEN: JAWWA5 ISSN: 0003-150X
Availability: AWWA
5 references, tables, figures
Language: English
Document Type: Jnl Article
The Fairfax County Water Authority embarked on a study to determine methods for improving the raw-water quality in the Occoquan Reservoir by eliminating the existing eutrophic conditions. Tests were conducted to determine the amount of deterioration caused by excessive algal blooms during the summer months. Problems of taste and odor in the water as well as hydrogen sulfide, manganese and low dissolved oxygen were also experienced. After evaluating various methods of aeration, it was concluded that a reservoir turnover system would yield the desired results. Three compressors were installed in Mar. of 1970, and the system has been running continuously since April 1970. The results showed that the algae problem along with the other problems previously mentioned were eliminated with the reservoir turnover system.
Descriptors: Water Quality; Algae; Fairfax County, VA; Destratification;
Subject Codes: 4100; 4211;
****
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Subject Codes: 1510 ; 4210 ; 4100

1/5/6
016535 JNEW8418
The Haverhill Water Treatment Plant
Poirier, Oliver E.
Journal of the New England Water Works Association, p 271-290, September 1984
Publ: New England Water Works Association
CODEN: JNEWA6 ISSN: 0028-4939
Availability: AWWA
Language: English
Document Type: Jnl Article
This article describes the history and operation of the Haverhill, Massachusetts water distribution system during recent years. In early 1976, design of a 12 MGD treatment plant was started. Processes incorporated into the plant included: flash mixing using static mixers; flocculation and sedimentation; dual media filtration and adsorption of organics causing tastes and odors by granular activated carbon filters; and alum sludge disposal. Chemicals used during pretreatment, flash mixing, and posttreatment include sodium hydroxide for alkalinity and pH adjustment, potassium permanganate for oxidation of seasonal manganese, chlorine solution for periodic "shocking" and postchlorination, polymers or clay minerals for coagulant aids, and sodium silica fluoride. Other subjects covered include lake storage increases, raw water pumping station design, instrumentation and telemetering, laboratory design, construction and associated costs, and treatment plant performance.
Descriptors: Distribution Systems; Treatment Plants; Design; Operation and Maintenance; Performance; Massachusetts
Subject Codes: 5000; 4200; 5100; 3000

1/5/7
007475 JNEW7803
Pilot Plant Studied for Upland Water Supplies
Bryant, Edward A.
Journal of the New England Water Works Association, p 22-29, March 1978
Publ: New England Water Works Association
CODEN: JNEWA6 ISSN: 0028-4939
Availability: AWWA
tables
Language: English
Document Type: Jnl Article
The firm of Hazen and Sawyer Consulting Engineers developed process design concepts for three upland reservoir supplies which in the past had yielded water of adequate quality without filtration. The supplies, Trap Falls of Bridgeport Hydraulic Company, Connecticut, Pequannock supply of Newark, New Jersey, and the Croton supply of New York City, New York, have been used for many years, with treatment limited to disinfection and pH control with occasional algae control by copper sulfate. The treatment goal in each case was reduction of color and turbidity, with seasonal removal of iron and/or manganese so that the final product met AWWA treatment goals. In all instances, it was found that removal of color also resulted in satisfactory turbidity levels. Office studies and jar tests were carried out to reduce the actual pilot plant work to a minimum. The pilot plant design and construction for each plant is discussed, along with the results of all the tests run and the costs of various treatment processes.
Descriptors: Reservoirs; Water Quality
Subject Codes: 1510; 4100
****
Press ENTER to return to list of items for display
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ATTACHMENT D

Andover, MA

Experiences manganese problem during low water, drought, conditions.

Haverhill, MA

Seasonal manganese problems associated with reservoir stratification and fall turn over.

Potassium permangante is used seasonally for control, aeration was evaluated.

Ipswich, MA

Manganese problems associated with low reservoir draw downs.

Previously treated with potassium permangante, now controlled with a reservoir aeration system.

North Andover, MA

Seasonal manganese problems associated with reservoir stratification and fall turn over.

No control until a treatment plant with pre-ozonation (on line 1992) was built. The new plant treated the elevated manganese levels successfully.

Peabody, MA

Seasonal manganese problem.

Controlled by year round aeration of reservoir and pH control during filtration.

Portsmouth, NH

Seasonal manganese problems associated with reservoir stratification.

Aeration is used to control, but oxidation with chlorine is sometimes necessary.

CITY OF CAMBRIDGE
CAMBRIDGE, MASSACHUSETTS 02139

TEL. 349-4300
FAX. 349-4307

EXECUTIVE DEPARTMENT
ROBERT W. HEALY
City Manager

RICHARD C. ROSSI
Deputy City Manager

7.

November 16, 1992

To the Honorable, the City Council:

In response to Awaiting Reports #22 and #27 regarding the color of the tap water, please find enclosed a report from the Managing Director of the Water Department, Nancy Barnes.

In addition to the efforts outlined in the attached report, the Water Department is exploring methods to improve its public notification system which include: phone messages for callers during off-hour detailing the water problem; a quarterly newsletter to inform residents about seasonal water quality issues; and in certain emergency situations, notification of area residents when a water problem exists via loud speaker.

Very truly yours,

Robert W. Healy
City Manager

Attachments

Consent Agenda # 7 S 958

Awaiting Report Item Nos. 22 and 27
regarding the color of tap water.

In City Council,

November 16, 1992

Placed on file