USACHPPM **TG 284**

Drinking Water Consumer Complaints: Indicators from Distribution System Sentinels

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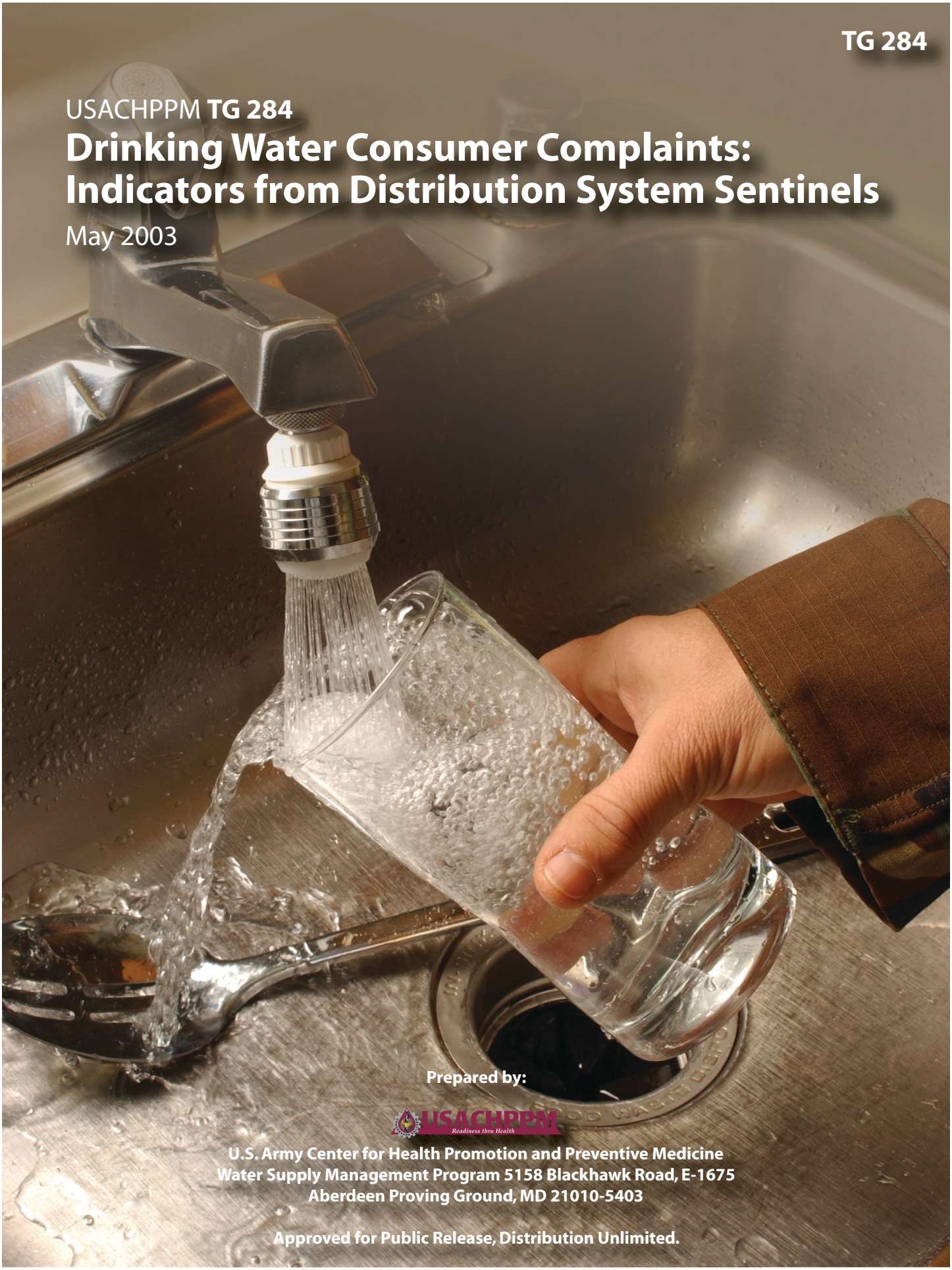

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Executive Summary

Contaminated drinking water on a U.S. military installation could adversely impact the health of personnel and the mission of the installation. Localized and widespread illness and fatalities could also generate a great deal of media attention, nationally and internationally. Confidence in the military's ability to protect soldiers, their families, and installation personnel from a terrorist attack would be greatly decreased. Such an attack would also lower morale and raise fear.

Many Army installations are searching for guidance on how to develop better drinking water monitoring systems. An "all-inclusive" sensor that alerts the installation to the presence of chemical, bacteriological, and radiological contaminants has not been developed. In this absence, Army installations have relied heavily upon commercial-off-the-shelf and Supervisory Control Data Acquisition (SCADA) system technologies to monitor water quality and safety. These technologies are effective, but require purchase, sometimes installment, and calibration. Also, their cost can be prohibitive.

Army installations can improve their drinking water surveillance system by following the low cost, systematic procedure outlined in this technical guide. The presence of many drinking water contaminants affects drinking water aesthetics and can be detected by consumers. In some cases, their sense of smell rivals highly expensive analytical instruments by detecting some chemicals at nanogram per liter (ng/L) or 10^{-9} grams per liter (g/L) levels. In fact, consumer complaints have been linked to contaminated water incidents such as the 1993 *Cryptosporidium* outbreak in Milwaukee, Wisconsin. Installation drinking water consumer complaints should be an integral part of a drinking water monitoring program.

From a health surveillance standpoint, drinking water consumers are the untapped surveillance resource. They act as "real-time" water quality and safety sensors that provide feedback. These water quality monitors are located at every point in the distribution system at all times. Unfortunately, consumer complaints have not been effectively handled at most Army installations, because installations have—

- Not designated one organization responsible for all complaints.
- No official standing operating procedures response, investigation, or documentation.
- Never received systematic guidance on handling complaints from any drinking water organization in the world.

USACHPPM developed this technical guide to aide Army water utility personnel, environmental managers, and Preventive Medicine personnel in the optimization of the

consumer complaint resource. To improve drinking water surveillance, the following actions should be taken—

- Contact the State primacy agency responsible for drinking water regulation, because some States, such as Pennsylvania and Tennessee, require records of consumer complaints be maintained.

- Promptly designate one organization responsible for all complaints and improve their consumer complaint handling procedures.

- Reevaluate missions and reprioritize tasks to address consumer complaint handling system upgrades outlined in this guide.

- Record and store all complaint information in one electronic database (preferable) or one paper log file.

- Display data visually on distribution system maps and other generated charts and graphs.

- Use this technical guide when conducting on-site visits, when determining what drinking water-related laboratory analysis tests should be conducted, and what appropriate follow-up investigation actions need to be taken.

- Use a risk communication approach when speaking with consumers. Contact installation public affairs officers to develop a strategy to effectively handle drinking water issues.

- Educate consumers about aesthetic problems and who to contact if they are concerned through installation newspapers, in-processing information packages, and Consumer Confidence Reports.

- Develop and implement programs for the reasons recommended in this guide at Army installations outside the continental United States.

- Responsible organizations at Army installations should contact the U.S. Army Center for Health Promotion and Preventive Medicine Water Supply Management Program for additional guidance on any drinking water issues (Water.Supply@apg.amedd.army.mil).

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Chapter I

Introduction

1-1. Purpose

Consumer complaints may be the first indicators of a terrorist attack. Currently many consumer complaints are not effectively handled at Army installations, because there are multiple investigators on post (that is, water system managers, environmental managers, and preventive medicine (PM) personnel), and they rarely coordinate with one another. This technical guide (TG)—

a. Provides U.S. Army installations with a basic understanding of the importance of these complaints.

b. Sets forth a systemic approach to effectively responding and investigating complaints, as well as provides direction on how to best use the data. Prior to this document, the Army had never developed complaint handling and investigation guidance.

c. Provides tools for evaluating installation complaint response and tracking systems.

1-2. References

Referenced publications are listed in appendix A.

1-3. Improving water quality surveillance

a. Drinking water contamination can be far reaching. The effect of the *Cryptosporidium* outbreak of 1993 in Milwaukee, Wisconsin emphasizes this point. In Milwaukee, more than 400,000 people became ill and more than 100 people died as a result of ingesting contaminated drinking water (Mac Kenzie et al., 1994). Similar to the severe health affects and many fatalities in Milwaukee, successful terrorist attacks can have health impacts along with long-lasting psychological effects such as anxiety (North et al., 1999; Blendon et al., 2002; Moores, 2002; Schlenger et al., 2002). Considering the likelihood of a terrorist attack that is directed at waterworks, utility personnel must remain vigilant and scrutinize their drinking water monitoring programs for their ability to effectively detect contaminated drinking water (Sloan, 1995).

b. Many water utilities are searching for an "all-inclusive" sensor that can alert the utility if a harmful chemical, bacteriological, and radiological contaminant is present. This thinking is reinforced in an article published in a 2003 *Journal of American Water Works Association* issue where the authors state:

> *"The ideal approach to analysis of water supplies for the presence of harmful substances is continuous online monitoring systems that detect sudden changes in water quality and provide real-time data to plant operators or SCADA [Supervisory Control Data Acquisition] systems"* (States et al., 2003)

c. Recent motivation for developing monitoring devices has been driven by the fear of terrorist attacks against drinking water systems (Bush, 2002; Schlueb, 2002; Sweet, 2002; States et al., 2003). Unfortunately, this "all-inclusive" detector has not been identified, and as a result, water utilities have focused on monitoring multiple water quality parameters such as pH, disinfectant residual concentration, turbidity, and coliform bacteria using commercial-off-the-shelf technology and existing SCADA systems. Ideally though, a fully functioning early warning system should be able to provide warning in sufficient time for action, to only require low skill and training, to allow for remote operation, to function year-round, and the cost should be affordable (International Life Science Institute, 1999).

d. Should terrorists attack the American people, many researchers have speculated that the first warning would likely be an increased number of people admitted to the emergency room, increased purchases of influenza medicine, or increased absences from school or work (Hickman, 1999; Barthell et al., 2002; Green and Kaufman, 2002; Hess, 2002). Therefore, public health officials are developing "syndromatic surveillance" systems, which specifically track the occurrence of reported signs and symptoms rather than positively diagnosed diseases (Lazarus et al., 2001; Barthell et al., 2002; Green and Kaufman, 2002). Water utilities are not likely to use this technology, but the methodology can be applied to track and analyze drinking water complaints.

1-4. Value of consumer complaints

a. Consumers of drinking water are the untapped surveillance resource at all Army installations. They can detect changes in water temperature, clarity, color, taste, odor, chlorine residual concentration, salinity, hardness, dissolved solid concentration, and mineral concentration (Mallevialle and Suffet, 1987; Whelton, 2001). Furthermore, consumers have demonstrated that their sense of smell is comparable to highly expensive analytical instruments. Consumers have detected some chemicals at nanogram per liter levels (ng/L) or 10^{-9} grams per liter (g/L) (Mallevialle and Suffet, 1987).

b. Feedback from drinking water consumers is particularly valuable to water suppliers, because it is a "real-time" water quality assessment at no cost to the utility. Additionally, these water quality monitors are located at every point in the distribution system where water is being used at all times. In the past, consumer feedback has been linked directly to drinking water contamination (Petersen et al., 1988; Ridder, 2002). Many water utilities around the United States acknowledge that consumer complaints are valuable, but their usefulness as contamination indicators has not yet been tapped. Routinely, some utilities use complaints to help prioritize flushing of the distribution system and locate problems of distribution quality (AwwaRF and AWWA, 1992; Bullock et al., 1999). Complaints have not yet been fully integrated into the early warning monitoring system.

c. The ability to detect free chlorine residual concentration changes makes drinking water consumers valuable water quality monitors. At most Army installations, free chlorine is the primary defense against contaminant stability in the distribution system water. This chemical disinfectant is effective at neutralizing almost all conceivable contaminants. For example, cyanide and botulinum toxin can be destroyed by free chlorine (Burrows and Renner, 1999; Whelton et al., 2003). In addition to the disinfection advantage of free chlorine, a secondary advantage is that changes in the free chlorine residual concentration cause consumer complaints and unmask other odors present (Worley et al., 2003). Therefore, consumer complaints are sometimes indicators that the concentration of free chlorine protecting the distribution system is changing and unwanted contaminants are present.

d. Historically, consumer complaints have accompanied some drinking water contamination incidents. For example, an inadvertently opened valve at a Connecticut water treatment plant diverted fluoride into a city water supply (Petersen et al., 1988) causing consumers to ingest fluoride and copper at concentrations 40 times greater than normal. Many of the consumers contacted the water utility and reported clinical symptoms such as severe nausea, vomiting, diarrhea, abdominal cramping, and skin irritation. Other consumers complained that their water had an abnormal taste or that it turned blue on contact with soap.

e. These consumer complaints were effective in alerting the Connecticut water utility that there was a problem and prompted an investigation. In another example, a review of telephone logs from the water department in Milwaukee, Wisconsin found a number of widespread complaints, which were caused by the presence of *Cryptosporidium* (Blair, 1995). Many U.S. Army water utilities, similar to these examples, have found that consumer complaints are good indicators of drinking water problems (Valcik et al., 1995).

1-5. Types of complaints

a. Consumers frequently judge water quality based on their perceptions of taste, smell, vision, and touch. Consequently, some consumers have higher response thresholds than others. This is exemplified by some consumers detecting an earthy odor (caused by a chemical called geosmin) at an aqueous concentration as small as 15 ng/L, while others detect this odor at only 5 ng/L (Mallevialle and Suffet, 1987). This consumer threshold variance is normal, but often misunderstood. For instance, some water utilities may not understand why one person may detect a water quality change (that is, odor) at their tap when others may not. Some common causes of consumer complaints are provided in appendix B and EPA (1991) and McGowan (1982).

b. At U.S. Army utilities, drinking water is highly scrutinized. The Environmental Protection Agency and State primacy agencies require drinking water be tested, in some cases numerous times per day, for a number of different chemicals. Since waterborne illness rarely occurs in the U.S., Army installations should consider complaints involving illness and drinking water to be extremely alarming. They should respond to and solve these complaints as quickly as possible, because the health of their consumer population may be negatively affected. These complaints may be indicators of intentional drinking water contamination, cross-connections with non-potable water, or water treatment process malfunctions.

c. Some noticeable water quality problems present a health risk to consumers while others may only affect the aesthetic water quality. For instance, the human sense of sight allows consumers to detect noticeable changes in the appearance of their water. Changes of clarity (measured as turbidity) or color are highly valuable water quality indicators. Detection of decreased clarity or changes in color could indicate the presence of toxic contaminants and or the suspension of sediment caused by operations, such as routine distribution system flushing activities.

d. Water utilities across the U.S. constantly want to provide consumers with water that is free of off tastes and odors. Fortunately, many toxic chemicals impart a taste or odor to the water when present. Detection of unwanted tastes and odors could indicate the presence of a non-toxic microbial byproduct or a toxic chemical. The most common odor complaint is chlorine. If the chlorine concentration is below 4.0 milligrams per liter (mg/L), it only poses an odor problem. Allowing water to sit for two minutes usually reduces or eliminates the odor.

e. The sense of touch is usually overlooked when dealing with water quality complaints. Several researchers have described the perception of how the water feels, or for lack of a better word, its texture. Consumers may attempt to describe this quality to the investigator by using some common textural descriptors such as gritty, putty, and sand-like. These descriptors could indicate such problems as the precipitation of metals

and or introduction of sediment into the distribution system after a main break. See appendix B for other examples.

1-6. Notable contaminants that affect consumer perception

a. Many public health officials have expressed concern that terrorists may attempt to contaminate drinking water with chemical and biological warfare agents. While such an attempt to disrupt water plant operations is possible, a high level of expertise is required to obtain, transport, and dose these hazardous chemical and biological agents. More likely, terrorists will contaminate drinking water using common chemicals such as industrial solvents, pesticides, and herbicides.

b. Water suppliers are fortunate that chemical agents have noticeable characteristics such as tastes and odors and also affect clarity and color. Consumers will most likely reject this characteristic water as safe and file a complaint (Sanchis, 1946). Table 1-1 contains the aesthetic attributes of several of the most prevalent chemical warfare agents (Sanchis, 1946; USACHPPM, 1985; OTSG, 1997). Of the chemicals in Table 1-1, cyanide has historically received a large amount of notoriety as a chemical that can be used to contaminate drinking water (Lyman, 2002). Cyanide has been used for thousands of years as a drinking water poison and has recently been found in the possession of terrorists (Craun and Calderon, 2001).

Table 1-1. Aesthetic Attributes of Water Containing Chemical Warfare Agents

Compound Name	Taste Descriptor	Odor Descriptor	Color Descriptor	Turbidity Present (Yes/No)
Tabun (GA)	Not reported	Fruity	Colorless to brown	No
Sarin (GB)	Not reported	Odorless	Colorless	No
Soman (GD)	Not reported	Fruity, camphor	Colorless	No
VX	Not reported	Odorless	Colorless to straw-colored	No
Lewisite (L)	Not reported	Geranium, obnoxious	Colorless	No
Sulfur mustard (H or HD)	Not reported	Garlic, mustard, obnoxious	Pale yellow	Yes
Nitrogen mustard (HN)	Fishy	Fishy	Colorless	No
Cyanogen chloride (CK)	Sharp, biting, metallic	Pepperish	Colorless	No
Hydrogen cyanide (AC)	Bitter, metallic	Almonds, marzipan, peach kernels	Colorless	No

c. Terrorists have been suspected of using chemical poisons such as pesticides, herbicides, and fungicides. These chemicals are easier to obtain and transport than chemical warfare agents. As illustrated in Table 1-2, many of the chemicals have associated odors, which if present in drinking water could indicate their presence. Also, ingestion of these chemicals at acute concentrations would result in consumers experiencing negative health affects (that is, nausea, vomiting, and diarrhea), and ingestion could be fatal. Appendix C contains information on several water quality parameters that may give rise to a complaint.

Table 1-2. Ingestion Symptoms and Odor Attributes of Water Containing Some Pesticides, Herbicides, and Fungicides

Compound	Classification	Odor	Symptoms
Alachlor	Pesticide	Chlorobenzene[1]	Nausea, vomiting, headache, dizziness, fatigue, unconsciousness
Aldicarb species	Pesticide	Not Reported	Nausea, vomiting, airway obstruction, seizures
Chlordane	Insecticide	Musty/ Chlorinous	Convulsions, deep depression, degenerative changes in liver
Chloropicrin	Insecticide/ Fungicide	Yes[2]; Not Reported	Nausea, vomiting, colic, diarrhea, skin irritant, headache, nausea, sweating, tearing, tremors, blurred vision
Cyanazine	Herbicide	Not Reported	Skin and respiratory tract irritant
2,4-D	Herbicide	Chlorophenol[1], musty	Nausea, vomiting, abdominal pain, burning sensation, diarrhea, headache, unconsciousness, weakness
2,4-dichlorophenol	Pesticide/ Herbicide	Not Reported	Abdominal cramps, burning sensation, sore throat
Dicamba	Herbicide	Not Reported	Death, blindness, gastro-intestinal disturbances, convulsions
2,4,6-trichlorophenol	Pesticide/ Herbicide	Phenolic[1]	Nausea, vomiting, diarrhea, weakness

[1]Odor research is limited; some of the odor descriptions attributed to these chemicals are other chemical names.
[2]The source for the chloropicrin odor did not specify an odor descriptor.

d. Public health officials have speculated that the most likely biological agent choices are botulinum toxin and *Cryptosporidium*. While biological agents have not been found to cause objectionable tastes, odors, or colors in drinking water, they are similar to chemical agents in that consumers will experience discomfort or severe health affects (Burrows and Renner, 1999; Craun and Calderon, 2001). Table 1-3 contains the ingestion symptoms of water containing some well-known microbiological contaminants. The most common complaints are nausea, vomiting, and diarrhea. Consumer complaints such as these could be prime indicators of contaminated drinking water. Also, changes in chlorine residual levels may indicate the presence of harmful microorganisms as the organic matter-chlorine reaction results in reduced chlorine concentrations.

Table 1-3. Ingestion Symptoms of Water Containing Several Microbiological Contaminants

Contaminant	Disease	Microorganism	Clinical Symptoms
E. coli 0157:H7	Dysentery	Bacteria	Diarrhea, abdominal pain, bloody stools
Campylobacte	Campylobacteriosis	Bacteria	Nausea, vomiting, diarrhea, bloody stools
Shigella	Shigellosis	Bacteria	Diarrhea, abdominal pain, and bloody stools
Salmonella typhimurium	Salmonelloses	Bacteria	Vomiting, diarrhea
Salmonella typhi	Typhoid fever	Bacteria	Vomiting, diarrhea
Vibrio cholerae	Cholera	Bacteria	Diarrhea, rapid dehydration to a state of collapse
Cryptosporidium parvum	Cryptosporidiosis	Protozoan	Nausea, diarrhea, and stomach cramps
Giardia lamblia	Giardiasis	Protozoan	Nausea, diarrhea, bloating, headache, stomach cramps, weight loss
Cyclospora	Cyclosporiasis	Protozoan	Nausea; vomiting; diarrhea; sometimes explosive, bowel movements; loss of appetite; substantial loss of weight; increased gas; stomach cramps; muscle aches; low-grade fever; fatigue
Norwalk virus	Viral gastroenteritis	Virus	Nausea, vomiting, diarrhea, fever
Hepatitis A virus	Hepatitis	Virus	Nausea, vomiting, may turn yellow, dark urine, tired, appetite loss, fever, stomach ache

Source: CDC (2002).

Chapter II

Complaints at Army Installations

2-1. Potable water system responsibilities

a. U.S. Army drinking water criterion identify water system managers, environmental managers, and PM personnel as having the shared mission of ensuring that safe drinking water is provided to the installation's consumers (DA, 1990; DA(a) 1997; DA(b), 1997). As a result, all of the aforementioned personnel are responsible for safe drinking water. Such responsibilities include—

(1) Reviewing drinking water laboratory data.

(2) Overseeing the distribution system.

(3) Responding to pipe breaks and consumer complaints.

b. Of the three aforementioned personnel, PM is usually the most understaffed and over tasked. As a result, PM should not handle consumer complaints alone. Some of the many tasks PM is charged with include controlling rodents and pest populations on post, ensuring people are properly protected from any onsite radiation, conducting training courses for soldiers on field sanitation, collecting data on installation disease and climactic injuries as well as teaching preventive measures, and overseeing wastewater treatment, air quality, hazardous waste, and solid waste (DA, 1990). Water utility personnel are usually the main consumer complaint investigators on Army installations, while environmental office managers typically handle installation compliance with applicable Federal and international regulations and guidelines. At some installations, environmental office personnel take part in the complaint investigation process. Fire departments have also been known to receive drinking water complaints.

2-2. Existing challenges

a. Frequently, consumers contact one or more of the aforementioned organizations when they are concerned about drinking water quality. This usually occurs because they do not know whom to contact. For example, at one installation persons concerned about their drinking water mainly contacted a Department of Public Works Work Order Desk. The Work Order Desk was developed to receive all telephone calls regarding installation infrastructure problems in addition to water such as housing and road

repairs. Once the call was received, Work Order Desk clerks are instructed to take down the complainant's name, telephone number and building number and forward this information on to the proper installation organization (that is, water utility, road repair, housing department). Upon USACHPPM's investigation though, the problem was found to be two-fold. First, work order clerks sometimes answer consumer's questions based on their previous experience and second, some of that consumer interaction is not recorded and relayed to the water system manager.

b. Another issue facing installation drinking water surveillance programs is that water system managers, environmental office personnel, and PM personnel rarely coordinate the consumer complaint investigation and follow-up. For instance, PM personnel may receive the complaint, investigate the problem by obtaining and testing water samples, and then document their findings within the PM office. Water system managers may never be informed of the complaint being filed, the investigation, or the sampling results.

c. Characteristic of many Army installations, there is a decentralized approach to handling and investigating complaints. As found at several Army water plants visited, complaint records are not stored in paper or electronic forms. For instance where complaint records were kept, complaint-related water testing results were not stored along with the complaint record. A decentralized approach to handling indicators of water quality problems is a recipe for disaster should a contaminated water incident occur.

2-3. Common complaints

a. Complaints about discolored water are the most common at Army installations. Many are a direct result of stagnation and subsequent corrosion of drinking water transmission lines and household plumbing. When metals such as iron and copper leach into the water, they can be found in dissolved or particulate form causing discoloration and affecting the water clarity. Inadequate corrosion control treatment, poor flushing programs, and defective piping materials can also contribute to this problem. Effective corrosion control and flushing can minimize these types of complaints (AWWA, 1986; AWWA, 1999; Friedman et al., 2002). Appendix D contains iron-related complaint guidance that can be used as a guide when addressing these water quality problems.

b. Other types of complaints are less common, and generalizations about their origin are more difficult. Some common complaints include earthy, musty, fishy, and rotten-egg odors and metallic, astringent, and bitter tastes. Also, a number of drinking water quality concerns at Army installations involve microbiological contamination, namely

coliform bacteria and *Cryptosporidium* (DA(a), 1997). Some Army installations have spent thousands of dollars to remedy aesthetic water problems.

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Chapter III

Systematic Complaint Response and Tracking

3-1. Complaint handling system elements

Integral parts of a consumer complaint handling system are listed below. These elements must be present in order for a complaint handling system to work effectively and efficiently.

a. Senior Personnel Oversight. Appropriate supervisory personnel from the water system operation and maintenance, environmental management, and PM should oversee the complaint handling system. Oversight includes reviewing frequent complaint database reports and follow-up actions.

b. Single Point-of-Contact. A single point-of-contact for the installation should be established; this is the most critical aspect of a consumer complaint handling system. Without a single point-of-contact, multiple organizations may find themselves investigating the same complaint, and previous complaint experience may not be used. Most importantly, early detection and timely response to a contaminated water incident would fail to occur.

c. Consumer Education. Installation water systems should make consumers aware of whom to call and encourage them to report any water quality or supply problems. Awareness can be accomplished through articles or advertisements in installation newspapers, in-processing information packages, and Consumer Confidence Reports (CCRs) (DOD, 1999).

d. Established Procedures. Consistent and effective procedures for handling complaints should be used at Army installations. Procedures should be adopted at the installation for receiving a complaint, conducting a field investigation, requesting minimum laboratory analyses, and coordinating follow-up actions. The above-mentioned procedures are discussed in more detail in chapter IV.

e. Complaint Database/Log. One complaint electronic database/log per installation should be developed (Tables 3-1 and 3-2). This information will be helpful to investigators when responding to future complaints and in identifying any chronic water quality problems such as locations of low chlorine residual concentrations in the distribution system.

Table 3-1. Example of Spreadsheet for Consumer Complaints: Receiving Information

Complainant Information				Complaint Information		
Complainant Name	Bldg No.[1]	Street Address	Telephone No.	Type[2]	Descr.	Location
Whelton, A.	127	Houndschase Blvd.	(410) 456 – 3254	Tste	Metals	Kitchen
Richards, T.	87	Sycamore Drive	(567) 235 – 3234	O	Dirt	Bathroom
Smith, J.	3422	Brier Court	(410) 465 – 7890	C	Red	Dryer
Epstein, J.	98	Particay Lane	(410) 333 – 1267	Turb	Visible	Kitchen
Whelton, A.	127	Houndschase Blvd.	(410) 456 – 3254	C	Yellow	Bathroom
Hangstrom, C.	1034	Ridge Street	(410) 989 – 5920	C	Green	Bathroom
Ford, B.	2	Dandelion Way	(410) 333 – 4521	O	Grassy	Kitchen
Junior, E.	78	Macafee Street	(410) 465 – 3265	O	Musty	Kitchen
Demetri, J.	4	Trisket Station	(410) 235 – 6417	Tste	Chlorine	Bathroom

[1]Bldg No. = building number.
[2]C = color, O = odor, Tste = taste, and Turb = clarity.

Table 3-2. Example of Spreadsheet for Consumer Complaints: Investigation Information

Filing Info.		Field Investigation Information Sample #1 - Location of Complaint							
Unique No.	Date Filed	Date Invest.	Invest. By	pH	Temp.	Cl_2 Res.[1]	NTU[2]	Taste	Odor
0001	1/3/00	1/3/00	JWH	7.50	25.0	0.42	1.0	Metallic	None
0002	1/5/00	1/5/00	DME	7.60	28.1	1.00	1.0	Earthy	Earthy
0003	1/5/00	1/5/00	AJW	7.52	5.0	1.40	1.0	NA	None
0004	1/5/00	1/5/00	DME	7.50	16.8	0.20	1.0	NA	None
0005	1/8/00	1/8/00	AJW	7.50	22.1	0.10	1.0	NA	None
0006	2/3/00	2/3/00	AHE	7.50	14.5	0.30	1.0	NA	None
0007	4/16/00	4/16/00	JHW	7.54	24.0	0.00	1.0	Grassy	Waxy
0008	4/16/00	4/16/00	JHW	9.10	23.5	0.40	1.0	Musty	Musty
0009	5/12/00	5/12/00	JHW	7.45	25.0	1.80	1.0	Chlorinous	Chlorinous

[1]Cl_2 Res. represents chlorine residual concentration.
[2]NTU = water turbidity.

f. Visual Data Representation. All consumer complaint data should be presented on maps, charts, graphs, and tables (Figures 3-1 through 3-4). These representations will give the installation a quick and easy summary of the water quality problem, the type of complaints filed, and the number and type of consumers being affected (that is, soldiers, children, and civilians).

Figure 3-1. Map of the XYZ Water Distribution System Showing the Spatial Location of Complaints. The darkened circles indicate the location of one consumer complaint.

Figure 3-2. Map of an Actual Army Water Distribution System Showing the Spatial Location of Water System Problems. The red circles indicate the location of one problem.

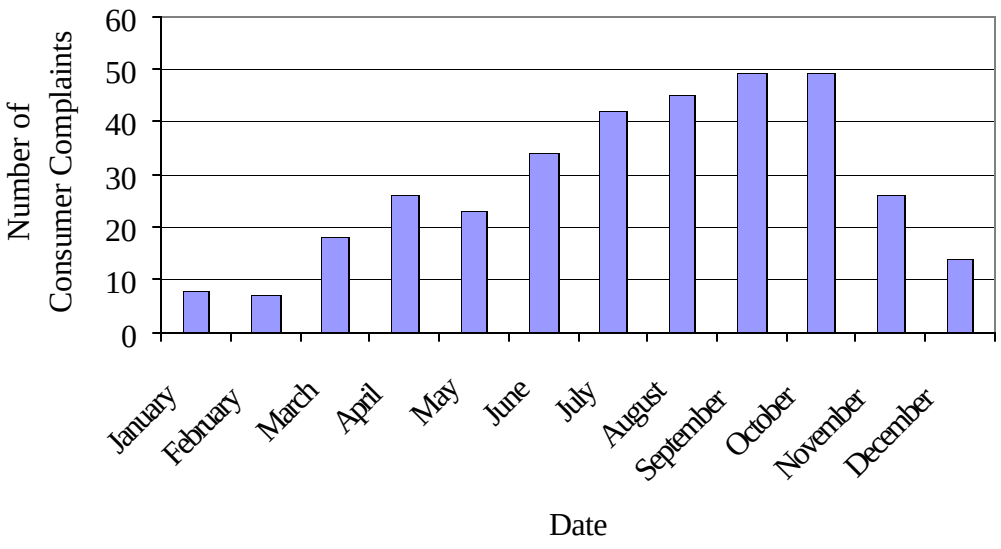

Figure 3-3. Bar Chart Showing Monthly Complaint Totals for the XYZ Water System

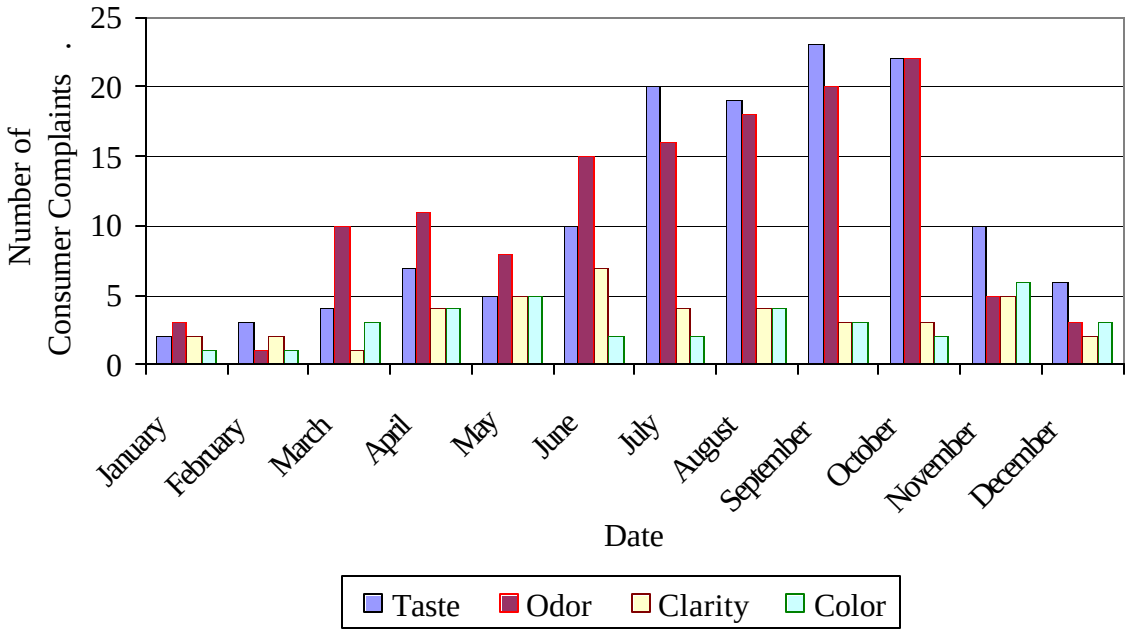

Figure 3-4. Bar Chart Showing Monthly Complaints Sorted by Type at the XYZ Water System

g. Flagging Illness. Specific complaints such as those that cause physical discomfort (such as nausea and vomiting) and most certainly death should be "flagged" or permanently marked in the electronic database and on a map. Illness complaints may indicate that a harmful contaminant is present in the drinking water. These types of complaints should receive immediate attention.

3-2. Documentation

All water system complaints, causes, investigations, and resolution actions should be documented at the installation. Appendix E contains examples of consumer drinking water complaint forms. These forms are currently used at public drinking water systems in the United States. Additionally, all information obtained from consumer complaints and the preceding investigations should be kept for future complaint investigations to determine if trends exist (that is, chronic water quality problems in that part of the distribution system).

a. All complaints should have a unique serial number assigned. This number will mark the complaint in the installation's historical complaint record and allow for quick reference. These unique reference numbers should be provided on every document including the on-site investigation form, laboratory analyses, and interoffice memorandums.

b. The most common way of documenting the history of consumer complaints is by writing the information in a paper log and physically marking the complaint on a paper map. This method is easy; however, it has many disadvantages:

(1) Paper files are vulnerable to deterioration with age.

(2) Paper files can be removed and potentially misplaced.

(3) The pencil and ink markings can fade and smudge over time.

(4) The data cannot be easily analyzed.

c. While paper files may prove adequate for a small water system under normal operating conditions (no presence of contaminated drinking water), they are extremely undesirable should a contaminated water situation develop, regardless of the water system size. First, if a contamination should occur, the installation is likely to receive an increased number of complaints. Handling paper files can be troublesome and can result in misplaced files. Also, installation managers and public health officials investigating the complaint will want to be able to access all complaint information quickly and easily. Furthermore, analyses on data recorded in a paper log can be very time consuming. This is particularly relevant in a medium to large drinking water facility. Army installations should develop an electronic database and keep any associated complaint paper files in storage as backup.

d. A Microsoft® Excel spreadsheet or Microsoft® Access database are examples of the current software products used to store consumer complaint information. Microsoft is a registered trademark of Microsoft Corporation, One Microsoft Way, Redmond, VA 98052-6399. An obvious advantage of this type of storage is that data can be saved in multiple locations fairly easily (that is, on a computer hard drive, floppy disk, or compact disk). Additionally, consumer complaint data can be tracked and even displayed graphically. The electronic tracking system is only effective if it is routinely checked and maintained for complaint accuracy. Paper documents created during the complaint investigation process should be kept on file as a backup to any electronic documentation. This "double documentation" is a preventive measure against loss of data.

e. Regardless of which filing methodology is used, standard information and actions should be documented in at least two locations throughout the investigation process. This documentation process will physically reflect that the water system personnel care for the consumers, the detection of contaminated water, and the discovery of water treatment problems on the installation. Storing complaint information in electronic format will better aid other investigators, such as public health officials, should their services be required. Having a paper file as a backup will also demonstrate to the

installation Commander and staff that the water utility is carefully monitoring the drinking water. Particular care must be taken to protect these files from damage (that is, water and fire) and theft.

f. Some Army water systems in the continental U. S. (CONUS) face State regulatory requirements for documenting consumer complaints and associated responses. For example, both Pennsylvania and Tennessee require maintenance of consumer complaint records (Commonwealth of Pennsylvania, 1999; State of Tennessee, 1999). The Pennsylvania and Tennessee regulations specifically relating to consumer complaints are shown below. Regulations applicable to installations outside the continental U. S. (OCONUS) do not address consumer complaints or their documentation; although tracking consumer complaints should be integrated in water utility daily operations.

> *"A public utility shall make a full and prompt investigation of complaints made by the Commission or by others, including customers…A public utility shall preserve for a period of at least 5 years, written service complaints showing the name and address of the complainant, the date and character of the complaint, and the final disposition of the complaint." Commonwealth of Pennsylvania [Section 109.701(b)(3)]*

> *"All community water systems must establish and maintain a file for consumer complaints. This file should contain the name of the person with the complaint, date, nature of the complaint, date of investigation and results or actions taken to correct any problems." - State of Tennessee [Section 1200-5-1-17(24)]*

3-3. Revising or establishing complaint-handling systems

a. Army criteria do not address the details concerning how installations should coordinate consumer complaints. The criterion does, however, explicitly require close coordination between installation water operations and maintenance, environmental management, and PM personnel responsible for the provision of safe drinking water. This rarely occurs.

b. The methods for addressing consumer complaints must be established locally. A forum to create the consumer complaint handling system could be the installation's Environmental Quality Control Committee [see Commonwealth of Pennsylvania (1999), paragraphs 1-27a(6) and 15-11]. Other mechanisms to address the consumer complaint system could be memorandums of understanding and or agreement (MOUs/MOAs) (MEDCOM, 1997). The MOUs and MOAs are official documents that explain the responsibilities and roles of two or more organizations when dealing with a multi-

departmental issue. They can also define the roles and responsibilities of multiple installation departments and water distribution system maintenance.

c. Prior to revising the consumer complaint system, current consumer complaint investigators should be consulted, because they are the persons solving the problems and will most likely provide useful suggestions. Although many of these individuals may not be in installation management, they do possess the practical field knowledge of Army installation consumer complaints. Their experience and expertise is needed to create a well functioning complaint system.

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Chapter IV

Complaint Handling Procedures

4-1. General guidance

a. Water systems personnel must initially consider every complaint pertinent and important and give each complaint immediate attention. Persons receiving the complaint may need to reprioritize tasks and or reassign personnel as needed to quickly resolve complaints. Complaints can be an indicator of significant health risks and could affect the complainant or multiple consumers. Some complaints may be resolved during the initial contact with the consumer, while others will require further investigation. Figure 4-1 depicts a decision wheel for handling consumer complaints.

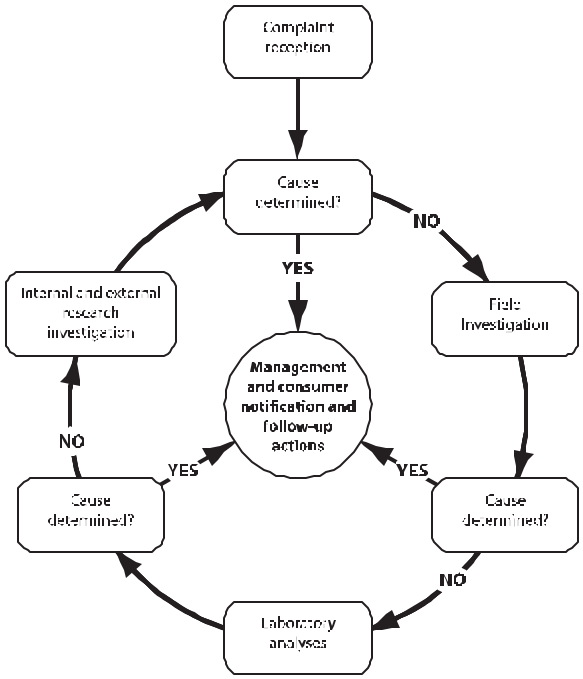

Figure 4-1. The Consumer Complaint Decision Wheel.

b. When dealing with consumers, the complaint investigator should be courteous and remember to thank the consumer for calling the water utility. When taking the complaint, the investigator must listen carefully and calmly. Complaining consumers are usually frightened and concerned about the safety of their water. Patience will be required, because most consumers will not understand that aesthetic problems might exist even after the drinking water has been treated.

c. Whenever an illness complaint is filed, all directors of the water system, public works, and PM divisions should be notified by the central point-of-contact receiving all complaints. These types of complaints must be addressed immediately to protect consumer health and to prepare for possible legal consequences. All illness complaints require an on-site visit and laboratory analyses. Directors of the water system, public works, and PM should also be informed about unusual or unresolved complaints and ongoing resolution efforts.

d. All complaints must be resolved promptly. A complete resolution includes providing an educated reason to the consumers and water system managers as to why the complaint was filed and what actions were taken to resolve the complaint. Also, the complaint investigator should contact the consumer a week after the last communication to see if there are any other drinking water problems or if the problem still persists.

e. Good customer service is necessary at Army installations. If the consumer is not satisfied by the investigation, they will likely file another complaint and quite possibly alert other installation personnel that their previous complaint was not adequately addressed. Another major reason to quickly address and resolve complaints is that installation managers may question the competence of the investigation team if there are unresolved complaints.

4-2. Receiving a complaint

a. Obtaining basic information from the consumer is the most important part of receiving a complaint. Inaccurate or scarce complaint information will result in communication problems and may possibly create tension between the two parties. This situation may also impact the ability of the investigator to discover an explanation for the problem. A standard, installation-specific form, similar to those provided in appendix E, should be used when taking a complaint. At the minimum, the investigator should collect the information listed below. More helpful information is provided in appendix F.

(1) The consumer's full name and telephone number.

(2) The building address where the complaint has been noticed.

(3) The room and or tap (that is, faucet, sink, or shower) where the suspect water is being detected and an accurate description of the problem (that is, taste, odor or appearance).

(4) The frequency and duration of the water quality problem (for example, 1 day or 3 weeks).

b. Consumers depend on their water utility to provide truthful information when they have a problem. According to a representative of the Philadelphia Water Department, it is better for the investigator or the supervisor to contact the customer later with the facts then to confuse them with inaccurate or speculative information (Burlingame, 1992). If the investigator can explain what is causing the complaint (from previous calls or experience) during the initial contact with the consumer, then he or

she should provide the explanation. With the exception of illness complaints, many consumer complaints can be easily explained during the initial contact. Following the explanation, the investigator should record the complaint information into the tracking system and annotate its location on a map for future reference. The investigation can then be considered closed.

c. If the complaint cannot be solved during the initial conversation, the investigator should carryout the actions listed below. Expeditious response to the complaint and analysis of the water at the consumer's tap is extremely important, because water quality can change quickly. For example, the contaminant(s) may be flushed from the building's service line, the chlorine residual may continue to react with contaminants, chemicals may absorb to the container, and the sample container may even impart a new taste or odor. An investigator should always be dispatched immediately, because the complaint is unsolved and the consumer is directed not to use water. Consumers may become upset or enraged if they do not have access to potable water for bathing and cooking activities.

(1) Ask the consumer to collect a water sample at the suspect plumbing fixture. Sample collection must be completed using a "clean" container, and competent installation drinking water professionals must evaluate the sample as soon as possible. The more time that has elapsed between the initial sampling and analyses allows for contaminants to react with other contaminants present and to even disappear.

(2) Thank the consumer for reporting their concerns and request that the customer refrain from using any appliances that use the water in question (for example, faucets, hoses, showers, or bathtubs). Inform the consumer that an investigator will be dispatched to their location immediately. Ceasing use of the water is important in the case of intentionally induced chemical and biological agents when entered as a finite quantity into the system. If the tap is continually flushed, these agents may only be present in the distribution system for a finite amount of time.

d. Once the conversation has ended, the investigator should make certain that all required complaint information is entered in the database and annotated on a consumer complaint-tracking map. The field investigation should be conducted immediately after the complaint has been filed, because this water could pose a significant health risk. A timely response will also prevent additional consumer exposure. Consumer complaints should be the highest priority for the water system managers, environmental office, and PM division, as they could be a precursor for consumers experiencing negative health effects.

4-3. Field investigation

a. If possible the water utility should have all necessary field investigation equipment and sampling bottles ready for an on-site complaint investigation. Preparation will reduce time spent searching for and calibrating the appropriate equipment. Also, preparatory efforts such as these will show a proactive approach to protecting consumer health on the Army installation. Fort Knox water utility developed several water system sampling kits. One of them is shown in Figure 4-2. This field sampling kit weighs approximately 5 pounds and contains a thermometer, pH meter, free available chlorine analyzer, several sampling bottles, a disposable laboratory and gloves, and a water sample chain-of-custody form.

Figure 4-2. Fort Knox Water System Emergency Sampling Kit.

b. Prior to field sampling, the water utility must ensure that the sample containers must be clean and free of any residuals. Residuals can impact the water quality analysis. Do not use containers provided by consumers. Water stored in plastic milk cartons should be evaluated for only visual quality. Plastic milk cartons have been known to impart tastes and odors. Before the on-site visit, the field investigator must ensure that all instruments are properly calibrated (for example, pH meters or turbidimeters). At a minimum, the investigator should bring the materials listed below to the consumer's residence/tap.

(1) Water sample chain-of-custody form (required).

(2) Sample bottle cooler (required).

(3) One notepad (required).

(4) A waterproof marker and pen (required).

(5) Three or more 1.0-liter bottles with caps and labels (required).
(6) A disinfectant residual test kit (required).

(7) Thermometer able to read zero to one hundred degrees Celsius (required).

(8) pH test kit (required).

(9) Turbidity test kit (preferable).

(10) A conductivity meter (preferable).

b. Once the on-site investigator arrives, he or she should inspect the area where the suspect water is located. Inspection may include visual as well as the physical removal and evaluation of the apparatus in question (that is, faucet and screen) to determine if there is any clogging or degradation of the consumer tap. Some common problems and conditions that can be found on-site are dirty sinks and bathtubs (off tastes and odors), new paint (off color), hot water heater dip tube deterioration and clogged fixtures (particles in water), water cloudiness (too much air in water), and dirty household filters. Whether or not the cause is determined by visual inspection, the investigator should take at least one water sample of at least 1 liter for bacteriological analysis. Colilert® is the preferred method of laboratory analysis and is widely available. Colilert is a registered trademark of IDEXX Laboratories, Inc., One IDEXX Drive, Westbrook, ME 04092. All on-site analyses results and observations should be noted on the field investigation data form. See appendix E.

c. If the investigator cannot explain the cause of the complaint during an on-site inspection, on-site drinking water analyses should be conducted. Table 4-1 shows several on-site analyses that can be conducted. Analyses should be conducted shortly after collecting the samples, because the water characteristics can change rapidly. As previously mentioned, a chlorine residual of 2.0 mg/L can be reduced to 0 in less than 1 minute depending on water temperature, ventilation, and light conditions.

Table 4-1. Recommended Field Water Quality Analyses

Measurement Type	Required	Preferable
Water pH	X	
Water temperature	X	
Disinfectant residual concentration	X	
Bacteria analysis[1]	X	
Turbidity		X
Conductivity		X
Describe appearance (that is, clarity and color)	X	
Describe taste[2]		X
Describe odor[2]		X

[1]Take one 1-liter water sample for coliform bacteria analysis.
[2]Use best judgment to determine if measuring these parameters is safe.

d. Prior to sampling, each bottle should be labeled. The labels should include:

(1) The name of the complainant.

(2) Sampling date.

(3) Sample location, (that is, kitchen faucet or bathroom sink).

(4) Building address where the sample was taken.

(5) The sample collector's initials.

(6) The complaint reference number.

e. A minimum of two 1-liter water samples should be taken at each faucet, or enough taken to represent the suspect water. During sampling, the investigator should take an initial sample draw from the cold-water source. Once completed, the investigator should allow the cold water to continue running for approximately 2 to 5 minutes before taking another sample. Flushing will remove any water sitting close to the suspect faucet or inside the building pipes. Flushing also allows water farther from the tap to be sampled. Before taking the second sampling, the sample bottle should be rinsed at least three times with the flushing water. Samples should be stored in a sealed and temperature controlled container and should be maintained at a constant temperature. Allowing water samples to heat-up, freeze, or be exposed to sunlight will compromise their usefulness. Generally, these water samples should be analyzed within 30 minutes to 24 hours after sample collection at the tap. The allowable holding time is dependant on the chemical or bacteriological analysis method chosen. Delaying water analysis greater than the allowable holding time may compromise the usefulness of the analytical data.

f. The investigator may also find it helpful to collect water samples from other taps in the building or from neighboring buildings. If the consumer only detects the water quality problem in one area of the house/building, it could be an internal problem. Water problems at several "taps" could indicate a more far-reaching problem. Questioning the complainant and the complainant's neighbors can help the investigator determine the extent of the water complaint.

g. On many occasions, customers will ask the onsite investigator what water they should use until laboratory results are received. Many water utilities advise consumers to "use their own judgment", because the utilities cannot guarantee the safety of any alternative water. The onsite investigator should not advise the customer to "buy bottled water" or "do not drink the water" unless directed by the drinking water plant chief.

4-4. Pertinent laboratory analyses

a. If intentional contamination is suspected or the cause of the consumer complaint cannot be identified or solved during the on-site visit, water samples should be taken for analysis at a qualified laboratory. Laboratory analyses may be accomplished through existing local contracts or U.S. Army Center for Health Promotion and Preventive Medicine (USACHPPM) laboratories. Additional assistance in choosing the appropriate laboratory analyses may be obtained by contacting the USACHPPM at Water.Supply@apg.amedd.army.mil.

b. Appropriate laboratory analyses should at a minimum include:

(1) Coliform bacteria.

(2) Conductivity.

(3) Color.

(4) Metals to include copper, manganese, iron, and zinc.

(5) Common aesthetic water quality analysis: flavor profile analysis (FPA)-Standard Method 2170, or the threshold odor number (TON) test-Standard Method 2150 (APHA, 2002).

c. Further complaint investigation may or may not be required once laboratory results are reviewed. For example, laboratory data indicating elevated metal concentrations and the knowledge of aging or recently installed piping may be the cause of a "metallic taste" complaint. The decision to continue the investigation should rest with the water system managers, environmental office, and PM personnel.

d. Once the cause is determined, the investigators should document all findings in the database and annotate the location on the consumer complaint-tracking map. Then, the investigators should notify the consumer about the cause, health risk, and any follow-up actions that the installation will take (that is, water main replacement, flushing, and increased chlorine residual concentrations). Consumer notification is discussed in more detail in paragraph 3-6. The investigator's recommendation should then be placed in the database along with the time and date the consumer was contacted.

4-5. Internal and external research investigation

a. If results from field and laboratory testing do not indicate the cause, more investigative work is required. Complaint investigators should conduct an internal

investigation of the water utility to determine if operational abnormalities exist. This includes reviewing recent records or actions that may have affected the drinking water. Some utility-moderated events that can affect water quality include:

(1) Startup or shutdown of treatment processes.

(2) Changes in treatment processes.

(3) Water main breaks.

(4) Fire fighting activities.

(5) Distribution system flushing activities.

(6) Storage tank painting.

(7) Construction near waterlines.

b. The existing consumer complaint database software may also be helpful to the investigator in determining if any similarities exist between previous complaints and the current complaint. Specifically, the investigator should look at the time of year, complaint frequency, complaint location, water quality parameters (for example, chlorine residual concentrations), and other recently reported complaints in the same geographic area to discover trends. A check for non-potable water cross-connections, water of different physical characteristics (for example, temperature, chlorine residual concentration, and hardness), or backflow incidents in the geographic area may also be helpful.

c. Information about the water quality at the point(s)-of-entry to the distribution system can be very helpful to complaint investigators, because some Army installations purchase water from neighboring towns and also produce water on post. Differences between multiple treated waters could help the investigator in solving the problem. For example, if consumers have become used to highly chlorinated water on post (2.0 mg/L concentration), a number of complaints might be filed if they receive purchased water having a 0.5 mg/L chlorine residual concentration. Similar to a field investigation, knowing typical values for water pH, temperature, chlorine residual, turbidity, conductivity, coliform bacteria counts, and bacteriological test results, at each finished water distribution system entry point can be helpful. Additional information about the distribution system, including a map, the location of any supplemental treatment processes, known problem areas such as those identified during previous complaints or main breaks, and typical pressures may also be useful.

d. If illness is the complaint and an internal audit is not helpful, the investigator should contact local and regional hospitals and possible health care providers to determine the cause of the illness and if it is more widespread. This type of crosscheck will link the consumer complaint tracking system to the public health syndromatic surveillance databases.

e. Additional complaint investigation procedures for specific types of complaints (for example, taste, odor and color) can be found in the *Maintaining Distribution-System Water Quality Manual* published by the American Water Works Association (AWWA, 1986). Also, more in-depth explanations of the causes of drinking water off-tastes and odors can be found in Mallevialle and Suffet (1987).

4-6. Management and consumer notification and follow-up actions

a. Informing installation management and the concerned consumer of the investigation results is as important as receiving the complaint. Again, if consumers do not feel satisfied with or understand the explanation, they are likely to call back with the same complaint or even become outraged and make their complaint public. Also, consumer confidence about installation drinking water safety can decrease; leading to the possibility of more complaints and the perception that installation management does not care about the safety of the consumer (McGuire, 1995).

b. Any communication with drinking water consumers should use a risk communication approach. Risk communication is commonly used in Army policy and in communicating technical issues such as water quality and safety to non-technical people. A brief fact sheet on handling complaints about public concerns can be found in appendix G. The USACHPPM's Health Risk Communication Program (HRCP) is available to provide strategic advice for working with consumers and can assist in developing a risk communication strategy to effectively handle drinking water issues. The HRCP may be reached through their website at http://chppm-www.apgea.army.mil/risk/. (Check under "Tools" on the HRCP website for a check list on how to effectively handle complaints.) Public affairs officers can also be a resource in helping address consumer concerns. Additional information on communicating with drinking water consumers can be found by contacting USACHPPM at Water.Supply@apg.amedd.army.mil and reading Bishop (2003).

c. Good communication includes listening to the concerns of the consumer, being truthful, and centering the discussion on the facts of the situation. Jargon should be avoided. Words and phrases such as "bact-T, Coliert, and corrosion" are water industry jargon, and people who do not deal with drinking water on a regular basis may be confused when these terms are used.

d. Managers and consumers should be informed about the suspected cause of the undesirable water characteristic, potential health risks, and corrective actions that are being taken to remediate and prevent the occurrence. This may be accomplished by speaking to them face-to-face (preferable) or by telephone. Postal mail and electronic email (e-mail) are more informal information transmission routes and are not recommended as the only communication method and should be used only after several in-person interactions. Brief letters can be prepared that discuss chronic water quality problems, such as source water algae blooms and subsequent earthy-musty odors. A sample letter is provided in appendix H. Further information on communication principles for water utilities is outlined in Bishop (2003).

e. Prior to contacting the customer, the explanations should be well thought out and made simple. Generally, consumers can better understand less technical explanations, such as changes in chlorine residual concentration and water temperature versus more detailed explanations of organic chemistry, microbial regrowth, or corrosion, unless they ask for it. The more technical explanation should be noted in the documentation of the complaint response. Installation managers, however, may request a more detailed explanation for the causes of consumer complaints. Depending on the extent of the water quality problem, public notification may be appropriate. Regardless, any communication between the consumer and water utility personnel should be objective and informative.

f. Failure to follow through on stated actions could result in the consumer's exposure to increased health risks that could lead to illness, future complaints, loss of confidence, outrage, or even fatalities. Several suggested remedial actions are listed below, and their implementation depends on the type of, frequency, and extent of the water quality problem. Public notification is appropriate before implementing these measures with regular updates after implementation.

(1) Water treatment process modification.

(2) Distribution system flushing.

(3) Increased chlorine residual concentration.

(4) Elimination of a cross connection.

(5) Replacement of transmission lines.

(6) Lining of the transmission line's interior with an approved coating.

g. Installment of a point-of-use or point-of-entry device can be effective but is not recommended at Army installations. At several Army installations point-of-use and

point-of-entry devices were installed but were not properly operated and maintained. As a result, the devices became a health threat due to bacterial growth inside the device. Point-of-use and point-of-entry devices can expose consumers to an increased health risk if not adequately maintained.

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Chapter V

Conclusions

5-1. Complaint value

In light of the increased terrorist threat to drinking water, all water system programs should review and improve their complaint handling procedures. Drinking water consumers are an integral part of the water quality monitoring system at Army installations, and their complaints should be taken seriously. Evidence provided in this guide, along with the fact that consumers detect contaminants at ng/L concentrations and are at every point in the distribution system, make them a critical surveillance resource for Army water systems.

5-2. Responsible organization

One of the most important parts of a complaint response and tracking system is the existence of a single point-of-contact. This individual or organization should receive, investigate, and document all consumer complaints on the installation. Furthermore, this individual or organization should be able to develop and manage routine reports and graphical representations from the data. The responsibility of receiving, investigating, and tracking consumer complaints should be formally delegated to the water utility or environmental managers. At many installations, shared-responsibility has resulted in overlapping, incomplete, and sometimes absent efforts to resolve complaints. In addition, complainants may receive different responses from the water utility, environmental managers, and PM. As a result of these inadequacies, Army installations will be unable to effectively detect and react to a contaminated water situation rapidly when it occurs.

5-3. Investigative procedures

Another key component is the implementation of systematic investigation procedures when a complaint is filed. Execution of these procedures will result in an effective determination of the water quality problem. The procedures include—

a. Guidance on receiving a consumer complaint.

b. Conducting a field investigation, pertinent laboratory analyses, and an internal investigation.

c. Ensuring notification of installation management and the concerned consumer(s).

5-4. Documentation

The importance of documenting the consumer complaint cannot be over emphasized. By creating an information library of consumer complaints and follow-up actions and results, Army installations will be able to better detect any acute water quality health risks, such as those caused by terrorist contamination. Also, documentation will provide the installation with a baseline understanding of where chronic water quality problems are located (that is, service lines with low chlorine residual concentrations and high iron and copper concentrations). Consumer complaints should be documented in electronic format or in the less desirable paper log.

5-5. Data evaluation

Data evaluation is required for a consumer complaint system to be effective. Complaint data is useless unless periodically reviewed for trends and commonalities. The electronic format provides for easier data analyses and display. A Microsoft Excel spreadsheet or Access database are just two of the available tools. Data analysis using paper logs is more difficult and extremely time consuming. Paper maps and geographic information system (GIS) mapping should also be used to display the location site of all complaints.

5-6. Database usefulness

When investigating water quality problems, the complaint database will prove extremely helpful. This database will provide public health officials with a baseline for understanding previous water quality problems. Water utility operations and maintenance, environmental management, and PM personnel will be able to determine where both acute and chronic water quality problems exist within the water system and will be able to appropriate infrastructure upgrade money accordingly.

5-7. Action value

Swift and effective responses to drinking water consumer complaints can limit and possibly prevent widespread illness. Installations can better gauge the extent of the water problem and number of persons affected by investigating complaints as soon as possible. In addition, rapid responses will also demonstrate that the Army installation cares about consumer concerns and the safety of its drinking water. Rapid responses can also improve consumer confidence.

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Appendix A

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Appendix B

Causes and Solutions to Common Consumer Complaints

B-1. The human senses

Human senses are what consumers use to evaluate water quality. Without the sense of sight, touch, taste, and smell, consumers would not complain about water quality. Changes in water clarity and color and the presence or absence of taste and odors can result in consumer complaints. In some cases, certain consumers have diminished or less response thresholds than others, while other consumers seem to have higher response thresholds. For example, consumers can detect geosmin (sometimes attributed to earthy odor problems) in water when present at 5 ng/L, while others require a concentration of 15 ng/L before detection. This variance in sense detection is normal and has been noticed throughout the population.

B-2. Clarity and color

The sense of sight allows consumers to detect noticeable changes in the appearance of water. Changes in clarity or color are highly valuable water quality indicators. These changes could indicate the presence or absence of chemicals such as iron, particles such as sand, and air. These changes can be caused by routine distribution system flushing activities or the presence of toxic contaminants. Water main breaks, distribution system flushing, valve exercising, and hydrant opening are some of the most common causes of clarity and discoloration complaints. These activities disrupt the normal flow of water and can re-suspend sediment. Other possible discoloration complaints and their possible causes are provided in Table B-1.

B-3. Taste and odor

a. The senses of taste and smell are extremely valuable to humans. Much of the research on these senses has been conducted in the food and beverage industry and has been focused on product development for the purposes of improving product sales. In comparison, the drinking water industry has the same purposes.

b. Water utilities across the U.S. are constantly looking to provide consumers with water that is free of off tastes and odors. Occasionally, chemicals pass through water treatment plants and reach consumer taps at detectable concentrations. For example,

earthy and musty odors, which are non-toxic algal byproducts, originate from algae present in lakes, rivers, and creeks. Other chemicals that affect how water tastes and smells enter drinking water as a result of pipe corrosion. This is most frequent with aged cast-iron pipes and newly installed household plumbing.

B-4. Textural feeling

a. The sense of touch is usually overlooked when dealing with water quality complaints. The perception of how the water feels, or for lack of a better word texture, has been described and evaluated. Many people have reported white scale deposits in pipes, water heaters, and on cooking utensils. This is primarily caused by high hardness or the presence of calcium (Ca^{+2}) and magnesium (Mg^{+2}) ions. Consumers may also note that more detergent is required to do laundry or that more soap is required to make soapsuds. This too is caused by the presence of Ca^{+2} and Mg^{+2}. These ions are naturally occurring and present no measurable health risk at typical drinking water concentrations. Enhancing the water treatment process or installing an appropriate ion exchange softener can remove these ions.

b. Another sense of touch complaint that has been documented is "grittiness" or an abrasive texture to water when washing or residue is left in the sink. This has been attributed to sand or silt in water and can be caused by distribution system flow change. Distribution system main and customer service line flushing usually can remediate this problem. Water utility managers should also check for any process upsets. Grittiness has also been identified by the deterioration of hot water heater anodes. These anodes decompose and sometimes get caught in the faucet.

Table B-1
CAUSES AND SOLUTIONS TO COMMON CONSUMER COMPLAINTS

The USACHPPM Water Supply Management Program developed this table from published and unpublished documents and Army water treatment plant (WTP) experiences. It provides a listing of common clarity and discoloration complaints, possible causes, and suggested remedial actions and should be used as a guide for solving consumer complaints. A brief discussion of the human senses and how they influence consumer complaints is provided in the USACHPPM Technical Guide 284.

Complaint	Possible Causes	Suggested Remedial Actions
Cloudy or milky water	Air in water (especially noticeable in the winter).	Allow all water to stand and the air to be released and or blow down the hot water heater periodically.
Particles in water	Resuspension of settled matter in distribution system (sand, silt, or clay) because of a water main break, distribution system flushing, or hydrant opening; suspended matter from source water (that is, dirt and sand); or pipe corrosion, organic matter in raw water (that is, algae), hot water heater dip tube corrosion, or deteriorating rubber materials in plumbing fixtures.	Flush main, service connection, and or WTP. This will adjust the treatment process for better removal of particles and chemicals.
Pink residue	Sometimes described as rust. Caused by a naturally occurring airborne bacterium or mold that attacks wet surfaces. This is usually found in the bathroom or chronic wet areas due to insufficient drying and inadequate air circulation.	Consumers should wipe down the affected area with cleaning solutions, preferably those containing chlorine or ammonia.
Stains in dishwashers or laundry	Could be caused by the presence of iron or as a result of a dirty dishwasher. Conditions exclusive to iron are further described in the USACHPPM Technical Guide 284.	Consumer should clean the device. WTP flushes main, service connection, and or adjusts treatment process for better removal of particles and chemicals.
Green stains on bathtubs and sinks	Low pH (≤ 6.8), and water reacts with copper and brass pipes and fittings causing the solubilization of metals, imparting a color.	WTP adjusts water corrosivity conditions (that is, pH and alkalinity).
Blackening and pitting of stainless steel	High chloride concentration (also referred to as salt). High drying temperature accelerates corrosion of stainless steel.	WTP adjusts water corrosivity conditions (that is, pH and alkalinity), and or consumers use other chloride resistant metals.
Blue-green water	Low pH (= 6.8), and water reacts with copper and brass pipes and fittings causing the solubilization of metal and imparting a color.	WTP adjusts water corrosivity conditions (that is, pH and alkalinity).
Yellow water	Humic acids in water (frequent occurrence near swamps) caused by peaty soils and decaying vegetation. Low pH (= 6.8), and water reacts with piping causing the solubilization of metals, imparting a color.	WTP flushes main and service connection and or adjusts treatment process for better removal of particles and chemicals.

Additional assistance in dealing with consumer complaints may be obtained from the USACHPPM, Water Supply Management Program (WSMP) at DSN 584-3919, commercial (410) 436-3919, or by electronic mail at Water.Supply@apg.amedd.army.mil.

Appendix C

Parameters that Affect Aesthetic Quality

C-1. Secondary maximum contaminant levels

Table C-1 provides a listing of contaminants and their associated drinking water secondary maximum contaminant levels (SMCL). Secondary maximum contaminant levels are not health-based standards; they are based on the public aesthetic acceptance of drinking water. At considerably higher concentrations, health implications may exist in addition to aesthetic degradation. Table C-1 was taken from the National Primary Drinking Water Regulation in 2002. This information can be used to better determine water quality and acceptability.

C-2. Additional parameters affecting water quality

Information provided in Tables C-2 and C-3 was taken from the World Health Organization (WHO). Table C-2 lists physical parameters and inorganic constituents at corresponding concentrations that many give rise to drinking water consumer complaints. Table C-3 includes some organic chemicals, disinfectants, and disinfection byproducts and respective concentrations that may cause aesthetic problems.

Table C-1. National Primary Drinking Water Regulations Secondary Maximum Contaminant Levels

Contaminant	SMCL	Noticeable Effects above the SMCL
Aluminum	0.05 – 0.2 mg/L	Colored water
Chloride	250 mg/L	Salty taste
Color	15 color units	Visible tint
Copper	1.0 mg/L	Metallic taste; blue-green staining
Corrosivity	Non-corrosive	Metallic taste; corroded pipes/fixtures
Fluoride	2.0 mg/L	Tooth discoloration
Foaming agents	0.5 mg/L	Frothy, cloudy; bitter taste; odor
Iron	0.3 mg/L	Rusty color, sediment, metallic taste, red-orange staining
Manganese	0.05 mg/L	Black to brown color; black staining; bitter taste
Odor	3 threshold odor number (TON)	Rotten-egg, musty, or chemical odor
PH	6.5-8.5	Low pH: bitter metallic taste; corrosion High pH: slippery feel; soda taste; deposits
Silver	0.1 mg/L	Skin discoloration; graying of the whites of the eye
Sulfate	250 mg/L	Salty taste
Total dissolved solids (TDS)	500 mg/L	Hardness; Deposits; Colored water; Stale taste
Zinc	5 mg/L	Metallic taste

Table C-2. Physical Parameters and Inorganic Constituents that may give Rise to Consumer Complaints According to the World Health Organization

Contaminant	Levels Causing Complaint	Reasons for Complaint
Color	15 NTU	Appearance
Turbidity	5 NTU	Appearance; for effective disinfection, median turbidity = 1 NTU, single sample 5 NTU
Aluminum	0.2 mg/L	Deposits, discoloration
Ammonia	1.5 mg/L	Odor and taste
Chloride	250 mg/L	Taste and corrosion
Copper	1.0 mg/L	Staining of laundry and sanitary ware (Health- based provisional guideline value 2 mg/L)
Hardness	------	High hardness: scale deposition, scum formation; Low hardness: possible corrosion
Hydrogen sulfide	0.05 mg/L	Odor and taste
Iron	0.3 mg/L	Staining of laundry and sanitary ware
Manganese	0.05 mg/L	Staining of laundry and sanitary ware (health-based guideline values 0.5 mg/L)
Dissolved oxygen	------	Indirect effects
pH	------	Low pH: corrosion; High pH: Taste, soapy feel; Preferably < 8.0 for effective disinfection with chlorine
Sodium	200 mg/L	Taste
Sulfate	250 mg/L	Taste, corrosion
Total dissolved solids (TDS)	1000 mg/L	Taste
Zinc	3 mg/L	Appearance, taste

1. Extracted from *Guidelines for Drinking Water Quality*, 2nd Ed. Vol. 2, Health criteria and other supporting information, 1996 (pp. 940-949) and Addendum to Vol. 2. 1998 (pp. 281-283), Geneva, World Health Organization.

Table C-3. Organic Constituents and Disinfectants and Disinfection By-Products that may give rise to Consumer Complaints According to the World Health Organization

Contaminant	Levels Causing Complaint	Reasons for Complaint
Toluene	24-170 µg/L	Taste and odor (Health-based guideline value 700 µg/L)
Xylene	20-1800 µg/L	Taste and odor (Health-based guideline value 500 µg/L)
Ethylbenzene	2-200 µg/L	Taste and odor (Health-based guideline value 300 µg/L)
Styrene	4-2600 µg/L	Taste and odor (Health-based guideline value 20 µg/L)
Monochlorobenzene	10-120 µg/L	Taste and odor (Health-based guideline value 300 µg/L)
1,2-dichlorobenzene	1-10 µg/L	Taste and odor (Health-based guideline value 1000 µg/L)
1,4-dichlorobenzene	0.3 – 30 µg/L	Taste and odor (Health-based guideline value 300 µg/L)
Trichlorobenzenes (total)	5-50 µg/L	Taste and odor (Health-based guideline value 20 µg/L)
Synthetic detergents	------	Foaming, taste, and odor
Chlorine	600 – 1000 µg/L	Taste and odor (Health-based guideline value 5 µg/L)
2-Chlorophenol	0.1 – 10 µg/L	Taste and odor (Health-based guideline value not found)
2,4-Dicholophenol	0.3 – 40 µg/L	Taste and odor (Health-based guideline value not found)
2,4,6-Trichlorophenol	2 – 300 µg/L	Taste and odor (Health-based guideline value 200 µg/L)

1. Extracted from *Guidelines for Drinking Water Quality*, 2nd Ed. Vol. 2, Health criteria and other supporting information, 1996 (pp. 940-949) and Addendum to Vol. 2, 1998 (pp. 281-283) Geneva, World Health Organization.

Appendix D

Iron-Related Discoloration Guidance

D-1. Introduction

a. Figure D-1 depicts a decision wheel from which water utilities can investigate and solve iron-related water quality problems. Other factors that should be considered include—

(1) Current corrosion control practices.

(2) The size of the problematic plumbing line.

(3) Whether or not water stagnation is contributing.

(4) If the problematic line is looped or dead-ended.

b. Table D-1 provides some guidance on several causes of iron-related complaints. Installations can use this information to target water quality analyses and select remediation options. Additional guidance can be obtained by contacting USACHPPM directly.

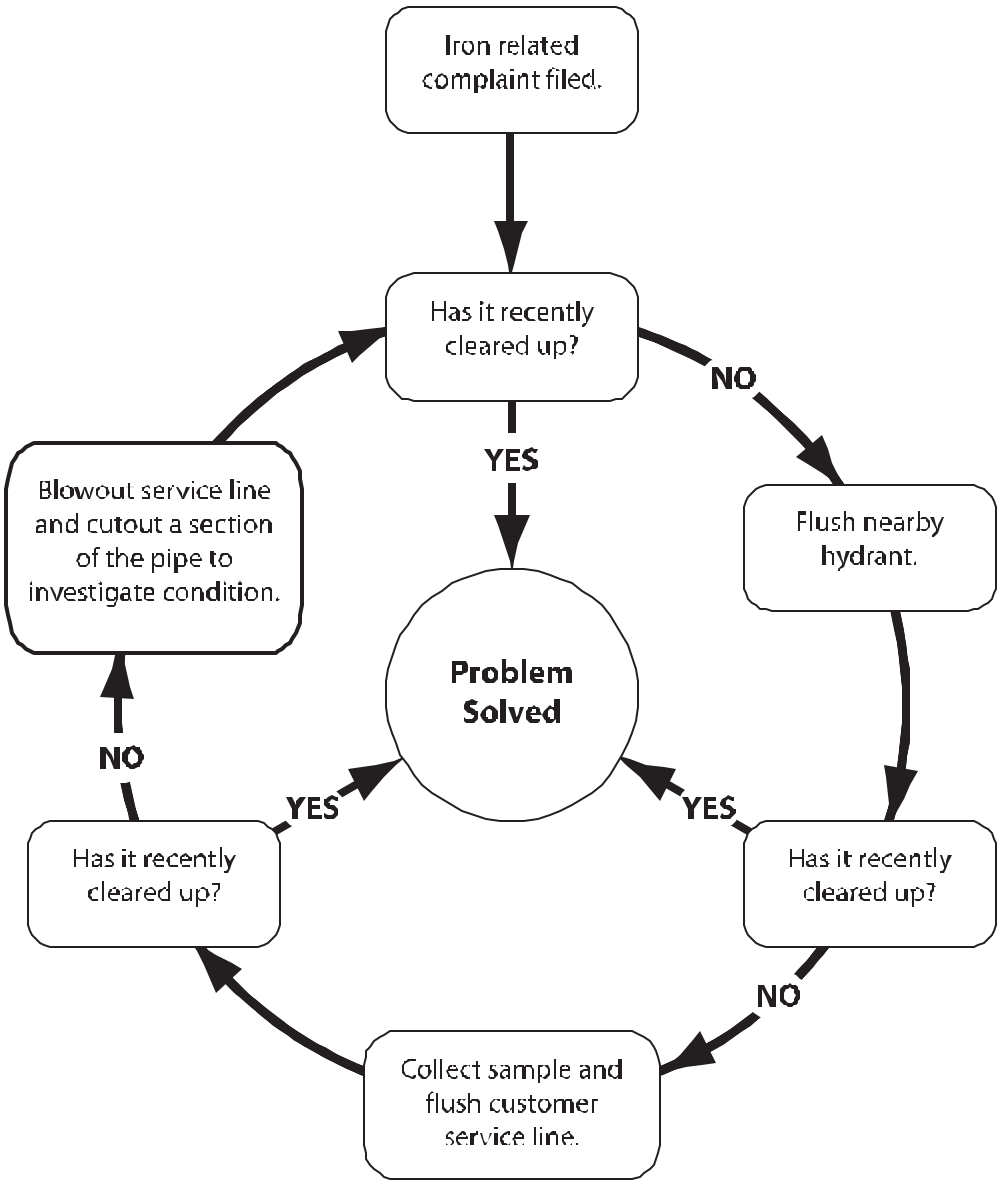

Figure D-1. Basic Thought Process for Iron-Related Discoloration: A Decision Wheel

Table D-1. Red or Brown Discoloration Complaints Due to the Presence of Iron

Complaint	Iron Condition
Stains on bathtubs and sinks. Cold water appears clear.	Dissolved iron in water (> 0.3 mg/L Fe^{+})
Stains on bathtubs and sinks. Cold water appears red-brown.	Precipitated iron in water.
Water turns red or brown upon heating. Cold water appears clear.	Dissolved iron in water (> 0.3 mg/L Fe^{+})
Water turns red or brown upon heating. Cold water appears red-brown.	Precipitated iron in water.
Clothing becomes discolored. Cold water appears clear	Dissolved iron in water (> 0.3 mg/L Fe^{+})
Clothing becomes discolored. Cold water appears red-brown	Precipitated iron in water
Brown water has no precipitate	Iron pick-up from old pipe with water having a pH < 6.8, caused by iron bacteria
Noticeable red color in water after standing 24 hours	Colloidal iron

D-2. Remedies

The following are possible remedies for reducing or eliminating water quality problems attributed to iron.

a. Adjusting water corrosivity conditions (that is, pH and alkalinity).

b. Adjusting treatment process for better removal of particles and chemicals.

c. Flushing the water main.

d. Flushing the customer's service connection.

e. Installing a lining in the pipe.

f. Replacing the main.

g. Superchlorinating the water main or well.

h. Installing a point-of-use device capable of removing the specific type of iron (soluble vs. precipitate). This device must be carefully monitored, because it could contaminate the water if not operated and maintained properly.

Appendix E

Sample Consumer Complaint Investigation Forms

Sample Complaint Investigation Form

(Courtesy of Gary Burlingame, Philadelphia Water Department)

(COMPLETE FORM WHEN SAMPLE IS COLLECTED. DELIVER FORM WITH SAMPLE TO LABORATORY)			
STREET ADDRESS OR SAMPLE LOCATION			
SAMPLE TAP DESCRIPTION (I.E., KITCHEN FAUCET, HYDRANT)			
DATE OF COLLECTION	TIME OF COLLECTION AM PM		COLLECTED BY
TEST RESULTS REQUESTED BY			TELEPHONE NUMBER
IS THE SAMPLE FROM A CONSUMER COMPLAINT? (CIRCLE ONE) YES NO	EXPLAIN THE NATURE OF THE COMPLAINT (CIRCLE ONE) ODOR	TASTE	OTHER
ASK THE CONSUMER TO DESCRIBE THE TASTE OR ODOR			
WHEN DID THE PROBLEM BEGIN		HOW OFTEN DOES IT OCCUR	
WHERE IS THE PROBLEM FOUND (I.E., BATHROOM, KITCHEN)			
OBSERVATIONS			
COMMENTS			
LAB USE ONLY	DATE OF TEST	METHOD (CIRCLE ONE) FPA	ODOR SCREEN FLAVOR SCREEN

TASTE AND ODOR SAMPLE TAG * PHILADELPHIA WATER DEPARTMENT

COMPLAINT INVESTIGATION FORM	Complaint No. 1

I. RECEIVING THE COMPLAINT

a. Date received:	b. Call taken by:	c. Time:

d. Name & Address

(1) Name:

(2) Telephone Number:

(3) Address:

e. Description

Check and describe all the apply: ☐ Taste ☐ Odor ☐ Color ☐ Clarity

Problem with: ☐ Hot Water ☐ Cold Water ☐ Both

Optional Descriptors: Metallic, Astringent, Plastic, Rusty, Rubber, Milky, Medicinal, Musty, Earthy, Chlorine, Swimming Pool, Septic,

II. ONSITE INVESTIGATION

a. Investigator Name:	b. Date & Time

c. Person(s) contacted onsite:

d. Location of water samples:

e. Number of samples taken and summitted for laboratory analyses:

f. Test to performed by laboratory (check all that apply):

☐ Free chlorine ☐ Combined chlorine ☐ pH ☐ Turbidity ☐ TON ☐ FPA ☐ TDS

☐ Hardness ☐ Alkalinity ☐ Flouride ☐ Iron ☐ Manganese ☐ Lead ☐ Copper

☐ Other _____

g. Onsite Results:

Free Chlorine _____ Turbidity _____ Conductivity _____

Combined Chlorine _____ Taste or Odor _____ pH _____

III. CONCLUSIONS AND REMEDIAL ACTIONS

a. Date consumer contacted:	b. Person(s) contacted:
c. Action required (check on): ☐ Yes ☐ No	d. Date action completed:

e. Description of correspondence and action:

CHPPM FORM 431-R-E, MAY 03 (MCHB-TS-EWS)

Appendix F

Helpful Investigation Questions and Laboratory Analyses

F-1. Introduction

The following lists have been compiled to help complaint investigators determine the cause of the problem. The questions can be presented to consumers, on-site investigators, and installation personnel such as the plumbing shop, Directorate of Public Works (DPW), fire department, and water treatment plant operators.

F-2. Questions for the consumer

a. General Questions

(1) What time and date was the anomaly first noticed?

(2) Can you detect the taste/odor in both hot and cold water?

(3) Is the problem noticed at multiple faucets?

(4) If there is a taste, is there an odor? What descriptor can you provide for the taste and or odor? (Earthy, musty, chlorinous, astringent, or others)

(5) Are there particles present? (large, small or colored)

(6) Does the water have a color? If so, what color?

(7) Are water softeners, filters, or other types of treatment devices used at or near the tap? In the house?

(8) Did you get a sample of the suspect water?

(9) Has there been any in-house construction recently?

b. Illness-Specific Questions

(1) When was the sickness or skin irritation first noticed?

(2) What type of discomforts are you experiencing?

(3) Have all consumers at the location been affected?

(4) Has a doctor been consulted?

(5) Have you been out of town?

c. Cloudy or Milky Water-Specific Questions

(1) Does air disappear when glass of water stands?

(2) Does water look milky or contain air?

(3) What time and date was the anomaly first noticed?

d. Hardness Specific Question. How did you determine that water was harder than usual?

F-3. Other questions to consider when investigating the complaint

a. What are the water pH, disinfectant residual, and temperature at the location?

b. Where is the complainant's service connection within the various pressure zones of the distribution system?

c. Is there a dead-end service line nearby?

d. Has new galvanized pipe been installed recently?

e. Has water to the location been shut off recently?

f. Has the fire department conducted any hydrant testing recently?

F-4. Suggested laboratory analyses

The laboratory analyses listed in Table F-1 are suggested for specific consumer complaints. Additional analyses may be required. Contact the USACHPPM WSMP for additional assistance (Water.Supply@apg.amedd.army.mil)

Table F-1. Suggested Analytical Laboratory Analyses for Specific Consumer Complaints

Complaint	Some Applicable Analyses
Discolored water	Manganese (black), iron (orange/brown), total organic carbon (TOC)
Odor	Flavor profile analysis or other sensory analysis methods, Hydrogen sulfide (rotten eggs), volatile organic compounds (VOC) (gasoline or plastic)
Taste	Flavor profile analysis or other sensory analysis methods, Copper, aluminum, zinc, manganese, iron (metallic), VOCs (organics)
Cloudy, frothy water	Color, detergents
Recurrent gastrointestinal illness	Total/fecal coliforms
Stained plumbing fixtures or laundry	Iron (orange), manganese (black), copper (blue/green)
Corrosion of pipes or rapid wear of water treatment equipment (bearings, gaskets)	pH, corrosion index, copper, lead, zinc, cadmium, iron

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Appendix G

Complaint Handling Guidance Using Risk Communication

The first document provided in appendix G is entitled "Risk Communication Guidelines and was developed by the USACHPPM Health Risk Communication Program (HRCP). Installations should employ these approaches when handling any drinking water consumer complaints. Additional assistance can be obtained by contacting Water.Supply@apg.amedd.army.mil.

The second document is also authored by the USACHPPM HRCP and is entitled "Effectively Handling Complaints." Even though this document was developed for handling noise-related complaints, it provides a listing of important considerations including the "Do's" and "Don'ts." Additional information, including on-site support on handling water quality problems at Army installations can be received by contacting USACHPPM.

Risk Communication Guidelines

Know the Stakeholders:
Identifying both external and internal stakeholders and finding out their diverse and sometimes competing interests and concerns is the first step to any successful risk communication effort. The best way to determine stakeholder interests and concerns is to ask them! Conduct interviews with key leaders both outside and inside your organization. Use the information gathered in this step to develop your risk communication program for establishing collaborative problem-solving and communication efforts.

Simplify language and presentation, not content:
When trying to communicate the complex issues behind a health risk, it is easy to leave out information that seems to be overly technical. Risk communication research and studies have proven that all audience members can understand any technical subject if it is presented properly. This can be done, for example, through the use of visuals and diagrams and by defining all technical/medical/scientific jargon and acronyms.

Be objective, not subjective:
It is often very easy to differentiate between opinions and facts. It can be difficult however, to respond credibly to opinions without substantiating them or offending the individual asking the question. In order to maintain credibility, respond to both opinions and facts in the same manner.

Communicate clearly and honestly:
To communicate clearly, present information at the audience's level of understanding. People can reject information that is too difficult for them or they can reject a communicator who is perceived to be dishonest or untrustworthy. As a result, they may refuse to acknowledge the information or become hostile. On the other hand, they may become hostile if they feel patronized. The bottom line is - know the audience! In addition, whenever possible, provide familiar examples and concrete information that can help put the risk in perspective.

Deal with uncertainty:
When communicating health risk, results are not definitive. Discuss sources of uncertainty, such as how the data were gathered, how they were analyzed, and how the results were interpreted. This demonstrates that the uncertainties are recognized, which can lead to an increase in trust and credibility. However, when discussing uncertainty, the communicator should stress his/her expertise and knowledge of the subject. This will reinforce the leadership's ability to handle the situation and could allay concerns and fears regarding the risk and the risk-management decision.

Be cautious when using risk comparisons:
In order to put risks in perspective, comparing an unfamiliar risk to a familiar one can be helpful. However, some types of comparisons can alienate audience members. Avoid comparing unrelated risks, such as the risks associated with smoking versus those associated with air contamination. People rarely accept the comparison of unrelated risk.

Develop key messages:
Key messages are those items of importance, the health risk information that needs to be communicated. They must be clear, concise, and to-the-point. No more than three messages should be communicated at one time. Repeat key messages as often as possible to ensure they are not misunderstood ro misinterpreted.

Be prepared:
When either presenting health risk information or answering questions regarding an individual's concerns, be prepared. Most questions and concerns can be anticipated if the audience is known. In fact, the communicator should know 70 percent of the possible questions that could be asked. Consider how to answer general questions and how to respond to specific inquiries.

Appendix H

Sample Consumer Notification Letter

DEPARTMENT OF THE ARMY
US ARMY CENTER FOR HEALTH PROMOTION AND PREVENTIVE MEDICINE
5158 BLACKHAWK ROAD
ABERDEEN PROVING GROUND MD 21010-5403

REPLY TO
ATTENTION OF

April 21, 2003

Water Utility Division

Mr. John Doe
18 Prescott Court
Alexander Army Post, DL 21009

Dear Mr. Doe:

The Army Sandstone Water Utility has recently completed an investigation of your complaint filed on March 2, 2002. After conducting an onsite visit, analyzing drinking water at your residence, and conducting an internal investigation, we have found that your drinking water is safe. The cause of the "earthy" drinking water odor you reported is the result of algal activity in the reservoir. The presence of this chemical is undesirable to you as well as our utility. Since you called our utility, we have modified our treatment processes to reduce this issue. If you have any other questions about your drinking water, please feel free to contact our utility at (123) 456 - 7891. Thank you for contacting our utility.

Sincerely,

John Smith, P.E.
Water Utility Division Chief

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May 2003

TG 284

Drinking Water Consumer Complaints: Indicators from Distribution System Sentinels