AN ABSTRACT OF THE THESIS OF

Francis Carle Carter for the degree of Master of Science

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Title: AN EVALUATION OF INDIVIDUAL WATER SUPPLY SYSTEMS' REFERENCE MATERIALS AS AVAILABLE IN LOCAL HEALTH DEPARTMENTS IN OREGON

Redacted for Privacy

Abstract approved: _____
Arthur Koski

Part of the responsibility of maintaining the sanitary quality of individual water supply systems has been placed on the local sanitarian of Oregon. Because of this, he must be knowledgeable about individual water supply systems. One such source of knowledge has been the supply of written reference materials available in his office. There have been no publications concerning individual water supply systems which have been directed to the sanitarian in Oregon. Materials used have been general in nature.

Considering this lack of a specific material concerning individual water supply systems in Oregon, the following hypotheses were formed:

1) There will be less than 100 percent uniform reference materials concerning individual water supply systems in each of the offices of the local sanitarians.

2) Utilizing their available references, the local sanitarians will not be able to document 70 percent or more of the specific statements on water supply systems.

3) The local sanitarians will agree with an expert technical committee's opinion on the basic knowledge a sanitarian should have concerning individual water supply systems.

Several assumptions concerning the design of this study were also made and are as follows:

1) Each member of the expert technical committee is an expert in individual water supply system construction, operation and maintenance.

2) The expert technical committee is competent to determine the basic knowledge of the sanitarians of Oregon concerning individual water supply systems.

3) All local sanitarian staffs are equally competent in using their reference materials to complete the survey.

4) The local sanitarians will respond to the survey accurately and honestly.

5) The survey form is a valid instrument.

A committee of seven professional persons familiar with individual water supply systems and the work of the sanitarian was formed for the purpose of determining a list of basic knowledge that a sanitarian in Oregon should have concerning individual water supply

systems. From each item on the list of basic knowledge, a corresponding statement of fact was derived. Each statement of fact was determined by the expert technical committee to be a fair representation of its corresponding item on the list of basic knowledge.

A three section survey form based on the list of basic knowledge was sent to each local sanitarian staff of the health departments in Oregon. In the first section, the sanitarians catalogued the reference materials in their offices. In the second section, the sanitarian staffs documented the list of specific statements utilizing their available references. In the third section, the sanitarian staffs gave their opinions on each item on the list of basic knowledge.

The results were limited by the size of the sample and by the number of completed sections on the survey forms.

Based upon the 71.4 percent return of the survey forms with Section I completed, a total of 71 different references were determined to be available in the offices of the participating health departments. The most common references had a frequency of availability of 42.9 percent.

Based upon the 50.0 percent return of the survey forms with Section II completed, the average number of documentations of the specific statements was 51.6 percent.

Based upon the 75.0 percent return of the survey forms with Section III completed, the sanitarian staffs agreed with the expert

technical committee on the list of basic knowledge that a sanitarian should have concerning individual water supply systems.

A recommendation was made that a manual concerning individual water supply systems be written for sanitarians in Oregon, and that this study of the propriety of reference materials be carried over to other aspects of the sanitarians' work.

An Evaluation of Individual Water Supply Systems' Reference Materials as Available in Local Health Departments in Oregon

by

Francis Carle Carter

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Mr. Bill Titus of the Oregon State Health Division.

To my loving and devoted wife Melissa,

this work is dedicated.

Drink water from your own cistern,
and fresh water from your own well.

- Proverbs 5:15 -

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AN EVALUATION OF INDIVIDUAL WATER SUPPLY SYSTEMS' REFERENCE MATERIALS AS AVAILABLE IN LOCAL HEALTH DEPARTMENTS IN OREGON

I. INTRODUCTION

Ubiquitous in nature, water can be directly observed in oceans, rivers and lakes. Looking at these bodies of water, it is apparent that they are continuously moving. Great ocean currents travel their courses causing various types of climates to occur, and more apparently large amounts of water in the form of rivers can be seen flowing in their channels toward the sea.

Occurring so frequently and in great abundance, water may well be taken for granted. Water does, however, hold an important meaning in the daily life of man. It is used for recreation, transportation, manufacturing and probably most importantly as a nutrient for the body's metabolic activities (12, 45). In addition to air, water is the most essential commodity to life itself (31, 45). Because of this, water takes on implications as to the health of the body, and this naturally leads to the question of how and where it is obtained.

Hydrological Cycle

As the sun shines down upon the oceans, water is evaporated off the surface forming familiar clouds which upon appropriate conditions, precipitate water in the forms of rain, snow, hail or

sleet. Once on the surface of the ground, this water may do one of several things. A large portion of it will run downhill forming small trickles which in turn gather into small streams and subsequently into the rivers returning to the ocean. Some of the water may be re-evaporated into the atmosphere. Some water soaks into the soil and is held by capillary action, and some is used by plants. The remainder of this water continues to soak downward into the ground filling the cracks and pores of the rock beneath the soil until its progress is halted by an impervious layer of geological formation. This water held by the impervious layer thus becomes groundwater (11, 45).

Water Supply and Quality

In order to obtain a supply of drinking water, it is necessary to withdraw it from some point in the hydrological cycle. One option is the use of groundwater. This may be accomplished by withdrawing from a spring, or by extraction by the use of a well. Since it is to be used for drinking purposes it stands to reason that it must meet certain standards of acceptance, and therefore the way in which it may become contaminated must be examined. Groundwater may dissolve natural substances in the ground itself, or it may react with other agents such as pesticides or fertilizers, rendering it unfit for consumption (45). It may also serve to carry biological agents

such as the normal microbial flora and fauna of the soil, or such as those found in fecal waste which has found way into the groundwater supply (45). The epidemiology of many diseases including amebiasis, primary amebic meningoencephalitis, capillariasis, cholera, diarrheas, dracontiasis, giardiasis, hepatitis, hydatidosis, leptospirosis, melioidosis, paratyphoid, typhoid and schistosomiasis involves transmission by water (12).

Supply Protection

Because of the many adverse substances which may be dissolved or carried by water, it is important that a drinking water supply be adequately protected. An individual water supply system usually does not enjoy the benefits of being carefully monitored by trained personnel as does a public or municipal supply (45). Protective provisions available to assist an individual in the operation and maintenance of his water supply system must then be determined.

One such provision is the services offered by the local sanitarian representing the local health department (2, 7, 18). The sanitarian investigates private water supply systems located within his jurisdiction by evaluating their sanitary conditions and taking samples for routine bacteriological analysis (10, 25). He also assists in conducting epidemiological investigations of disease outbreaks (12). By his expertise, the sanitarian helps insure that the individual's water

supply system is acceptable both in terms of physical construction and biological quality.

A sanitarian must be knowledgeable in the realm of water supply systems because of the important role he plays in relation to them. In addition to his formal schooling, the sanitarian would likely need to have a supply of references on hand from which to draw. One such supply would be his stocks of printed material in his office concerning individual water supply systems.

The Oregon State Health Division has published two booklets concerning individual water supply systems, both of which are intended to show the fundamental features of a rural water supply system and are intended as handout references for the general public (31, 32). W. S. Titus of the Oregon State Health Division, has stated that there is no publication concerning individual water supply systems which relates to the basic concepts of well design, construction, operation and maintenance to the specific physical and legislative conditions in Oregon and that such a publication would be well received by sanitarians in Oregon (41). D. T. Ohlsen, formerly of the Oregon State Health Division, has agreed that a publication would be helpful as a guide for the sanitarian, and also elaborated by stating that some of the material most needed by sanitarians in order to be effective in their work is that which would extract from the legal terminology the basic key points in concise and readable form (27).

There are undoubtedly many of the general materials in the offices of the local sanitarians and the question has been raised as to the applicability of these materials to the specific needs and conditions in Oregon. The crux of this study is the determination of the adequacy of the reference materials to the sanitarian in the field in Oregon.

Hypotheses

Considering this lack of a specific material concerning individual water supply systems in Oregon, the following hypotheses are presented:

1) There will be less than 100 percent uniform reference materials concerning individual water supply systems in each of the offices of the local sanitarians.
2) Utilizing their available references, the local sanitarians will not be able to document 70 percent or more of the specific statements on water supply systems.
3) The local sanitarians will agree with an expert technical committee's opinion on the basic knowledge a sanitarian should have concerning individual water supply systems.

Definitions

The following terms are used in this study:

1) Aquifer - An underground layer of rock or soil which contains and transmits groundwater.

2) Basic knowledge concerning individual water supply systems - Information which is necessary for the local sanitarians to have in order to be efficient in their work concerning individual water supply systems.

3) Community water system - A water supply system that serves four (4) or more individual dwellings.

4) Document - To have a reference material that contains the information stated in a specific statement.

5) Expert technical committee - A committee of professional persons with adequate backgrounds in individual water supply system construction, operation and maintenance.

6) General comprehensive list - A list of the statements of the basic knowledge concerning individual water supply systems that a sanitarian in Oregon should have.

7) General statement - A statement of basic knowledge concerning individual water supply systems belonging to the general comprehensive list.

8) Groundwater - Water within the interior of the ground, that is not held by the capillary action of the soil.

9) Individual water supply system - A dug, drilled, driven or bored hole through the surface of the ground to an aquifer for the purpose of extracting groundwater; including materials used to aid in extraction, storage, and distribution of groundwater; and is intended for domestic use and is not defined by Oregon State Law as a community water supply system.

10) Local health department - A health department in Oregon, from which a local sanitarian staff operates; is either a) county-operated, b) health-district operated or c) a regional or satellite office of the Oregon State Health Division, Office of Protective Health Services.

11) Local sanitarian - One who by virtue of education and qualifications has demonstrated the expertise in environmental sanitation; is registered as a Sanitarian or a Sanitarian Trainee by the Sanitarians Registration Board of the Oregon State Health Division; and whose responsibility as a representative of a local health department includes assisting the owner and/or operator of an individual water supply system in the sanitary quality of that system.

12) Reference materials - Printed materials that either belong to, or are in the official custody of a local health department; that are duplicated and available for distribution to the local sanitarians throughout Oregon.

13) Respondent - A sanitarian staff who has completed a survey form that is used in statistical tabulations.

14) Sanitary quality - A condition in which those environmental factors which cause or can cause a deleterious effect upon the health or well-being of an individual, are controlled.

15) Specific representative list - A list of the specific statements, which reflect basic knowledge of individual water supply systems.

16) Specific statement - A statement of fact, which reflects basic knowledge of individual water supply systems, and is a fair representative of a general statement.

17) Unavailable information - Information not available in a reference material.

18) Uniform - With respect to the reference materials, being the same in kind by title, author and publisher; and being available in each respondent's office.

Assumptions

In order to successfully implement a study design, several assumptions had to be presented.

1) Each member of the expert technical committee is an expert in individual water supply system construction, operation and maintenance.

2) The expert technical committee is competent to determine the

needs of the sanitarians of Oregon concerning individual water supply systems.

3) All local sanitarian staffs are equally competent in using their reference materials to complete the survey.

4) The local sanitarians will respond to the survey accurately and honestly.

5) The survey form is a valid instrument.

Limitations

This study will be limited to local health departments in the State of Oregon with the exception of the Benton County Health Department because of the participation of some of its employees in the design of the survey.

II. REVIEW OF THE LITERATURE

Historically, an adequate, safe water supply has been recognized as a major consideration in public health (4). Ever since Snow published his famous work on cholera in 1849 (36), much attention has been focused to the sanitary maintenance of water supplies. The Public Health Act of 1848 in the United Kingdom required the appointment of "inspectors of nuisances" who were to investigate the occurrence of typhoid, cholera, diphtheria and tuberculosis (55). Sedgwick in 1901 provided sanitary science principles in a field handbook, which identified water as a vehicle for many epidemic diseases (35). Handbooks containing principles of water sanitation were written later on and gave the sanitarian in the field a concrete source of information from which to draw (6, 10, 21).

Even today, a safe water supply is a fundamental concern of the sanitarian (10). He is to be concerned over water supply construction; pumping, distribution and storage; purification and disinfection; and sampling (6). He also needs a knowledge of water microbiology, chemistry, physics, hydraulics and sanitary science in general (10, 24, 28). Many references concerning individual water supply systems have therefore been written and are currently available to the sanitarian. Freedman's "Sanitarian's Handbook," Ehlers and Steel's "Municipal and Rural Sanitation" and the Environmental Protection

Agency's "Manual of Individual Water Supply Systems" are among the many references frequently utilized by the sanitarian.

A search of the literature revealed no studies which evaluated materials used by the sanitarian in the field. In order to determine what specific information concerning individual water supply systems is needed by the sanitarian in Oregon, the general information available in written form must be determined. A literature review must consider what has been written about the various aspects of individual water supply systems.

Water Supply System Construction

Construction of individual water supply systems is mainly concerned with preventing contamination of water (8, 45). Faulty construction is the chief cause of contaminated wells (42). Accordingly the basic consideration in the construction of a system is the location of an acceptable source. The use of groundwater requires the location of an acceptable aquifer. The most productive aquifers are deposits of unconsolidated materials of high permeability and filtration capabilities. The aquifer should be overlaid with some impervious or restrictive layer such as clay or hardpan. This would act as a barrier against any pollutants which may be washed downward.

Upon the location of an acceptable aquifer, the system should be located certain minimum distances away from any known sources

of pollution. Considerations should be made for septic tank installations, land drainage, irrigation water infiltration, chemicals such as pesticides and fertilizers, solid wastes and other sources of contamination (9, 20, 22).

Locating a water supply a safe distance from a known source of contamination does not lessen the need for proper construction (45). The system should be so designed and constructed to prevent the entrance of contaminants which may appear.

After a hole has been excavated to an acceptable aquifer, a casing is placed or constructed within the hole and sealed both to the sides of the hole and to the impervious layer. Since the hole to the acceptable aquifer may pass through an undesirable aquifer, sealing the casing precludes the possibility of undesirable water from flowing downward into the desired water.

Contaminates from the ground surface are also precluded from entering the system by extending the casing past the ground surface. A sloping concrete slab is poured around the extended casing to keep surface run-off away and a sanitary seal is placed over the top of the casing. The entire exposed system then has a pumphouse constructed around it (5, 8, 10, 11, 13, 14, 17, 23, 31, 32, 37, 39, 42, 43, 45).

Pumping, Distribution and Storage

After construction has taken place, a method of extraction and delivery of the water to some point must be devised. The most common way is by the use of pumps, storage reservoirs and piping.

Pumps lift the water from the aquifer and into a distribution and storage system, and are available in several different types including positive displacement, centrifugal, turbine, submersible and jet. The specific type of pump selected is to depend upon yield of the water source, needs of the user, size of the pressure or storage tank, total lift of water from the aquifer to the point of delivery, and hydraulic frictional losses in the piping. Drop pipes convey water from the aquifer up and through an opening in the sanitary seal and out through the top of the casing.

The storage of the pumped water is in a storage facility of sufficient size to meet the demands of the user. Facilities commonly used are pressure tanks, elevated storage tanks, ground level reservoirs and cisterns. Storage facilities should be so constructed as to prevent the possibility of outside pollution.

The distribution system is ordinarily made up of piping which is usually galvanized iron or steel, cast iron, concrete, plastic or copper. Piping should be protected against damage and corrosion and also should be installed to preclude any cross-connections (1, 6, 10, 13, 15, 32, 39, 44, 45).

Purification and Disinfection

The possibility exists that in spite of all precautions, the water produced is of unacceptable quality. The aquifer itself may contain undesired substances and the removal of these must be considered.

Of prime importance is the presence of micro-organisms in the water. Many pathogenic microbes can be transmitted by water and because of this a means for the disinfection of contaminated water is needed. Disinfection can be accomplished physically by the use of aeration, sunlight or pasteurization; or chemically by the use of chlorine. Chlorinators for individual water supply systems are available in several forms including positive displacement feeders, aspirator feeders, suction feeders and tablet dispensers. Chlorinators must be in acceptable condition and be capable of introducing a given amount of chlorine into the water supply.

The groundwater may also contain other undesired substances including suspended particulate matter causing turbidity; the dissolved "hardness" ions of magnesium or calcium; disease-producing minerals such as nitrates, sulfates or salts; staining minerals such as iron or manganese; or dissolved gases. Water containing these properties may cause corrosion or physical impairments or have an undesirable appearance. Filters, water softeners and chlorination can do much to alleviate these problems (1, 5, 8, 13, 23, 37, 39, 45).

Pollutants and Sampling

The presence of life-injuring substances in water is the greatest concern of the sanitarian (3). Sampling provides a method for determining the biological and chemical quality of the water. Moving groundwater may intermittently contain undesired substances and for this reason sampling, in order to be truly representative of water conditions, must be continuously done. A sample which proves negative cannot justify the conclusion that the water supply is safe (42). Conversely a well cannot be contaminated in the same amount at all times. To equate water samples with groundwater quality, continuous pumping will produce samples of similar quality. If samples vary rapidly in density of contaminants after a period of pumping, it can be assumed that the contamination is entering the aquifer from some point in the system itself (19).

The presence of micro-organisms in water is primarily a health concern because of the potential presence of pathogenic forms. It would be impractical to assay a sample of water for the presence of each pathogenic organism because of sheer numbers that could be involved and also the complexity of the tests. Because of this indicator organisms are used. The most common of these are members of the coliform group and the intermediate aerogenes cloacae (IAC) groups. Both of these groups are the normal inhabitants of the

intestinal tract of homeothermic animals. While neither of these are pathogenic, they do serve as an indicator of fecal pollution of the water. The presence of fecal coliforms in a sample indicates recent pollution, while the presence of the IAC group suggests less recent pollution (48). The coliform test is but a gross indicator of pollution (54).

Samples taken to determine the presence of micro-organisms must be taken in a sterilized container. If a faucet is selected as a point from which to take a sample, the end of the faucet is sterilized by a flame to destroy any micro-organisms present. The faucet is turned on and allowed to run for a period of time in order to obtain water that is fresh from the aquifer. The sterilized container is then filled with water and submitted to a laboratory for testing.

Chemical pollution is also of concern to the sanitarian. Although the effects of small amounts of toxic chemicals in water supplies on humans are not known, the sanitarian is concerned over their potential effects (42). The U. S. Public Health Service provides acceptable limits of various chemical pollutants in drinking water supplies (50) and the Environmental Protection Agency has proposed new limits for concentrations of certain chemicals for community supplies (46).

Most toxic substances in water are derived from industrial or agricultural processes (4) and the most common chemical pollutant in an individual water supply is nitrate salts (53), which can cause

methemoglobinemia in infants (18, 53). Samples for chemical analyses are taken in clean inert containers such as plastic or glass and sent to an appropriate laboratory (5, 8, 23, 37, 39, 50).

Hydraulics

In order to more fully understand water supply, the sanitarian needs to have a basic knowledge of hydraulics (10). This would include the basic principles of hydraulics, water at rest and fluid flow. Information of this type is offered by the U. S. Public Health Service Center for Disease Control in a home study course (49).

Sanitary Survey

Having a basic knowledge of sanitary science, the sanitarian needs to apply this information in order to make a final judgment of the potability of the water. This is accomplished by the use of a sanitary survey (10, 39). The survey is not solely for the purpose of verifying pollution (3), but should be to evaluate the total water supply system. A complete sanitary survey determines the local land drainage area, human habitation, local geology, vegetation, location of adjacent wells, evidence of blasting, slope of the water table, cross-connections, as well as water sampling (38). Only when these aspects are considered, can a safe water supply be attained (5, 38).

Groundwater Supply in Oregon

Statewide interest for water supplies in Oregon lies with several agencies. The U. S. Geological Survey determines the quality and quantity of groundwater (47); the Oregon State Engineer insures the public health, safety and welfare by promulgating standards and regulations relating to water wells (28); the Oregon State Health Division is concerned with the sanitary construction, maintenance and sampling (34); and the Oregon Department of Environmental Quality insures proper setbacks of sub-surface sewage disposal systems from potable water supply systems (29) and also provides a laboratory for chemical analyses of water (52).

The recharge of aquifers is usually considerably more than the sustained yield, and because of this there is usually an adequate supply of groundwater available state-wide. Groundwater from most sources contains few enough dissolved solids or "hardness," making it acceptable for any public purpose (47). The groundwater supply data are evaluated by the State Engineer and critical areas of water shortage are determined. Potential hazards to groundwater including solid waste disposal sites, hazardous waste sites, and other sub-surface water quality problems are evaluated. Water supply developers are licensed, well construction is enforced, and water well reports are filed (30).

The State Health Division provides technical assistance in the sanitary quality of individual water supply systems and publishes booklets to advise the public. The Health Division also provides a laboratory for the routine bacteriological analysis of water as well as more specific tests for certain suspected pathogens (33). Supervision of individual water supply systems is carried out by a local health agency. The specific function of this agency should be to stimulate owners of these systems to bring them to state standards (51).

Duties of the Sanitarian in Oregon

The local sanitarian in Oregon should be required to have a basic knowledge of water supply construction; pumping, distribution and storage; principles of disinfection and purification; pollutants and sampling; and hydraulics. He needs to synthesize this information in a sanitary survey and should use this as a base for the understanding of groundwater supplies in his area of jurisdiction.

III. METHODOLOGY

In order to correlate the content of reference materials concerning individual water supply systems to the basic knowledge of the sanitarians in Oregon, a determination must be made regarding what information is necessary for the local sanitarians to have to be efficient in this aspect of their work. The necessary information must be developed because there have been no publications aimed directly for use by the local sanitarian concerning individual water supply systems.

An expert technical committee was formed to determine what information a sanitarian in Oregon should know about individual water supply systems. Each committee member selected was familiar with the work of a sanitarian in the field. The committee members came from various backgrounds and disciplines, including practicing sanitarians, university professors and public health administration.

Committee Members

1) Heyden, Roger, M. Ed., R. S., Supervising Sanitarian, Benton County Health Department.
2) Magenheim, Mark, M. D., M. P. H., Administrator, Benton County Health Department.
3) Peterson, John D., M. S., R. S., Campus Sanitarian and Instructor of Health, Oregon State University.

4) Rahe, Terrance, R. S., Graduate Assistant, Department of Soils, Oregon State University.

5) Stoner, John, R. S., Director, Environmental Health Division, Lane County Health Department.

6) Titus, Willard S., Manager, Watershed Survey Program, Office of Protective Health Services, Oregon State Health Division.

7) Willrich, Ted L., Ph. D., Professor, Agricultural Engineering Technology, Oregon State University.

Determining the Basic Knowledge of the Sanitarians Concerning Individual Water Supply Systems

After being informed of the intent of this investigation, each committee member gave his own viewpoint as to the basic knowledge he felt that a sanitarian should know concerning individual water supply systems. These first viewpoints from each member were then incorporated into one composite listing. This new list was re-submitted to each committee member for his opinion on the viewpoints of the other members, and he either agreed or disagreed on each item presented. If there were items of disagreement, they were modified or deleted. The committee member added his additional viewpoints to the list. A subsequent edited list was compiled and re-submitted to each member for review. This process continued until

a general comprehensive list that was in agreement with all members of the expert committee was obtained.

From each statement on the general comprehensive list, a specific representative factual statement was derived and a specific representative list was compiled. The committee reviewed this list to determine if each statement was a fair representation of the corresponding statement on the general comprehensive list. If a member felt that a specific statement was not a fair representation of the corresponding statement on the general comprehensive list, he so indicated by writing on the list. Specific statements determined not to have been fair representations were removed and new statements were substituted. A new specific representative list was re-submitted to each member for approval. This process continued until a series of factual statements which were representative of the items on the general comprehensive list was obtained. In this manner, the basic knowledge of the sanitarians concerning individual water supply systems was determined in a general comprehensive list, and was adequately represented in a specific representative list.

Correlation of the Basic Knowledge of the Sanitarian Concerning Individual Water Supply Systems to the Reference Materials

The intent of this investigation was to evaluate the suitability and extent of available reference materials rather than to evaluate

the sanitarian, and for this reason it was decided not to utilize questions which may have been answered incorrectly. The specific representative list was instead submitted to the sanitarians and they determined if each specific statement could or could not be documented by their available reference materials. If a particular specific statement could not be documented by available reference materials, it was determined to be unavailable information. If a particular specific statement could be documented, the appropriate reference was provided in writing by the sanitarian. There may have been more than one available reference to document a given specific statement, however only one reference needed to be identified.

Survey

The correlation of the determined basic knowledge of the sanitarians concerning individual water supply systems to their reference materials could be best accomplished through a survey conducted through the mail. This survey technique was required because of the distance between local health departments.

A certified cover letter (Appendix 1) explaining the intent of the investigation was sent to each local health department in Oregon (Appendix 2). This letter solicited participation in the survey and requested each department to indicate whether it would be willing to collaborate in the study. A 14-day period from the date of mailing

was permitted to pass allowing each department enough time in which to respond. If no response was received from a department during this time, a telephone call was initiated to determine the response. After the end of the 14-day period, the co-operating or positive respondents were sent a survey form to complete. A 14-day period from the date of mailing the survey was permitted to pass allowing each positive respondent enough time in which to complete and return the form. If a positive respondent failed to return the completed survey form within 14 days, a telephone call was initiated to determine if the form would be returned. An additional seven days were allowed to pass, permitting any other forms enough time in which to be returned.

The survey form was in three sections, each of which dealt with one of the hypotheses (Appendix 3).

In the first section, the sanitarians catalogued their reference materials according to title, author or source; and, if applicable, edition and publisher.

The second section contained the specific statements which the sanitarians documented utilizing their reference materials.

The third section of the survey asked the sanitarians their evaluation of the general comprehensive list. Each general statement was evaluated on a five-point Likert-Type scale as to how the sanitarians felt the statement was necessary to know for their work

efficiencies. Responses to each general statement were "Agree Strongly," "Agree," "Undecided," "Disagree," or "Disagree Strongly."

Statistical Analyses of Data Obtained

Since this study was limited to the local health departments in Oregon and each department was given the opportunity to participate, a statistical inference on data obtained needed not apply. A total population given the opportunity to participate precluded the necessity for a pilot study of the survey form (40). However non-respondents were taken into account as explained below in section "b."

Statistical tabulations were applied to each of the three hypotheses and were as follows:

a. Hypothesis 1): There will be less than 100 percent uniform reference materials concerning individual water supply systems in each of the offices of the local sanitarians.

Each local health department office listed all of their reference materials concerning individual water supply systems. All the materials utilized throughout Oregon were tabulated along with the frequency of availability in each health department and a simple percentage of statewide availability was calculated for each reference material. If a given reference material did not have a 100 percent availability in all the local sanitarians' offices, it was not considered a uniform reference material in this investigation.

b. Hypothesis 2): Utilizing their available reference materials, the local sanitarians will not be able to complete at least 70 percent of the specific statements on water supply systems.

The total number of specific statements on each survey returned by a given respondent was divided by the total number of documented statements to yield a percentage score. A score of less than 70 percent determined that the reference materials concerning individual water supply systems of that sanitarian staff were inadequate for the basic knowledge.

The mean of the scores of all survey forms returned was calculated and a mean of less than 70 percent determined that the reference materials available in Oregon were not adequate for the basic knowledge of the sanitarians concerning individual water supply systems.

An analysis was also done of each specific statement in the survey form. For a given specific statement the total number of respondents was divided into the number of documentations given to yield a percentage score for that statement. A score of less than 70 percent determined that the reference materials available in Oregon concerning that statement were inadequate for the basic knowledge of the sanitarians concerning individual water supply systems.

Non-respondents were considered in two ways. First, the non-respondents were assumed to have not been able to document any of the specific statements on the survey. Therefore, each

received a score of 0 percent. All of these scores were included with the scores of the positive respondents and a new mean was calculated. This new mean represented the lowest possible mean had all local health departments participated in the survey.

Secondly, all non-respondents were assumed to have been able to document every specific statement on the survey. Each, therefore, received a score of 100 percent. All of these scores were included with the scores of the positive respondents and a second new mean was calculated. This mean represented the highest possible mean had all local health departments participated in the survey.

By calculating both the highest and lowest possible mean, the domain of the true mean score can be determined had all local health departments in Oregon participated in the survey.

c. Hypothesis 3): The local sanitarians will agree with an expert technical committee's opinion on the basic knowledge a sanitarian should have concerning individual water supply systems.

Each of the responses on the Likert-type scale was assigned a numerical value. "Agree strongly" was assigned a value of 5, "Agree" was assigned a value of 4, "Undecided" was assigned a value of 3, "Disagree" was assigned a value of 2, and "Disagree strongly" was assigned a value of 1. For a given respondent, the mean of all the numerical values of the responses on the scale was calculated. A mean of greater than 3.50 determined, in this investigation, that

the respondent agreed with the basic knowledge of the sanitarians concerning individual water supply systems, as determined by the expert technical committee.

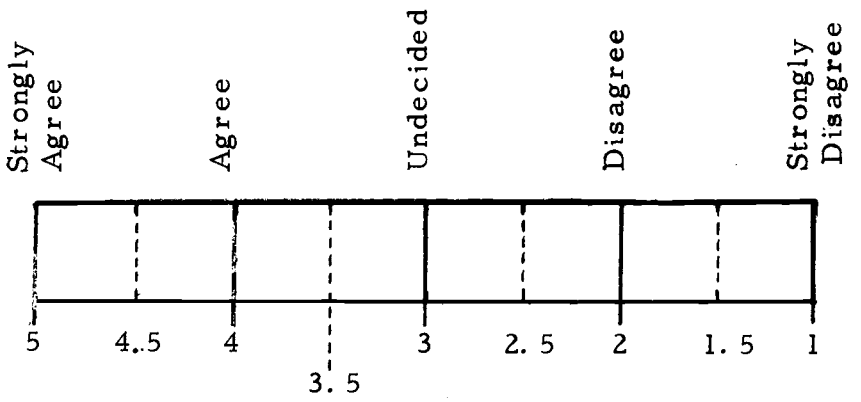

Figure 1. Likert-type scale showing ranges of subdivisions.

The mean of the means of the respondents was also calculated and a collective mean of greater than 3. 50 determined, in this investigation, that the local sanitarians of Oregon agreed with the basic knowledge of the sanitarians concerning individual water supply systems, as determined by the expert technical committee.

An analysis of each general statement was done also. For a given general statement, the total of the numerical values recorded on all survey forms was divided by the total number of respondents to yield a score for that general statement. A score of greater than 3. 50 determined, in this investigation, that the local sanitarians of

Oregon agreed with the general statement developed by the expert technical committee.

IV. RESULTS

A request for participation in the survey was mailed to each of the 35 health departments in Oregon. A total of 14 days were allowed to elapse, and those departments who did not reply were telephoned to determine their response.

The discovery was made that two local health departments no longer had sanitarian staffs. From the 33 remaining health departments, 30 indicated that they would participate in the survey. This yielded a 90. 9 percent positive response.

Participating health departments were mailed a survey form (Appendix 3). Fourteen days were allowed to elapse and those departments who did not return the form were telephoned to determine if the form would soon be returned. Two health departments stated that they did not receive the survey form in the mail. These two departments were then considered as non-participants, reducing the total number of participants to 28.

An additional seven days were allowed to elapse to permit other forms to be returned. At the end of the seven-day extension, an overall total of 22 forms were received for a 78. 6 percent return for participating health departments.

Some of the forms returned were not completed. Twenty of the 22 forms had Section I completed. This yielded a 90. 9 percent

completion for forms returned, or a 71.4 percent completion for the 28 participating health departments for Section I.

Fourteen of the forms had Section II completed. This yielded a 63.6 percent completion for the 22 forms returned, or a 50.0 percent completion for the 28 participating health departments for Section II.

Twenty-one of the forms had Section III completed. This yielded a 95.5 percent completion fo the 22 forms returned, or a 75.0 percent completion for the 28 participating health departments for Section III.

Evaluation of Hypothesis 1

Hypothesis 1) There will be less than 100 percent uniform reference materials concerning individual water supply systems in each of the offices of the local sanitarians.

Out of the 20 health departments who listed their references concerning individual water supply systems, a total of 71 different references were available. The most frequent reference listed was available to 12 of the departments. This yielded a 42.9 percent availability. Out of the 71 references listed, 41 had a frequency of one. This yielded a 3.6 percent availability (Table I).

The lack of a 100 percent availability for each of the references listed did not provide for uniformity of any reference, and thus hypothesis 1 that there will be less than 100 percent uniform

reference materials concerning individual water supply systems in each of the offices of the local sanitarians, was proven true.

Evaluation of Hypothesis 2

Hypothesis 2) Utilizing their available references, the local sanitarians will not be able to document 70 percent or more of the specific statements on individual water supply systems.

Fourteen of the health departments completed Section II of the survey form which dealt with the documentations of the specific statements. Considering the 22 specific statements on each form, there was a total of 159 specific statements documented on all forms with Section II completed.

The total number of specific statements documented by each health department was converted to a percentage score. Four of the health departments who completed Section II scored at least 70 percent, while ten of the departments scored less than 70 percent. The mean of the scores of the health departments who completed Section II was 51.6 percent (Table II). The hypothesis is accepted because the findings determined that the reference materials concerning individual water supply systems available in Oregon were not adequate for the basic knowledge of the sanitarians.

TABLE I. Availability of individual water supply systems' reference materials as listed by local health departments in Oregon.

Reference	Frequency of Availability	Percentage of Availability
1) Manual of Individual Water Supply Systems, Environmental Protection Agency.	12	43.9%
2) Municipal and Rural Sanitation, V. Ehlers and E. Steel.	12	42.9%
3) Oregon Administrative Rules, Health Division.	11	39.3%
4) Protection and Purification of Rural Water Supplies, Oregon State Health Division.	10	35.7%
5) Sanitarian's Handbook Theory and Administrative Practice, B. Freedman.	9	32.1%
6) A Safe Water System, Oregon State Health Division.	8	28.6%
7) Purification of Well Water Supplies, Oregon State Health Division.	6	21.4%
8) Environmental Engineering and Sanitation, J. Salvato.	5	17.9%
9) Oregon Revised Statutes, State of Oregon.	5	17.9%
10) Standard Methods for the Examination of Water and Wastewater, American Public Health Association, American Water Works Association.	5	17.9%
11) Oregon Administrative Rules, State Engineer.	4	14.3%
12) Primer on Water Quality, U. S. Department of the Interior.	4	14.3%
13) Water and Man's Health, Miller	3	10.7%
14) Water Supply and Plumbing Cross-Connections, U. S. Public Health Service.	3	10.7%
15) Basic Hydraulics for the Sanitarian, U. S. Public Health Service, Center for Disease Control.	2	7.1%
16) Danger in Flooded Wells, State Health Division.	2	7.1%

TABLE I. (Continued)

Reference	Frequency of Availability	Percentage of Availability
17) Drinking Water Standards, U. S. Public Health Service.	2	7. 1%
18) Groundwater and Wells, U. O. P., Johnson Division.	2	7. 1%
19) Manual of Individual Water Supply Systems, U. S. Public Health Service.	2	7. 1%
20) Manual of Instruction for Water Treatment Plant Operators, New York State Department of Health.	2	7. 1%
21) Oregon State Health Division Bulletin, State Health Division.	2	7. 1%
22) Planning for an Individual Water System, American Association for Vocational and Instructional Materials.	2	7. 1%
23) Primer on Water, U. S. Department of the Interior.	2	7. 1%
24) Safe Drinking Water in Emergencies, U. S. Public Health Service.	2	7. 1%
25) Safe Water Act, U. S. Government.	2	7. 1%
26) Source Book on Community Water Supplies, J. Ameen.	2	7. 1%
27) Water Encyclopedia, D. Todd.	2	7. 1%
28) Water Supply and Sewerage, E. Steel.	2	7. 1%
29) Water System and Treatment Handbook, Water Systems Council.	2	7. 1%
30) Analytical Quality Control, Environmental Protection Agency.	1	3. 6%
31) Aquatic Microbiology, Rheinheimer.	1	3. 6%
32) Bergey's Manual of Determinate Bacteriology.	1	3. 6%
33) Chlorination of Wells, Curry County Health Department.	1	3. 6%

TABLE I. (Continued)

Reference	Frequency of Availability	Percentage of Availability
34) Clear, Cool, and Pure Drinking Water, Marion County Health Department.	1	3. 6%
35) Commission on Rural Water Report, Groundwater Council.	1	3. 6%
36) Community Water Systems, J. Ameen.	1	3. 6%
37) Cross-Connection Control Manual, Environmental Protection Agency.	1	3. 6%
38) Ecology of Inland Waters.	1	3. 6%
39) Environmental Health, P. Purdom.	1	3. 6%
40) Environmental Health Practices in Recreation Parks, U. S. Public Health Service.	1	3. 6%
41) Foodborne and Waterborne Disease Outbreaks, U. S. Public Health Service.	1	3. 6%
42) Free Water, Water Systems Council.	1	3. 6%
43) Freshwater Biology, Ward and Whipple.	1	3. 6%
44) Fundamentals of Microbiology, Saunders.	1	3. 6%
45) Ground Water Hydrology, D. Todd.	1	3. 6%
46) Groundwater, Van der Leeden.	1	3. 6%
47) Hydrogeology, Davis and Dewiest.	1	3. 6%
48) Hydrogeology, Wisler and Bratler.	1	3. 6%
49) Journal of the American Water Works Association, American Water Works Association.	1	3. 6%
50) Manual of Water Purification Procedures, U. S. Army Corps of Engineers.	1	3. 6%
51) Methods for Chemical Analysis of Water and Wastes, Environmental Protection Agency.	1	3. 6%
52) Microbiology, Pelczar and Reid.	1	3. 6%

TABLE I. (Continued)

Reference	Frequency of Availability	Percentage of Availability
53) Microbiology for Sanitary Engineers, McKinney.	1	3. 6%
54) Oregon State Plumbing Code, Oregon State Department of Commerce.	1	3. 6%
55) Sanitary Significance of Fecal Coliforms in the Environment, E. Geldreich.	1	3. 6%
56) Simplified Procedures for Water Examination, American Water Works Association.	1	3. 6%
57) Textbook of Microbiology, Burrows.	1	3. 6%
58) The Design of Small Water Systems, J. Salvato.	1	3. 6%
59) Water Chlorination Principles and Practices, American Water Works Association.	1	3. 6%
60) Water Handbook, State of Missouri.	1	3. 6%
61) Water, Health, Society, Wolman.	1	3. 6%
62) Water Microbiology, Environmental Protection Agency.	1	3. 6%
63) Water Purification Control, Hopkins and Bean.	1	3. 6%
64) Water Quality and Treatment, American Water Works Association.	1	3. 6%
65) Water Resources Data, U. S. Geological Survey.	1	3. 6%
66) Water Supply and Treatment, Straub.	1	3. 6%
67) Water Supply for Rural and Small Communities, Wagoner and Lennox.	1	3. 6%
68) Water Treatment Plant Design, American Water Works Association.	1	3. 6%
69) Water Well Technology, Campbell.	1	3. 6%
70) Water Works Manual Basic, Co-ordinating Council for Occupational Education.	1	3. 6%
71) Water Works Operator's Manual, Westgarth.	1	3. 6%

TABLE II. Documentations of the 22 specific statements of basic knowledge concerning individual water supply systems by various local health departments in Oregon.

Health Department	Number of Documentations	Percentage Score
1) Clackamas County	3	13. 6%
2) Coos County	11	50. 0%
3) Curry County	1	4. 5%
4) Deschutes County	17	77. 3%
5) Douglas County	17	77. 3%
6) Jackson County	15	68. 2%
7) Lincoln County	10	45. 5%
8) Marion County	15	68. 2%
9) Multnomah County	10	45. 5%
10) Pendleton Satellite*	0	0. 0%
11) Portland Regional	12	54. 5%
12) Tillamook County	15	68. 2%
13) Umatilla County	17	77. 3%
14) Washington County	16	72. 7%
Total	159	722. 4
Mean	11. 4	51. 6%

*Department responded that it had no reference materials concerning individual water supply systems. Therefore, no documentations are possible.

TABLE III. Reference documentations for each specific statement of basic knowledge concerning individual water supply systems by 14 local health departments in Oregon.

	Specific Statement	Number of Documentations	Percentage Score
1)	Wells should be located in areas where groundwater is found in unconsolidated formations.	7	50.0%
2)	Because older rocks are more likely to have reduced porosity and permeability, younger rocks are better yielding aquifers.	3	21.4%
3)	Groundwater from most sources in Oregon contains dissolved solids between 100 and 300 ppm and hardness between 50 and 150 ppm.	0	0.0%
4)	The most productive aquifers are deposits of clean, coarse sand and gravel; coarse, porous sandstone; cavernous limestones; and broken lava rock.	10	71.4%
5)	All water within Oregon from all sources of water supply belong to the public, and therefore "riparian rights" do not exist.	2	14.3%
6)	The purpose of well "development" is to remove finer material from the aquifer, thereby enlarging passages so that water can enter the well more freely.	9	64.3%
7)	In a well screen, proper slot sizes are critical in governing the extent to which well "development" is carried.	10	71.4%
8)	When corrosive water or soil is encountered, brass, wrought iron, plastic or cast iron pipe will have a longer, more useful life than would galvanized pipe.	8	57.1%
9)	Two factors are essential for backflow of polluted water into potable water: A link between the two systems and a resultant force towards the potable supply.	6	42.9%
10)	After construction or repair of an individual water supply system, the entire system should be flushed out and disinfected.	10	71.4%

TABLE III. (Continued)

	Specific Statement	Number of Documentations	Percentage Score
11)	The total "head" on a pump is composed of lift from the water surface to the pump, elevation to the highest point of water delivery, friction losses in the piping and the pressure desired at outlet.	8	57.1%
12)	One foot of "head" is equal to the weight of a column of water one inch square and one foot in height.	3	21.4%
13)	A water softener removes calcium and magnesium ions from water and replaces them with sodium ions.	9	64.3%
14)	Because of the contamination potential of sub-surface sewage disposal areas to water supply systems, Oregon requires a minimum horizontal separation distance of 100 feet.	10	71.4%
15)	Organisms of the Intermediate Aerogenes Cloacae (IAC) group tend to survive longer in water than do organisms of the coliform group.	7	50.0%
16)	At breakpoint chlorination, the dosage at which minimal residual occurs; it is believed that all the ammonia and other nitrogen compounds are completely oxidized.	10	71.4%
17)	The more turbid the water, the higher will be the dosage of chlorine needed for disinfection.	11	78.6%
18)	The contact time required for chlorine to effectively kill bacteria depends upon the concentration of the chlorine solution, the temperature and pH of the water.	10	71.4%
19)	In testing for the presence of coliform organisms in water, a positive presumptive test indicates that coliforms may be present, while the confirmatory test confirms the presence of the coliform group.	10	71.4%

TABLE III. (Continued)

	Specific Statement	Number of Documentations	Percentage Score
20)	The Public Health Laboratory of the Oregon State Health Division can conduct Most Probable Number (MPN) tests on water samples.	3	21.4%
21)	The laboratory of the Oregon Department of Environmental Quality can test for the presence of chemicals in water samples.	0	0.0%
22)	When a well is to be permanently abandoned, it should be filled with concrete or other similar material with sealing properties.	11	78.6%

The total number of documentations for each specific statement was also tabulated. For each specific statement, the total number of documentations was divided by the 14 health departments who completed Section II to yield a percentage score. Thirteen of the statements yielded scores of less than 70 percent, indicating that the reference materials available in Oregon concerning each of these statements were not adequate for the basic knowledge of the sanitarians (Table III).

The assumed number of documentations of the 19 non-respondents to Section II were incorporated into the number of actual documentations. Assuming that the non-respondents would not have been able to document any of the 22 specific statements, the highest number of documentations for all 33 possible respondents would remain at 159. This would yield an average of 4. 8 documentations for all possible respondents, or 21. 6 percent (Table IV).

Assuming that the 19 non-respondents would have been able to document all of the 22 specific statements, the highest number of documentations for all 33 possible respondents would be 577. This would yield an average of 17. 5 documentations for all possible respondents, or 79. 5 percent (Table IV).

The possible range from 21. 6 percent to 79. 5 percent yields a median score of 50. 5 percent. If the assumption is made that the scores of non-respondents fall within a normal distribution of this

range, then it is probable that the true mean, had all sanitarian staffs completed the survey form, would fall in close proximity to the actual obtained mean of 51.6 percent.

If the assumption is made that the 14 respondents to Section II are representative of all 33 possible respondents, then it can be said on the basis of the data that hypothesis 2 that utilizing their available references, the local sanitarians will not be able to document 70 percent or more of the specific statements on individual water supply systems, is proven true.

TABLE IV. Incorporation of the possible assumed documentations of non-respondents into the total number of substantiations for the 22 specific statements of basic knowledge concerning individual water supply systems in reference to Section II of the survey form.

	Number of Documentations		
	Actual	Highest Assumed	Lowest Assumed
Number of Respondents (14)	159	159	159
Number of Non-Respondents (19)	0	418	0
Total Assumed Documentations		577	159
Total Number of Assumed Documentations divided by 33 possible respondents		17.5	4.8
Percentage Score		79.5	21.9%
Median of the Range		50.5%	

Evaluation of Hypothesis 3

Hypothesis 3) The local sanitarians will agree with an expert technical committee's opinion on the basic knowledge a sanitarian should have concerning individual water supply systems.

A total of 21 health departments completed Section III of the survey form. The total of the numerical values of all responses on the Likert-type scale were calculated for each respondent. All of the respondents had a mean response of greater than 3. 50. Mean responses ranged from 3. 81 to 4. 91, with the average mean being 4. 23 (Table IV). This confirms hypothesis 3 that the local sanitarians will agree with an expert technical committee's opinion on the basic knowledge a sanitarian should have concerning individual water supply systems.

The total numerical values recorded for each general statement were divided by the number of respondents[1] to Section III to yield a score for each general statement. Scores for each general statement ranged from 3. 20 to 4. 71. Twenty of the 22 general statements received scores greater than 3. 50, while the remaining two general statements received scores of less than 3. 50 (Table VI).

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[1] Some respondents recorded only 21 of the 22 statements.

TABLE V. Frequency and mean of responses on the Likert-type scale recorded by local health departments in Oregon.

	Health Department	Frequency of Response: Strongly Agree (5)	Agree (4)	Undecided (3)	Disagree (2)	Strongly Disagree (1)	Total	Mean of Values
1)	Bend Regional	12	8	1	1	0	22	
	Value Total	(60)	(32)	(3)	(2)	(0)	(97)	4.41
2)	Clackamas County	3	16	2	1	0	22	
		(15)	(64)	(6)	(2)	(0)	(87)	3.95
3)	Clatsop County	8	11	1	2	0	22	
	Value Total	(40)	(44)	(3)	(4)	(0)	(91)	4.13
4)	Coos County	1	18	3	0	0	22	
	Value Total	(5)	(72)	(9)	(0)	(0)	(86)	3.91
5)	Curry County	11	8	3	0	0	22	
	Value Total	(55)	(32)	(9)	(0)	(0)	(96)	4.36
6)	Deschutes County	20	2	0	0	0	22	
	Value Total	(100)	(8)	(0)	(0)	(0)	(108)	4.91
7)	Douglas County	0	22	0	0	0	22	
	Value Total	(0)	(88)	(0)	(0)	(0)	(88)	4.00
8)	Eugene Regional	1	18	2	1	0	22	
	Value Total	(5)	(72)	(6)	(2)	(0)	(85)	3.85
9)	Hood River County	7	9	5	0	0	21	
	Value Total	(35)	(36)	(15)	(0)	(0)	(86)	4.10
10)	Jackson County*	7.5	8.5	5	1	0	22	
	Value Total	(37.5)	(34)	(15)	(2)	(0)	(88.5)	4.02

*Six persons responded individually on the Likert-type scale. Mode score was selected as the overall response of the department. If the response was bimodal, the middle-occurring value was selected.

TABLE V. (Continued)

	Health Department	Frequency of Response: Strongly Agree (5)	Agree (4)	Undecided (3)	Disagree (2)	Strongly Disagree (1)	Total	Mean of Values
11)	Lincoln County	3	15	1	3	0	22	
	Value Total	(15)	(60)	(3)	(6)	(0)	(84)	3.82
12)	Linn County	13	9	0	0	0	22	
	Value Total	(65)	(36)	(0)	(0)	(0)	(101)	4.59
13)	Malheur County	0	22	0	0	0	22	
	Value Total	(0)	(88)	(0)	(0)	(0)	(88)	4.00
14)	Marion County	18	1	3	0	0	22	
	Value Total	(90)	(4)	(9)	(0)	(0)	(103)	4.68
15)	Multnomah County	15	3	4	0	0	22	
	Value Total	(75)	(12)	(12)	(0)	(0)	(99)	4.50
16)	Polk County	14	4	1	3	0	22	
	Value Total	(70)	(16)	(3)	(6)	(0)	(95)	4.32
17)	Portland Regional	18	0	4	0	0	22	
	Value Total	(90)	(0)	(12)	(0)	(0)	(102)	4.64
18)	Roseburg Regional	3	19	0	0	0	22	
	Value Total	(15)	(76)	(0)	(0)	(0)	(91)	4.14
19)	Tillamook County	14	6	1	1	0	22	
	Value Total	(70)	(24)	(3)	(2)	(0)	(99)	4.50
20)	Umatilla County	0	18	2	1	0	21	
	Value Total	(0)	(72)	(6)	(2)	(0)	(80)	3.81

TABLE V. (Continued)

	Health Department	Frequency of Response: Strongly Agree (5)	Agree (4)	Undecided (3)	Disagree (2)	Strongly Disagree (1)	Total	Mean of Values
21)	Washington County	10	7	3	1	1	22	
	Value Total	(50)	(28)	(9)	(2)	(1)	(90)	4.00
							Total of Mean Values	88.73
							Average Mean	4.23

TABLE VI. Mean scores of numerical values of all responses recorded by local health departments in Oregon for each of the 22 general statements of basic knowledge concerning individual water supply systems.

General Statement	Total of Numerical Values Assigned	Number of Respondents	Mean Score
The sanitarian in the field should know:			
1) proper location.	95.5*	21	4.55
2) hydrogeology	75	21	3.57
3) natural water quality	86	21	4.10
4) occurrence of groundwater	82	21	3.90
5) rights to groundwater	64	20	3.20
6) well development	86	20	4.30
7) proper design	92	21	4.38
8) proper distribution system	94	21	4.48
9) plumbing and cross-connections	94	21	4.48
10) mainline flushing and disinfection	95	21	4.52
11) proper operation	87.5*	21	4.17
12) hydraulics	69	21	3.29
13) equipment used to modify water properties	84.5*	21	4.02
14) pathways for entry of pollutants into groundwater	98	21	4.67
15) bacteriology and coliform significance	99	21	4.71
16) halogen chemistry	81.5*	21	3.88
17) raw water factors pertaining to bacteriology and halogen chemistry	86.5*	21	4.12

TABLE VI. (Continued)

	General Statement	Total of Numerical Values Recorded	Number of Respondents	Mean Score
18)	procedures to treat water of pollutants	90	20	4.50
19)	water analyses and interpretation of results	96	21	4.57
20)	servives of the Public Health Laboratory and private laboratories	96	21	4.57
21)	services of the Department of Environmental Quality laboratory	94	21	4.48
22)	well abandonment	95	21	4.52

*Six persons responded individually on the Likert-type scale. Mode score was selected as the overall response of the department. If the response was bimodal, the middle-occurring value was selected.

The two general statements which received scores of less than 3. 50, or those not agreed upon by the sanitarians, were concerned with rights to groundwater (General Statement 5), and hydraulics (General Statement 12). The corresponding specific statement to each of these had a low percentage documentation by the sanitarians. The percentage documentation for Specific Statement 5 was 15. 4 percent and the percentage documentation for Specific Statement 12 was 23. 1 percent. These two general statements which were scored lowest by the sanitarians, were also ones containing information not readily found in available reference materials.

Conversely, the two highest scored general statements were concerned with bacteriology and coliform significance (General Statement 15), and pathways for entry of pollutants into groundwater (General Statement 14). The corresponding specific statements had comparatively higher percentage documentations. The percentage documentation for Specific Statement 15 was 53. 8 percent, and the percentage documentation for Specific Statement 14 was 76. 9 percent. These two general statements which were scored highest by sanitarians were also ones containing information more readily found in available reference materials (Table III, Table VI).

Comparison of Results in Sections II and III of the Survey

A comparison of the responses was carried out to determine if any relationship existed between the documentations of the specific statements (Section II) and the average Likert scores (Section III).

The 22 general statements were each placed under one of three broad categories. These categories included "Pre-Construction," "Mechanics," and "Pollution Control."

"Pre-Construction" included general statements which pertained to considerations needed before a water supply system was actually constructed. The general statements included under this category were proper location, hydrogeology, natural water quality, occurrence of groundwater, and rights to groundwater.

"Mechanics" included general statements which pertained to physical mechanical equipment used in a water supply system. The general statements included under this category were well development, proper design, proper distribution system, plumbing and cross-connections, proper operation, hydraulics, equipment used to modify water properties, and well abandonment.

"Pollution Control" included general statements which pertained to the quality of the water delivered for use. The general statements included under this category were mainline flushing and disinfection, pathways for entry of pollutants into groundwater, bacteriology and coliform significance, halogen chemistry, raw water factors

pertaining to bacteriology and halogen chemistry, procedures to treat water of pollutants, water analyses and interpretation of results, services of the Public Health Laboratory and private laboratories, and services of the Department of Environmental Quality laboratory.

The average mean for the general statements in each category was calculated. The average mean for general statements under "Pre-Construction" was 3. 86, the average mean for general statements under "Mechanics" was 4. 21, and the average mean for general statements under "Pollution Control" was 4. 45. This gave some insight as to the relative importance the sanitarians gave to each category. The sanitarians tended to feel that pollution control was the most important aspect of their work in individual water supply systems (Table VII).

The average percentage scores of specific statements corresponding to the general statements in each category was also done. These average scores were compared to the average mean for each category. The average percentage score for specific statements under "Pre-Construction" was 33. 8 percent, the average percentage score for specific statements under "Mechanics" was 61. 5 percent, and the average percentage score for specific statements under "Pollution Control" was 60. 7 percent (Table VII).

There was a tendency, therefore, for the average percentage score for specific statements to increase as the average mean for

TABLE VII. Comparison of average means for general statements and average percentage documentations for corresponding specific statements in each of three broad categories.

	Statements pertaining to:		Section II Percentage Documentations	Section III Average Mean
a) Pre-Construction				
1)	Proper location		53.8%	4.55
2)	Hydrogeology		23.1%	3.57
3)	Natural water quality		0.0%	4.10
4)	Occurrence of groundwater		76.9%	3.90
5)	Rights to groundwater		15.4%	3.20
		Total	169.2	19.32
		Average	33.8%	3.86
b) Mechanics				
1)	Well development		69.2%	4.30
2)	Proper design		76.9%	4.38
3)	Proper distribution system		61.5%	4.48
4)	Plumbing and cross-connections		46.1%	4.48
5)	Proper operation		61.5%	4 17
6)	Hydraulics		23.1%	3.29
7)	Equipment used to modify water properties		69.2%	4.02
8)	Well abandonment		84.6%	4.52
		Total	492.1	33.64
		Average	61.5%	4.21

TABLE VII. (Continued)

Statements pertaining to:	Section II Percentage Documentations	Section III Average Mean
c) Pollution Control		
1) Mainline flushing and disinfection	76.9%	4.52
2) Pathways for entry of pollutants into groundwater	76.9%	4.67
3) Bacteriology and coliform significance	53.8%	4.71
4) Halogen chemistry	76.9%	3.88
5) Raw water factors pertaining to bacteriology and halogen chemistry	84.6%	4.12
6) Procedures to treat water of pollutants	76.9%	4.50
7) Water analyses and interpretation of results	76.9%	4.57
8) Services of the Public Health Laboratory and private laboratories	23.1	4.57
9) Services of the Department of Environmental Quality laboratory	0.0%	4.48
Total	546.6	40.0
Average	60.7%	4.45

general statements increased. Generally, as the availability of reference materials concerning each of these three broad categories increased, increasing importance on each category was recorded by the sanitarians.

The results of this study were limited by the size of the sample and by the number of completed sections on the returned survey forms. If a larger sampling size were possible, the results could have possibly produced more significant data than that which was obtained.

The results of this study were also limited by the degree of importance that the sanitarian staffs placed upon their work concerning individual water supply systems. Sanitarian staffs which placed a higher priority on their work concerning individual water supply systems may have had more complete reference materials and may have been more rigorous in their documentations.

Sanitarian staffs which placed a lower priority on their work concerning individual water supply systems, may not have had many references, nor may not have been as rigorous in their documentations.

The measurement of the priorities that the sanitarian staffs placed on their work concerning individual water supply systems is beyond the scope of this investigation. This investigation will have

to make the assumption that sanitarian staffs placed equal priorities on their work concerning individual water supply systems.

V. SUMMARY, ANALYSIS OF FINDINGS AND RECOMMENDATIONS

Summary

The local sanitarian in Oregon plays an important part in the promulgation of public health standards. One of the more important standards is maintaining the sanitary quality of individual water supply systems. In order to be knowledgeable in individual water supply systems, the sanitarian would likely need a supply of reference materials on hand. There are presently no publications concerning individual water supply systems which are written for sanitarians in Oregon. Written reference materials available for use are numerous and are of a general nature.

An evaluation by survey was made of these reference materials to determine how appropriate they were for the sanitarian in Oregon. Three hypotheses were made:

a. Hypothesis 1): There will be less than 100 percent uniform reference materials concerning individual water supply systems in each of the offices of the local sanitarians.

b. Hypothesis 2): Utilizing their available references, the local sanitarians will not be able to document 70 percent or more of the specific statements on water supply systems.

c. Hypothesis 3): The local sanitarians will agree with an expert technical committee's opinion on the basic knowledge a sanitarian should have concerning individual water supply systems.

An expert technical committee was established for the purpose of determining the basic knowledge that a sanitarian in Oregon should have concerning individual water supply systems. This basic knowledge was then compared with the content of the available references to determine if the references contained the basic knowledge.

At least seventy-one different references were being utilized by sanitarians in Oregon. The most common references listed in the survey were available to 42.9 percent of the sanitarian staffs.

The reference materials available could only document an average of 51.6 percent of the basic knowledge determined essential for the sanitarians.

The sanitarians also agreed that they should have the basic knowledge as determined by the expert technical committee.

All three hypotheses were therefore proven true.

Analysis of Findings

The great fragmentation of available reference materials is one outstanding feature of the results of this study. Forty-two of the 71 references listed had a frequency of availability of only one. Collectively, these numerous references could well have been sufficient to contain all the basic knowledge concerning individual water supply systems. However, since many of them were relatively exclusive to a particular health department, the basic knowledge contained in them

was also distributed among health departments in a fragmented manner. This is reflected in the statewide average of 11.6 documentations out of 22 possible statements of basic knowledge.

In order to equalize the content of the references to each sanitarian staff, all of the listed references would have to be available in each health department. There would undoubtedly be tremendous overlap of material should this occur. The only benefit would be in obtaining that portion of the basic knowledge which would not be found in the references already available.

Considering the distribution of reference materials which provides for fragmentation of the basic knowledge, and the agreement of the sanitarians that the basic knowledge is necessary to have; the conclusion in this investigation is that the written reference materials concerning individual water supply systems are not sufficient for the sanitarians of Oregon.

Recommendations

As a result of this investigation the following recommendations are made:

1) A recommendation is made that a manual concerning individual water supply systems be written for sanitarians in Oregon. This manual should include and elaborate on the basic knowledge on individual water supply systems in Oregon.

2) Maintenance of the sanitary quality of individual water supply systems is but one of the public health duties of sanitarians. Some of the sanitarians' other duties include food sanitation, solid wastes, sub-surface sewage disposal, housing, vector control, institutional sanitation and swimming pool sanitation. As a sequel to this investigation, a recommendation is made that the written reference materials concerning these and other duties should be evaluated for sanitarians in Oregon.

3) The 50 percent completion for Section II of the survey form indicates revision is necessary to permit that section to be completed in a shorter period of time.

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APPENDIX 1

OREGON STATE UNIVERSITY
Department of Health
Corvallis, Oregon 97331 (503) 754-2686

June 9, 1976

Sir:

I am a sanitarian associated with Oregon State University and am doing graduate work in environmental health. I am currently gathering information for a research study which concerns individual water supply systems and the local sanitarian.

As you well know, water is of great public health importance because it can be a medium for transporting many substances adverse to humans. Individual water supply systems usually do not enjoy the benefits of being carefully monitored as do community supplies, and because of this the local sanitarian plays an important role in safe-guarding these systems.

There is, at present, a great amount of general reference material available in written form concerning individual water supply systems, many of which are undoubtedly used by the local sanitarians in their daily activities. There are however, no publications concerning this which are tailored specifically for the sanitarian according to conditions prevailing in Oregon.

The purpose of the research study is to determine how appropriate these general reference materials are for the sanitarian in the field. A state-wide survey is planned to determine the appropriateness of these reference materials as to the specific conditions prevailing in Oregon. Tentative plans are to mail the survey in June.

Your department is respectfully invited to participate. Could you please indicate to me if you would be willing to collaborate on this matter? It must be emphasized that this survey will not evaluate the sanitarians themselves, but rather the materials with which they work. I believe the results of the survey to be worthwhile and would be willing to share them with you if you so desired.

A reply postcard is enclosed for your convenience. Your expedient reply would be most appreciated.

Thank you,

Frank C. Carter, R. S.
Graduate Assistant
Department of Health

APPENDIX 2

LOCAL HEALTH DEPARTMENTS IN OREGON

1) Baker County Health Department, Baker, Oregon**
2) Clackamas County Health Department, Oregon City, Oregon
3) Clatsop County Health Department, Astoria, Oregon
4) Columbia County Health Department, St Helens, Oregon*
5) Coos County Health Department, Coquille, Oregon
6) Crook County Health Department, Prineville, Oregon
7) Curry County Health Department, Gold Beach, Oregon
8) Deschutes County Health Department, Bend, Oregon
9) Douglas County Health Department, Roseburg, Oregon
10) Hood River County Health Department, Hood River, Oregon
11) Jackson County Health Department, Madras, Oregon
12) Jefferson County Health Department, Madras, Oregon**
13) Josephine County Health Department, Grants Pass, Oregon
14) Klamath County Health Department, Klamath Falls, Oregon
15) Lane County Health Department, Eugene, Oregon
16) Lincoln County Health Department, Newport, Oregon
17) Linn County Health Department, Albany, Oregon
18) Malheur County Health Department, Vale, Oregon
19) Marion County Health Department, Salem, Oregon
20) Multnomah County Health Department, Portland, Oregon
21) Polk County Health Department, Dallas, Oregon
22) Tillamook County Health Department, Tillamook, Oregon
23) Umatilla County Health Department, Pendleton, Oregon
24) Union County Health Department, La Grande, Oregon*
25) Wasco-Sherman County Health Department, The Dalles, Oregon
26) Washington County Health Department, Hillsboro, Oregon
27) Yamhill County Health Department, McMinnville, Oregon
28) Portland Regional Office, Oregon State Health Division, Portland, Oregon
29) Portland Satellite Office, Oregon State Health Division, Columbia Office, St. Helens, Oregon
30) Eugene Regional Office, Oregon State Health Division, Eugene, Oregon
31) Roseburg Regional Office, Oregon State Health Division, Roseburg, Oregon
32) Roseburg Satellite Office, Oregon State Health Division, Myrtle Point, Oregon**
33) Pendleton Regional Office, Oregon State Health Division, Pendleton, Oregon
34) Pendleton Satellite Office, Oregon State Health Division, La Grande, Oregon
35) Bend Regional Office, Oregon State Health Division, Bend, Oregon

*Health department did not have a sanitarian staff. **Health department declined to participate.

APPENDIX 3

OREGON STATE UNIVERSITY
Department of Health
Corvallis, Oregon 97331 (503) 754-2686

July 1, 1976

Sir:

Thank you for your participation in this study.

Your office undoubtedly has many reference materials which pertain to individual water supply systems. The purpose of this research survey is to determine how appropriate these reference materials are with respect to the specific conditions prevailing in Oregon. This survey is not an attempt to evaluate the sanitarians, but rather the reference materials with which they work. For purposes of this study "reference materials" are defined as follows:

> Printed materials that either belong to, or are in the official custody of your office, are duplicated and available for distribution. This will include books, journals, booklets, manuals, pamphlets, leaflets, laws, rules, regulations, policies, circulars, memoranda, or other similar items. This will not include materials that are originated in your office exclusively for your own use, e.g. memoranda to files, copies of letters your office has sent out, etc., nor will it include materials issued exclusively to your office from an outside source, e.g. letters or memoranda from an outside agency addressed specifically to you.

The survey form is divided into three sections. Please answer each section as accurately and completely as possible according to the specific instructions given. An example is provided in each section, illustrating the correct answer format.

If you could complete this survey and return it within <u>fourteen (14) days</u>, it would be greatly appreciated.

If you have any questions concerning this survey, please feel free to contact me at the Department of Health, Waldo Hall 321, Oregon State University, Corvallis, Oregon 97331 (TEL: 754-2686), or at my home telephone 757-1974.

Cordially,

Frank C. Carter, R. S.
Graduate Assistant
Department of Health

fcc
Enclosure

Section I

Please list all the reference materials concerning individual water supply systems that are available in your office. Use the back of this paper if necessary.

Example:

Title	Author	Publisher	Date
a) Manual of Individual Water Supply Systems	Environmental Protection Agency	U. S. Gov't Printing Office	1973

	Title	Author	Publisher	Date
1)				
2)				
3)				
4)				
5)				
6)				
7)				
8)				

Section II

The following is a list of true statements. Using any of your reference materials, please locate the information given in each statement, recording an appropriate reference beside it. If you do not have an appropriate reference, please leave the item blank.

Example:

a) A sanitary well seal should be installed at the top of a well casing to prevent contamination from entering the well.

Reference: Manual of Individual Water Supply Systems, EPA, 1973, GPO, p. 48

1) Wells should be located in areas where groundwater is found in unconsolidated formations.

Reference: _____

2) Because older rocks are more likely to have reduced porosity and permeability, younger rocks are better yielding aquifers.

Reference: _____

3) Groundwater from most sources in Oregon contains dissolved solids between 100 and 300 ppm and hardness between 50 and 150 ppm.

Reference: _____

4) The most productive aquifers are deposits of clean, coarse sand and gravel; coarse, porous sandstone; cavernous limestones; and broken lava rock.

Reference: _____

5) All water within Oregon from all sources of water supply belong to the public, and therefore "riparian rights" do not exist.

Reference: _____

6) The purpose of well "development" is to remove finer material from the aquifer, thereby enlarging passages so that water can enter the well more freely.

Reference: _____

7) In a well screen, proper slot sizes are critical in governing the extent to which well "development" is carried.

Reference: _____

8) When corrosive water or soil is encountered, brass, wrought iron, plastic or cast iron pipe will have a longer, more useful life than would galvanized pipe.

Reference: _____

9) Two factors are essential for backflow of polluted water into potable water: A link between the two systems and a resultant force towards the potable supply.

Reference: _____

10) After construction or repair of an individual water supply system, the entire system should be flushed out and disinfected.

Reference: _____

11) The total "head" on a pump is composed of lift from the water surface to the pump, elevation to the highest point of water delivery, friction loss in the piping and the pressure desired at outlets.

Reference: _____

12) One foot of "head" is equal to the weight of a column of water one inch square and one foot in height.

Reference: _____

13) A water softener removes calcium and magnesium ions from water and replaces them with sodium ions.

Reference: _____

14) Because of the contamination potential of sub-surface sewage disposal areas to water supply systems, Oregon requires a minimum horizontal separation distance of 100 feet.

Reference: _____

15) Organisms of the Intermediate Aerogenes Cloacae (IAC) group tend to survive longer in water than do organisms of the coliform group.

Reference: _____

16) At breakpoint chlorination, the dosage at which minimal residual occurs; it is believed that all the ammonia and other nitrogen compounds are completely oxidized.

Reference: _____

17) The more turbid the water, the higher will be the dosage of chlorine needed for disinfection.

Reference: _____

18) The contact time required for chlorine to effectively kill bacteria depends upon the concentration of the chlorine solution, and the temperature and pH of the water.

Reference: _____

19) In testing for the presence of coliform organisms in water, a positive presumptive test indicates that coliforms may be present, while the confirmatory test confirms the presence of the coliform group.

Reference: _____

20) The Public Health Laboratory of the Oregon State Health Division can conduct Most Probable Number (MPN) tests on water samples.

Reference: _____

21) The laboratory of the Oregon Department of Environmental Quality can test for the presence of chemicals in water samples.

Reference: _____

22) When a well is to be permanently abandoned, it should be filled with concrete or other similar material with sealing properties.

Reference: _____

Section III

How would you agree on the following with regard to the knowledge a sanitarian in the field should have concerning individual water supply systems? Mark one box for each statement.

	Example:	Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
a)	A sanitarian in the field should know: The EPA's Primary Interim Drinking Water Standards	☐	☒	☐	☐	☐

	The sanitarian in the field should know:	Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
1)	proper location	☐	☐	☐	☐	☐
2)	hydrogeology	☐	☐	☐	☐	☐
3)	natural water quality	☐	☐	☐	☐	☐
4)	occurrence of groundwater	☐	☐	☐	☐	☐
5)	rights to groundwater	☐	☐	☐	☐	☐
6)	well development	☐	☐	☐	☐	☐
7)	proper design	☐	☐	☐	☐	☐
8)	proper distribution system	☐	☐	☐	☐	☐
9)	plumbing and cross-connections	☐	☐	☐	☐	☐
10)	mainline flushing and disinfection	☐	☐	☐	☐	☐
11)	proper operation	☐	☐	☐	☐	☐
12)	hydraulics	☐	☐	☐	☐	☐
13)	equipment used to modify water properties	☐	☐	☐	☐	☐
14)	pathways for entry of pollutants into groundwater	☐	☐	☐	☐	☐
15)	bacteriology and coliform significance	☐	☐	☐	☐	☐
16)	halogen chemistry	☐	☐	☐	☐	☐
17)	raw water factors pertaining to bacteriology and halogen chemistry	☐	☐	☐	☐	☐
18)	procedures to treat water of pollutants	☐	☐	☐	☐	☐
19)	water analyses and interpretation of results	☐	☐	☐	☐	☐
20)	services of the Public Health Laboratory and private laboratories	☐	☐	☐	☐	☐
21)	services of the Department of Environmental Quality laboratory	☐	☐	☐	☐	☐
22)	well abandonment	☐	☐	☐	☐	☐