Drinking Water Systems On And Along The National System Of Interstate And Defense Highways

A PILOT STUDY

U.S. ENVIRONMENTAL PROTECTION AGENCY, WATER SUPPLY DIVISION

A PILOT STUDY
OF
DRINKING WATER SYSTEMS
ON AND ALONG THE
NATIONAL SYSTEM OF INTERSTATE
AND DEFENSE HIGHWAYS

Water Supply Division
Office of Air and Water Programs
Environmental Protection Agency

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Introduction

INTRODUCTION

The safety and adequacy of water delivered to the public in cities and towns has received an increasing level of attention in recent years, however, little attention has been given to the drinking water systems provided for the use of the traveling public along Interstate Highways. Although the attention given to these systems has been small, their significance cannot be overlooked. It is estimated that there are approximately 9100 water supply systems serving the traveling public on and along Interstate Highways and it is estimated from Federal Highway Administration sources that over one million travelers use these facilities daily. The importance of maintaining high standards of reliability for these facilities cannot be overemphasized if the interstate spread of communicable disease, which may be contracted at inadequately constructed, operated and/or maintained installations, is to be prevented.

In the Spring of 1972 the State and Local health departments and the State highway departments in Virginia, Oregon, and Kansas cooperated with the Water Supply Division of the Environmental Protection Agency (EPA) to conduct a pilot study of 119 water supply systems along Interstate Highways in those three States. The purpose of the pilot study was to assess the water quality, construction, operation and health surveillance of the water supply systems provided for the traveling public at safety rest areas, motels, restaurants and service stations along Interstate Highways.

Summary of Findings and Recommendations

SUMMARY OF FINDINGS AND RECOMMENDATIONS

The findings of the pilot study indicate that of 119 water supply systems along Interstate Highways in Virginia, Oregon and Kansas 75 (63 percent) of the water systems surveyed delivered water which failed to meet one or more constituent limits of the Drinking Water Standards; 22 (19 percent) systems failed to meet at least one mandatory limit; and 18 (15 percent) systems were contaminated with coliform bacteria. The contaminated systems were either not disinfected or the disinfection equipment available was not operated properly. Only 14 (12 percent) of the systems had a bacteriological surveillance program which met the criteria in the 1962 U. S. Public Health Service Drinking Water Standards. Although these figures represent all of the systems studied it should be pointed out that the safety rest area water systems were distinctly superior to the commercial service facilities.

In order to rectify the problems highlighted by this study, the following general recommendations are offered:

1. The State and County governmental agencies are primarily responsible for the surveillance of the water systems. *These agencies need to set a higher priority to initiating and maintaining an acceptable program of bacteriological and chemical surveillance and to providing regular sanitary surveys of the water systems. The cost of an adequate surveillance program, which would typically include a complete chemical analysis of the water every third year, two bacteriological samples per month, and one sanitary survey each year, approaches $300 per system. This is the recommended minimum amount that State and County agencies should be spending annually to provide the needed surveillance.* It is estimated that, on the average, less than $50 per system is being spent yearly. This is primarily for bacteriological surveillance.

2. It is estimated that there are 8,500 commercial service facilities (service stations, motels, restaurants, etc.) and over 600 safety rest areas serving drinking water to the traveling public along Interstate Highways throughout the United States. Their large numbers present a burden to State and County personnel who must provide a program for their regulation and control. Many (about 70 percent) of the commercial service facilities surveyed were located at an interchange directly adjacent or opposite to others serving drinking water to the traveling public. *An effort by the appropriate State agency responsible for the surveillance of these systems should be made to reduce the number of systems requiring health surveillance by requiring or encouraging consolidation measures, where possible and economically feasible.*

3. Where a direct interconnection between systems is not feasible, an effort should be made by the State or County to concentrate surveillance activities on facilities which present the greatest potential public health risk. Observations during the field survey indicate that the traveling public seldom drinks water at service stations. *Priority should be given to maintaining surveillance over systems serving restaurants, motels and safety rest areas where people normally drink water.*

4. Many of the physical, operational, and surveillance deficiencies revealed by this study would have been eliminated if proper and uniform sanitary standards had been employed. *The State and County surveillance agencies should establish and implement a permit program for water systems serving the traveling public to ensure compliance with State standards for public water supplies. A permit should be required before any private or public entity would be allowed to provide drinking water to the traveling public. The permit program would apply to both commercial service facilities as well as safety rest areas and would require that State standards be met.*

5. The Federal Highway Administration requires that water systems at safety rest areas be designed, constructed, and maintained so that State health regulations are met. In addition, surveillance of drinking water supplies is the maintenance responsibility of the State Highway department and such maintenance should be in accordance with State health standards for public water supplies. *Surveillance should be an integral part of the Federal Highway Administration's annual review of the State highway department's maintenance program to assure that appropriate standards are being met. The Federal Highway Administration should require, as a condition to receiving any Federal highway financial assistance, that an adequate maintenance program is being carried out.*

The specific findings and recommendations of the study are:

Water Quality

1. Seventy-five (63 percent) of the water supply systems delivered water which failed to meet some constituent limit of the Drinking Water Standards. Sixty-seven (56 percent) systems failed to meet at

least one recommended limit, and 7 (6 percent) failed to meet at least one mandatory chemical limit. *Systems failing to meet mandatory chemical limits should be provided with proper treatment equipment to produce a water meeting the Drinking Water Standards and/or another raw water source meeting these Standards should be found. Systems failing to meet recommended limits should also employ proper treatment or seek another raw water source where economically feasible.*

2. Bacteriological analysis of the distribution system water showed that 18 (15 percent) of the systems contained coliform bacteria, an indicator of pollution. To prevent bacteriological contamination of the source, improved source protection is necessary. *Disinfection plus additional treatment should be a mandatory requirement for all systems using surface water. The treatment required should be determined to ensure that the turbidity level meets the limit established in the Drinking Water Standards. Disinfection should be a mandatory requirement for all drinking water systems using ground water unless a history of satisfactory bacteriological sampling and sanitary surveys has consistently been demonstrated.*

Facilities and Operation

3. Sixteen (14 percent) systems were chlorinated to disinfect the water. Five (31 percent) of these systems did not have a chlorine residual in the distribution system or storage tank. Where chlorination was practiced, at the commercial service facilities, daily chlorine residuals were not taken and in some cases the chlorination equipment was not operative at the time of the survey. All of the safety rest areas that practiced chlorination kept daily records of residuals and the chlorination equipment was inspected on a daily basis. *Daily inspection of the chlorine feed equipment and daily records of chlorine residuals should be maintained. Chlorine residuals should be present at the ends of the distribution systems.* Unless bacteriological or other tests indicate a need for maintaining a higher than minimum concentration of residual chlorine a minimum of 0.4 milligrams per liter of free chlorine should be maintained for a contact period of at least 30 minutes.

4. Many of the individuals responsible for the operation of the water systems studied were not fully aware of their responsibilities or the reasoning behind these duties. *The State and County surveillance agencies should assure that all persons responsible for the operation of a water system along Interstate Highways are knowledgeable of the water system and its operation.* This could be achieved during routine periodic visits by State or County personnel through informal instruction and discussion with the responsible operator.

Surveillance

5. Records of the bacteriological surveillance for the twelve months preceding the study were investigated for each water system. The results of this investigation show that 105 (88 percent) of the water systems surveyed were not sampled with a frequency meeting the bacteriological surveillance criteria of the Drinking Water Standards. Records could not be found for any bacteriological testing within the preceding twelve months at 38 (32 percent) of the water systems studied. Fourteen (12 percent) water systems had bacteriological samples which were contaminated with coliform bacteria during at least one month in the past year, and 8 (7 percent) systems showed contamination in two months or more. The results of the study showed that surveillance is not provided for some systems during the winter months even though the systems are operational during these months. *A bacteriological sampling program which will meet the minimum requirements of the Drinking Water Standards should be required at each system. This program should be continued at all times the system is operational.*

6. Chemical surveillance was not practiced at any of the systems surveyed. The water from all drinking water systems should be tested for all chemical constituents listed in the Drinking Water Standards before the water is made available to the traveling public. *Complete chemical analysis is recommended for systems supplied by groundwater every third year or more often when there is reason to believe the chemical quality is deteriorating. Water systems supplied by surface water should receive chemical analysis on a yearly basis.*

7. None of the systems surveyed were subject to regular sanitary surveys although maintenance personnel at the safety rest areas make daily visits and are generally aware of sanitary conditions. The sanitary deficiencies found by this study could have been identified and corrected with a program of frequent and thorough sanitary surveys by the appropriate State or County governmental agency. *Yearly sanitary surveys of each water system should be provided. For water systems which are not operated during the winter months, the sanitary surveys would ideally be performed prior to placing the system into operation in the Spring. No water system should be placed into operation until at least two satisfactory bacteriological samples have been obtained.*

The preceding recommendations address problems that can be best solved by the Federal Highway Administration and the State and local governments. The following recommendations relate to problems that should be considered by appropriate Federal agencies and others having broad water supply responsibilities and interests.

1. The problems inherent in the operation of small water systems are unique. One example is the extreme variations in weekly and seasonal usage as peak demands normally occur on weekends and during the summer months. *Criteria and standards should be developed for the construction, operation and health surveillance of small public drinking water systems serving the traveling public along Interstate Highways. There is a need to evaluate the bacteriological sampling frequency based upon usage.*

2. Chlorination as a means of disinfection for small, isolated water systems is associated with several problems. The feed system can easily become inoperable, the chlorine residual dissipates during periods of low usage and needed maintenance and daily inspections are not always performed. *In order to help rectify some of the problems in disinfection by chlorination, alternative means of disinfection should be reviewed.*

Scope

SCOPE OF SYSTEMS STUDIED

Water supply systems along Interstate Highways in Virginia, Oregon, and Kansas were included in this pilot study to obtain a geographical cross-section of the water supply systems serving the traveling public. The pilot study covered a total of 119 water supply systems. A water supply system as defined by this study includes the collection, treatment, and distribution facilities from the source of supply to the free-flowing outlets of the distribution system.

Two main categories of water supply systems were studied; safety rest areas owned and operated by the respective State Highway Departments and commercial service facilities (restaurants, service stations and motels). Table I summarizes by category the number of water systems surveyed. The greatest percentage of water systems studied were service stations although they were not specifically chosen for this pilot study. Rather, all systems along a designated segment of highway were included.

The water systems to be surveyed were determined several months in advance of field visits. To be included in this study the systems had to be located on rural sections of Interstate Highway and be within one-half mile of an Interstate Highway interchange. An effort was made to select as many systems as possible within a given geographical area so that the time required to transport the bacteriological samples would be minimized. Most of the water systems surveyed used groundwater as a raw water source. The exceptions were systems that purchased finished water from a nearby public water system and either piped or hauled the water by truck to the distribution system. The source and treatment of this water is beyond the scope of this study and no investigation was attempted; however, samples were collected and analyzed to determine water quality. A summary of the water system types studied is presented in Table II.

All six of the hand-pumped wells identified in Table II were located in Kansas and were serving safety rest areas. Of the four commercial service facilities in Kansas which purchased finished water, three piped their water and one hauled water by truck from a nearby municipal system and pumped the water into an on-site storage tank. The system in Virginia that purchased finished water was a safety rest area that piped water from a nearby sanitary district water system.

The water treatment practices of the systems surveyed are listed in Table III. Ninety (79 percent) of the water systems provided no treatment for the water. Sixteen (14 percent) of the water systems studied disinfected their water and 9 (8 percent) of the systems softened their water. In every case, the method of disinfection used was chlorination, with a hypochlorite solution added by an automatic feeder. One water system serving a safety rest area in Virginia depended on manual chlorination to maintain a chlorine residual. All of the systems that softened their water used an ion-exchange resin.

DRINKING WATER SYSTEMS ALONG INTERSTATE HIGHWAYS

TABLE I

SUMMARY OF THE CATEGORIES OF WATER SYSTEMS SURVEYED

System Category		Virginia	Oregon	Kansas	Total Number	Total Percent
Safety Rest Area		9	10	10	29	24
Commercial Service Facilities	Service Station	20	18	22	60	50
	Restaurant	3	6	8	17	14
	Motel	7	6	0	13	12
Total		39	40	40	119	100

DRINKING WATER SYSTEMS ALONG INTERSTATE HIGHWAYS

TABLE II

SUMMARY OF TYPES OF WATER SYSTEMS SURVEYED

System Type	Virginia	Oregon	Kansas	Total
Well Distribution	36	40	30	106
Hand-pumped Well	0	0	6	6
Spring	2	0	0	2
Purchased Finished Water	1	0	4	5
Total	39	40	40	119

DRINKING WATER SYSTEMS ALONG INTERSTATE HIGHWAYS

TABLE III

SUMMARY OF WATER TREATMENT* PRACTICES AT SYSTEMS SURVEYED

Treatment	Virginia	Oregon	Kansas	Total	
				Number	Percent
None	32	29	29	90	79
Disinfection Only	5	9	1	15	13
Softening Only	1	1	6	8	7
Disinfection & Softening	0	1	0	1	1
Total	38	40	36	114	100

* Excludes those systems that purchased wholesale finished water.

Evaluation Criteria

EVALUATION CRITERIA

Each water supply system was investigated on three bases:

1. Drinking water quality was determined by sampling the finished and distributed water. These samples were sent to the EPA Laboratories for bacteriological, chemical, physical, and trace metal analyses.
2. The adequacy of the water supply system facilities and their operation was determined by a field survey of the system. (Samples of the survey forms appear in Appendix A).
3. The adequacy of the surveillance program for the water supply system was evaluated by reviewing the bacteriological and chemical quality data available for the previous 12 months of record from State and Local Health Department files or State Highway Department files. The date of the last sanitary survey of the system was also noted.

Water Quality Criteria

Based on samples collected during the field survey, water quality was judged as follows:

1. Meets the constituent limits of the 1962 PHS Drinking Water Standards*
2. Failed to meet at least one "recommended" constituent limit, but did not fail any "mandatory" constituent limit.
3. Failed to meet at least one "mandatory" constituent limit. The Drinking Water Standards constituent limits utilized in this study are summarized in Table IV.

* 1962 USPHS Drinking Water Standards. PHS Publication No. 956, Superintendent of Documents, Government Printing Office, Washington, D.C., 61 pp.

** See "Manual for Evaluating Public Drinking Water Supplies," EPA, 1971, for basis of judgment.

Facilities and Operation Criteria

Source, treatment, operation, and distribution facilities were judged** either:

1. To be essentially free from major deficiencies, or
2. To be deficient if one or more of the following were inadequate:
   (a) Source protection
   (b) Control of disinfection
   (c) Pressure (20 psi minimum) in all areas of the distribution system.
   (d) Operation

Surveillance Criteria

The surveillance program over the water supply system was judged to be adequate if it met the following criteria:

1. Collection of the required number*** of bacteriological samples during the period of the year the water system is in operation. The required number of samples is based on the population using the water system. A minimum of two samples per month is recommended for systems serving less than 2500 people. For the water systems in this study the required number of samples is two per month.

2. Collection and complete chemical analysis of a sample of the water every three years.

3. At least one sanitary survey of the water system each year by the appropriate State or County agency.

*** See pages 3-6 of the Drinking Water Standards

TABLE IV

CRITERIA FOR EVALUATING BACTERIOLOGICAL, CHEMICAL, AND PHYSICAL QUALITY OF WATER SYSTEMS STUDIED

*Recommended Limits**

If the concentration of any of these constituents are exceeded, a more suitable supply should be sought.

Constituent	*Limit*
Arsenic	0.01 mg/l
Chloride	250 mg/l
Color	15 s.u.
Copper	1.0 mg/l
Fluoride	
Temp. (Ann. Avg. Max. Day, 5 years or more)	
50.0–53.7	1.7 mg/l
53.8–58.3	1.5 mg/l
58.4–63.8	1.3 mg/l
63.9–70.6	1.2 mg/l
70.7–79.2	1.0 mg/l
79.3–90.5	0.8 mg/l
Iron	0.3 mg/l
M.B.A.S.	0.5 mg/l
Manganese	0.05 mg/l
Nitrate	45 mg/l
Sulfate	250 mg/l
Total Dissolved Solids	500 mg/l
Turbidity	5 s.u.
Zinc	5.0 mg/l

*Mandatory Limits**

The presence of the following substances in excess of the concentrations listed shall constitute grounds for the rejection of the supply; therefore, their continued presence should be carefully measured and evaluated by health authorities and a decision made regarding corrective measures or discontinuing use of the supply.

Constituent	*Limit*
Arsenic	0.05 mg/l
Barium	1.0 mg/l
Cadmium	0.01 mg/l
Chromium	.05 mg/l
Coliform Organisms	Fails standards in any one month if: a. Arithmetic average of samples collected greater than 1 per 100 ml; b. Two or more samples (5% or more if more than 20 examined) contain densities more than 4/100 ml.
Fluoride	
Temp. (Ann. Avg. Max. Day, 5 years or more)	
50.0–53.7	2.4 mg/l
53.8–58.3	2.2 mg/l
58.4–63.8	2.0 mg/l
63.9–70.6	1.8 mg/l
70.7–79.2	1.6 mg/l
79.3–90.5	1.4 mg/l
Lead	0.05 mg/l
Mercury**	0.002 mg/l
Selenium	0.01 mg/l
Silver	0.05 mg/l

*1962 U.S. Public Health Service Drinking Water Standards

**Proposed for inclusion in the Drinking Water Standards

Procedures

PROCEDURES

Field Survey

Several months in advance of the field activities, planning sessions were held with State Health and Highway Department officials, Federal Highway Administration officials, and regional office staff of the Environmental Protection Agency. The purpose of the planning sessions was to determine the water systems to be studied and make the necessary local arrangements. An effort was made to select as many systems as possible within a given geographical area so that the time required to collect and transport the bacteriological samples to the laboratory would be within the 30 hour requirement.

The field surveys were performed by engineers from the regional and headquarters offices of the Water Supply Division of EPA. State and Local Health Department officials were invited to accompany the field team and in most cases did participate. The field inspection included a sanitary survey of the source, treatment plant, and distribution system of the water supply as well as an examination of the bacteriological records available on the supply for the year prior to the survey. In addition, field determinations of pH, pressure, temperature, and chlorine residual (where applicable) were made at each point a water sample was collected.

Sampling Program

The following samples were collected from each water system and dispatched to various EPA Laboratories for analyses.

1. Raw Water

   Where possible, one bacteriological sample was taken of the water before treatment unless treatment was not provided. In many systems, a raw water sample could not be collected because of the physical arrangement of the piping system.
2. Finished Water
   a. A one gallon sample was taken and sent to the Northeast Water Research Laboratory in Narragansett, Rhode Island, to be analyzed for the following chemical and physical parameters:

Boron	
Chloride	Sulfate
Color	Total Dissolved Solids
pH	Turbidity
Fluoride	Specific Conductance

   b. A one quart sample was taken and preserved by the addition of 1 ml. of a 20,000 ppm solution of mercury (2.71 g $HgCl_2$ per 100 ml.) in the field. The sample was sent to the Narragansett Laboratory and analyzed for nitrates and MBAS.
   c. A one quart sample was taken and preserved by the addition of 1¼ ml. of concentrated nitric acid in the field. The sample was sent to the EPA Laboratory in Cincinnati, Ohio to be analyzed for the following constituents:

Arsenic	Lead
Barium	Manganese
Cadmium	Mercury
Chromium	Nickel
Cobalt	Selenium
Copper	Silver
Iron	Zinc

   d. Two bacteriological samples were collected from the distribution system at each water supply except at those supplies served by a hand-pumped well in which case only one sample was taken.

The bacteriological samples were collected at different points in the distribution system, one close to the treatment plant and one near the end of a distribution line. Sampling points were hose bibs, restroom lavatory taps, and drinking fountains. Bacteriological samples were collected after drawing water for at least 30 seconds; the chemical samples were taken after the bacteriological samples.

Bacteriological samples were collected in 8-ounce sterile, plastic, wide-mouth, screw-capped bottles which contained 0.2 ml of a 10% solution of sodium thiosulfate as a dechlorinating agent. These samples were iced after collection and during transportation to the laboratory according to Standard Methods. Maximum time between collection and analysis did not exceed 30 hours.

Laboratory Procedures

The bacteriological and chemical procedures were those of *Standard Methods**. The membrane filter (MF) procedure was used to examine water samples for total coliforms. All finished and raw water samples were examined for total coliforms using M-Endo

* *Standard Methods for the Examination of Water and Wastewater*, 13th Edition, APHA, AWWA, and WPCF. American Public Health Association, New York, N.Y. 874 pp. (1971).

MF broth, incubated at 35°C for 20-24 hours. Any coliform colonies detected in the examination of a sample were further verified by transfer to phenol red lactose for 24-and 48-hour periods at 35°C incubation. All positive phenol red lactose broth tubes then were confirmed in brilliant green lactose at 35°C for verification of total coliforms and in EC medium at 44.5°C for detection of fecal coliforms. This procedure further confirmed the standard total coliform MF test and supplied additional information on the potentially hazardous occurrence of fecal coliforms in the potable water supplies surveyed.

Findings

FINDINGS

Drinking Water Quality

Seventy-five (63 percent) of the water supply systems delivered water that did not meet all the constituent limits of the Drinking Water Standards. Sixty-seven (56 percent) of the water systems delivered water which failed to meet at least one recommended limit for chemical and physical quality and 22 (19 percent) systems distributed water which failed to meet at least one mandatory chemical or bacteriological limit. Figure 1 displays these findings in graphic form. Figure 2 shows the relative numbers of each constituent limit exceeded. The limits most frequently exceeded in this study were those for total dissolved solids, iron, and manganese.

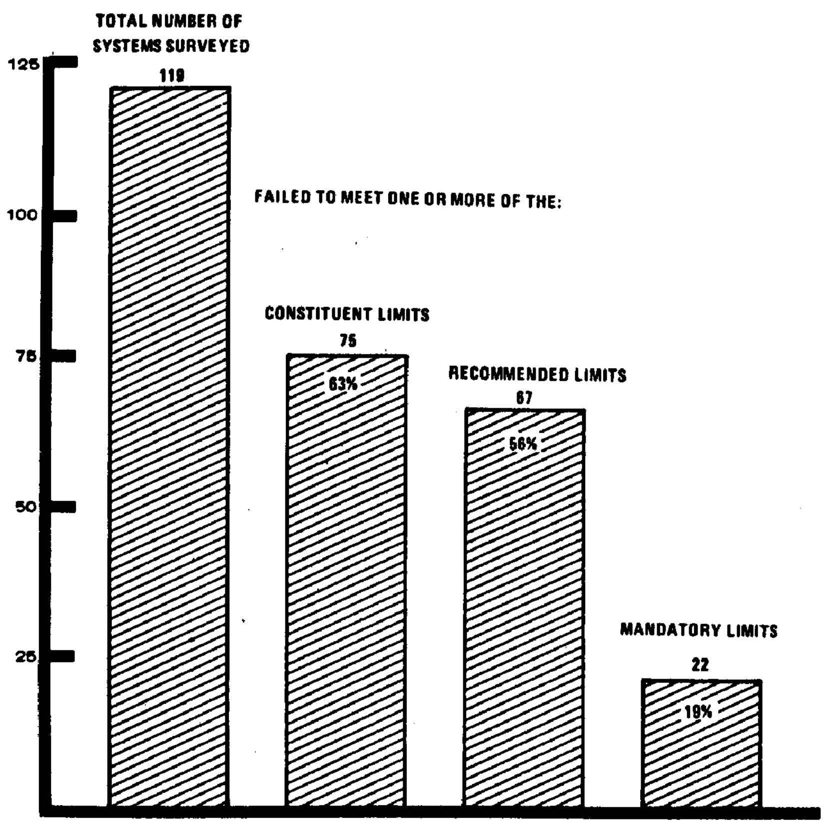
Examination of laboratory results indicates the water systems surveyed in Kansas had the poorest water quality. Twenty-nine (73 percent) of the water systems in Kansas failed to meet the limit for total dissolved solids and a significant percentage had high concentrations of iron, manganese, sulfate and turbidity. In addition, four wells in Kansas delivered water which failed to meet the mandatory limit for lead and nine systems supplied water failing to meet the mandatory limit for coliform organisms.

The maximum concentration of physical and chemical constituents found in the survey is presented in Table V.

DRINKING WATER SYSTEMS ALONG
INTERSTATE HIGHWAYS

FIGURE 1

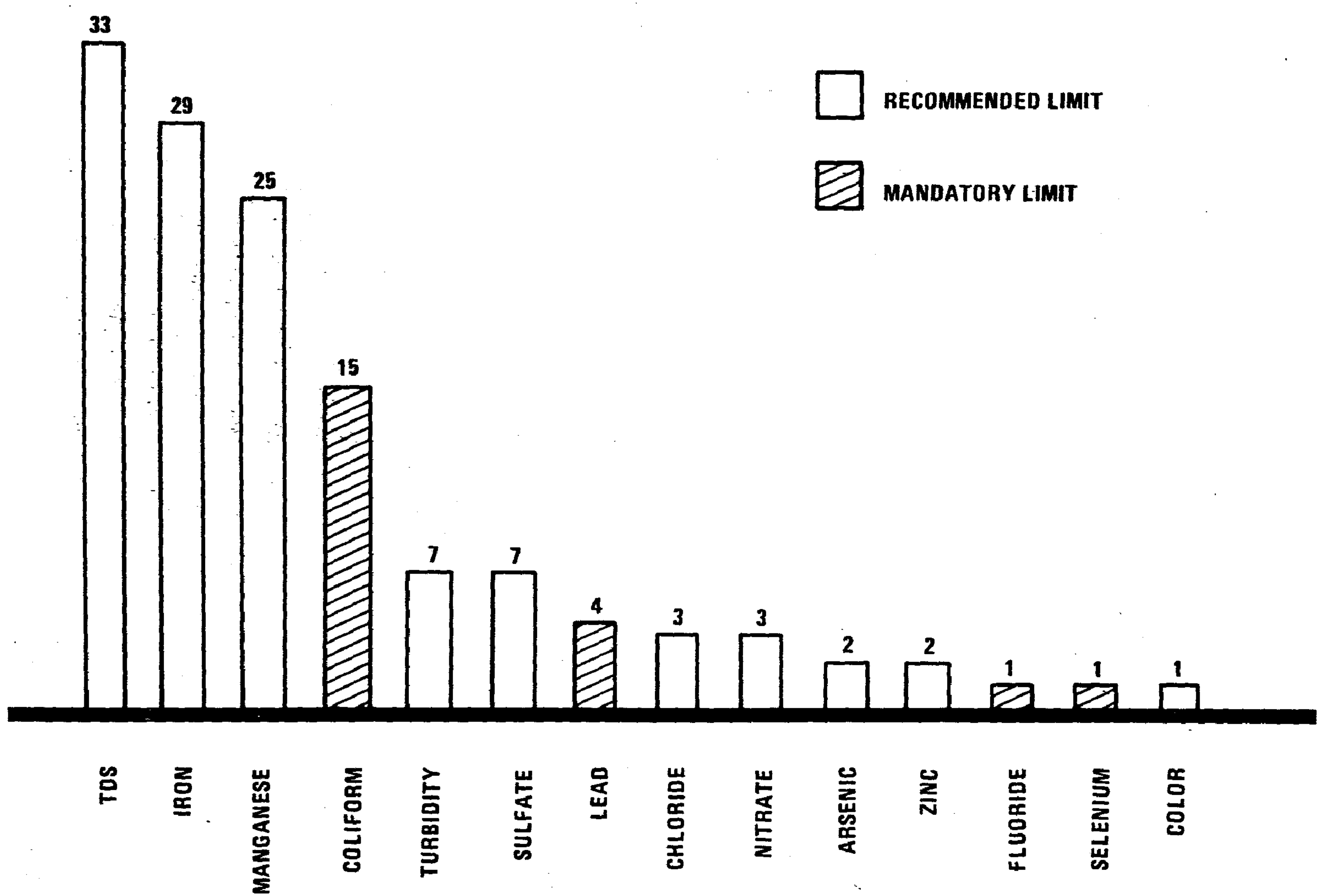
NUMBER OF SYSTEMS SURVEYED FAILING
TO MEET STANDARDS



DRINKING WATER SYSTEMS ALONG INTERSTATE HIGHWAYS

FIGURE 2

PERCENT OF SYSTEMS SURVEYED FAILING TO MEET A CONSTITUENT LIMIT



DRINKING WATER SYSTEMS ALONG
INTERSTATE HIGHWAYS

TABLE V

MAXIMUM CONCENTRATION FOUND IN PHYSICAL AND CHEMICAL CONSTITUENTS FAILING TO MEET STANDARDS

Arsenic	0.020	mg/1	(0.05)*
Chloride	370.0	mg/1	(250)
Color	65.0	s.u.	(15)
Fluoride	3.0	mg/1	(see Table IV)*
Iron	8.20	mg/1	(0.3)
Lead	0.120	mg/1	(0.05)*
Manganese	2.2	mg/1	(0.05)
Nitrate	58.6	mg/1	(45)
Selenium	0.015	mg/1	(0.01)*
Sulfate	820.0	mg/1	(250)
Total Dissolved Solids	2841.7	mg/1	(500)
Turbidity	33.0	s.u.	(15)
Zinc	8.0	mg/1	(5)

( ) PHS Drinking Water Standard
* Mandatory Limit

A summary of Drinking Water Standards limits that were not met in each of the States surveyed is presented in Table VI. Again, this Table shows that iron, manganese and TDS were the most frequently failed limits in all three States. The most frequently failed mandatory limit was that for coliform organisms where 18 (15 percent) systems had samples which contained an average of more than one coliform organism per 100 ml.

Table VII compares bacteriological water quality and the categories of systems surveyed (i.e. service station, restaurant, motel or safety rest area).

DRINKING WATER SYSTEMS ALONG
INTERSTATE HIGHWAYS

TABLE VI

SYSTEMS FAILING TO MEET U.S. PUBLIC HEALTH SERVICE DRINKING WATER STANDARDS

LIMITS

	Failed to Meet Recommended Limits					
	Virginia (39)		*Oregon (40)*		*Kansas (40)*	
	No.	*%*	*No.*	*%*	*No.*	*%*
Arsenic	0	0	1	3	1	3
Chloride	0	0	3	8	1	3
Color	0	0	0	0	1	3
Iron	3	8	16	40	15	38
Manganese	5	13	15	38	10	25
Nitrate	1	3	0	0	2	5
Sulfate	0	0	0	0	8	20
TDS	1	3	9	23	29	73
Turbidity	1	3	3	8	4	10
Zinc	1	3	1	3	0	0

	Failed to Meet Mandatory Limits					
	Virginia (39)		*Oregon (40)*		*Kansas (40)*	
	No.	*%*	*No.*	*%*	*No.*	*%*
Coliform Organisms	7	18	2	5	9	23
Fluoride	0	0	0	0	1	3
Lead	1	3	0	0	4	10
Selenium	0	0	0	0	1	3

DRINKING WATER SYSTEMS ALONG INTERSTATE HIGHWAYS

TABLE VII

PERCENT BY CATEGORY OF SYSTEMS SURVEYED FAILING TO MEET BACTERIOLOGICAL LIMIT

System Category	Virginia	Oregon	Kansas	Total
Service Stations	15	6	27	17
Restaurants	33	0	25	18
Motels	29	17	—	23
Safety Rest Areas	11	0	10	7

Facilities and Operation

The adequacy of the physical water system facilities used to treat, distribute and store drinking water was determined by site surveys and interviews with operating personnel. Site surveys of the source included an investigation as to the type and quality of source protection. Generally this involved an inspection of the well for sanitary well seals, formation seals, pit drains, etc. Also included in the site surveys were a visual inspection of the storage tanks and chlorinators if such were provided and the taking of distribution system pressure readings at each sampling point. No investigation of the source was made at those systems that purchased finished water, however, the quality of the water delivered and the distribution system pressure was evaluated.

Source protection throughout the study was generally good. Ninety-two percent of the systems were judged to have adequate source protection. The remaining 8% were judged inadequate with respect to source protection because of a flooded well pit or the lack of a sanitary well seal.

Eight percent of the water supply systems had pressures less than 20 psi in the distribution system at the time of the survey. This condition was usually caused by high volume instantaneous water demands on the system. Generally, pressure was maintained by the use of a steel, glass-lined pressure tank.

Operation and control of the water systems studied were generally poor, this was particularly true at the commercial service facilities where daily surveillance of the system was not usually conducted. Where chlorination was practiced, at the commercial service facilities, daily chlorine residuals were not taken and in some cases the chlorination equipment was not operative at the time of the survey. All of the safety rest areas that practiced chlorination kept daily records of residuals and the chlorination equipment was inspected on a daily basis. Table VIII summarizes the chlorination practices at the water systems surveyed.

DRINKING WATER SYSTEMS ALONG INTERSTATE HIGHWAYS

TABLE VIII

SUMMARY OF CHLORINATION PRACTICES AT WATER SYSTEMS SURVEYED

System Category	Percent of systems that chlorinate or buy chlorinated water	Percent of systems where no chlorine residual was detected	Percent of systems that check chlorine residuals daily
Safety Rest Areas	33	0	100
Commercial Rest Areas	10	55	0

Surveillance

A. Bacteriological

To determine the adequacy of the bacteriological surveillance program for each water supply system studied, records of bacteriological examinations for the previous 12 months were sought from the State and other agencies responsible for the operation, maintenance and surveillance of the systems. Although the primary concern with respect to bacteriological surveillance was the number of samples collected per month, the bacteriological quality determinations were also recorded. The degree of bacteriological surveillance varied widely throughout the study sample, and generally did not meet the bacteriological surveillance criteria set forth in the Drinking Water Standards. Only 14 (12 percent) systems collected the required number of samples. Records could not be found of any bacteriological testing within the preceding twelve months for 38 (32 percent) of the water systems studied. Fourteen (12 percent) water systems had bacteriological samples which were contaminated with coliform bacteria during at least one month in the past year, and 8 (7 percent) systems showed contamination in two months or more.

All the water supply systems that purchased wholesale finished water and the safety rest areas in Orgeon were sampled at the required frequency. Most of the other water supply systems surveyed had been sampled periodically during the past year and some were sampled regularly once per month. There was no record of bacteriological examination for the commercial service facilities in Kansas that did not purchase finished water.

In the States of Oregon and Kansas, the safety rest areas were sampled by the State Highway Departments while in Virginia the sampling was done by the State Health Department. In all cases, the laboratory work was performed by the respective State Health Departments. In nearly all cases, the safety rest areas were re-sampled when an unsatisfactory sample was obtained. In Kansas, the safety rest areas were sampled once per month, however, samples were not collected during the Winter months. Table IX compares, by State, the bacteriological sampling practices of the safety rest areas and commercial service facilities.

B. Chemical

None of the systems surveyed were subject to routine chemical surveillance. Some of the systems had been sampled for chemical constituents prior to placing the system into operation, however, no samples had been collected afterwards.

C. Sanitary Surveys

Regular sanitary surveys (one per year) were not performed for any of the systems surveyed. However, operating personnel at the safety rest areas made daily visits and were generally aware of sanitary conditions.

TABLE IX

BACTERIOLOGICAL SAMPLING PRACTICES BY STATE

Safety Rest Areas

	Number of Systems				Percent of Systems			
	Virginia	Oregon	Kansas	Total	Virginia	Oregon	Kansas	All Systems
Collected the required number of samples annually according to the Drinking Water Standards	1	10	0	11	11	100	0	38
Collected less than half the required number	8	0	10	18	89	0	100	62
Collected at least half but less than the required number	0	0	0	0	0	0	0	0
No samples collected in the 12 months preceding the study	0	0	0	0	0	0	0	0

Commercial Service Facilities

	Number of Systems				Percent of Systems			
	Virginia	Oregon	Kansas	Total	Virginia	Oregon	Kansas	All Systems
Collected the required number of samples annually according to the Drinking Water Standards	0	0	3	3	0	0	10	3
Collected less than half the required number	26	20	0	46	86	67	0	51
Collected at least half but less than the required number	2	0	0	2	7	0	0	2
No samples collected in the 12 months preceding the study	2	10	27	39	7	33	90	44

Discussion

DISCUSSION

General

Millions of people travel the Nation's interstate highways every day and the effort of the State and Federal agencies to provide comfort facilities at safety rest areas for these travelers must be commended. The traveling public assumes that the drinking water provided at these facilities, as well as at commercial service facilities, is of a safe and sanitary quality and will be esthetically pleasing. Since it is estimated that there are over 9100 water supply systems serving over one million people per day along interstate highways (Appendix C) the significance of these systems, as a possible source of waterborne disease, cannot be overlooked. This report summarizes the results of field studies and makes recommendations for needed improvements in surveillance, facilities, and operation.

Water Quality

The study revealed that 67 (56 percent) of the water supply systems delivered water which failed to meet one or more recommended limits in the Drinking Water Standards. The constituents most frequently not met were those for TDS, iron and manganese. While these are not considered to be health related they contribute to an esthetically unacceptable water. When any recommended limit is not met an effort should be made to provide adequate treatment, or another water source which meets the Standards should be sought if economically feasible.

Twenty-two (19 percent) of the water supply systems failed to meet the Drinking Water Standards mandatory limits for chemical or bacteriological contamination. Where mandatory limits are not met another raw water source which meets the Standards should be sought and/or an effective treatment process employed.

The water systems which purchased finished water from a municipal water system met the constituent limits of the Drinking Water Standards. This generally confirms the findings of other similar studies which show that municipal water systems are more reliable and are more effective in producing a better quality water. Where possible and economically feasible, the small systems should interconnect with a nearby municipal system.

Facilities and Operation

The most obvious operational deficiencies were disinfection practices at the commercial service facilities. No chlorine residuals were detected at 55 percent of these facilities which practiced chlorination. Chlorine residuals were not checked on a daily basis nor were the chlorinators inspected for proper operation. The chlorinators at several commercial service facilities were not operating at the time of the field visit and the owners were unaware of it. Chlorination as a means of disinfection for small, isolated water systems, such as those studied, is relatively complicated from the standpoint of the personnel usually available for the operation. The feed system can easily become inoperable, the chlorine residual dissipates during periods of low usage, and the maintenance required calls for a degree of skill frequently not available. In order to help rectify some of these problems in disinfection by chlorination, simplified, alternative means, such as iodination, should be evaluated by appropriate Federal agencies and others having broad water supply interests and responsibilities.

Source protection at nine (8 percent) of the water systems was judged inadequate. The source protection deficiencies usually consisted of a flooded well pit or the lack of a sanitary well seal. Twenty-four (8 percent) of the water supply systems had low pressure areas (< 20 psi) in some part of the distribution system. The low pressure condition, caused by placing an instantaneous high volume water demand on the system, could have been the result of inadequate pipe sizes in the plumbing network. This observation reinforces the need for acceptable criteria and standards for the construction of small water systems of this type to assure adequate pressures at all times.

Surveillance

Bacteriological:

Bacteriological surveillance throughout the study sample was inadequate. An adequate program of bacteriological surveillance was considered to be the collection of a minimum of two samples per month during the entire period the system is operational and serving water to the traveling public. On this basis only 14 (12 percent) of the water supply systems surveyed were judged to have an adequate bacteriological surveillance program.

There is a great need to expand the existing bacteriological sampling practices by the responsible State agencies so that a regular program of surveillance is implemented which would comply with Drinking Water Standards requirements. This regular program should be continued during the entire period the system is operational and serving drinking water to the traveling public and should include the provision for follow-up or check samples when unsatisfactory results are obtained.

Chemical:

None of the systems studied were subject to a regular program of chemical surveillance, although some of the systems had been tested for chemical quality prior to being placed into operation. The water from all drinking water systems should be tested for all chemical constituents listed in the Drinking Water Standards before the water is made available to the traveling public. In addition, complete chemical analysis, which would include at least all those constituents listed in Table IV, is recommended for systems supplied by wells every three years, or more often when there is reason to believe the chemical quality is deteriorating. Signs of deteriorating water quality might include unpleasant taste and/or odor or the occurrence of water-borne disease. In the latter case a complete investigation of the situation, including a complete chemical and bacteriological analysis as well as a sanitary survey of the system, would be indicated. Frequent public or operating personnel complaints could also be indicative of this condition.

Sanitary Surveys:

None of the systems surveyed were subject to a regular program of frequent and thorough sanitary surveys. Although operating personnel at the safety rest areas generally make daily visits and seemed to be aware of sanitary conditions, more thorough investigations of the condition of the water systems is needed. Yearly sanitary surveys of each water system should be conducted. Sanitary surveys should include checks on the system's physical facilities used to treat, distribute and store the water and the adequacy and condition of source protection. Any deficiencies noted in the sanitary surveys should be corrected. Many of the deficiencies noted by this study would have been corrected with a regular program of sanitary surveys by the appropriate State agency.

State and County Responsibilities:

To ensure compliance with State standards for public water supplies the State and County surveillance agencies should establish and implement a permit program for water systems serving the traveling public. A permit should be required before any private or public entity would be allowed to provide drinking water to the traveling public. This permit program would apply to both commercial facilities as well as safety rest areas and would require that State standards for public water supplies be met.

The State and County governmental agencies are primarily responsible for the surveillance of the water systems and surveillance practices were found to vary between the States that were studied. Generally, as stated in the Findings, surveillance practices were not adequate to meet the criteria in the Drinking Water Standards. The State and County governmental agencies need to set a higher priority to initiate and maintain an acceptable program of bacteriological and chemical surveillance and to provide regular sanitary surveys of the water systems. The cost of an adequate surveillance program, which would typically include a complete chemical analysis of the water every third year, two bacteriological samples per month, and one sanitary survey each year, approaches $300 per system. (The derivation of this cost is presented in Appendix B.)

One of the problems observed during this study, that contribute to the surveillance problem, was the large numbers of commercially owned water systems along Interstate Highways. It is estimated that there are approximately 8,600 commercially owned water systems along Interstate Highways in the United States and the cost of an adequate surveillance program for these systems might approach 8,600 $\times$ \$300 = \$2,580,000 per year on a national basis, assuming an annual surveillance cost of approximately $300 per system. Where possible and economically feasible, consolidation of these water systems should be sought and promoted. The field visits performed during this study revealed a number of situations that would theoretically lend themselves to a consolidation effort. Most (70 percent) of the water systems were located at an interstate highway interchange directly adjacent and/or opposite to another water system. By interconnecting these systems at an interchange thereby resulting in only one system, the total number of water systems could be greatly reduced. Unfortunately, this consolidation is impractical in the case of most existing systems; however, as new commercial facilities are added serious consideration should be given to the establishment of a common water supply system.

Another approach aimed at making the best possible use of available resources is to concentrate surveillance efforts on those systems that pose the greatest public health risk. For instance, one-half of the systems surveyed were service stations where customers are not served drinking water on a regular basis and observation has shown that only a relatively few travelers stop at a service station to obtain drinking water. It is therefore recommended that a higher priority be given to the surveillance of restaurants and motels along Interstate Highways where travelers normally drink water.

The Federal Role:

The Federal Government, through the Federal Highway Administration (FHWA), assists the States in the construction of Interstate Highways by providing approximately 90 percent of the cost for facilities and rights-of-way. This financial assistance is not limited to actual highway construction but also includes provisions for safety rest areas and their water and sewerage systems. A FHWA Policy and Procedure Memorandum dated April 10, 1973,[1] states that:

"All water supply and sewage treatment facilities in conjunction with safety rest area projects shall be designed, constructed, and maintained so that the water supply and the sewage effluent will meet the standards established by the responsible State agency or agencies.

There may be Federal-aid participation in the cost of constructing, expanding, or improving facilities required for adequate water supply or sewage treatment. Participation in costs to modify public facilities shall be fully justified and documented."

In order to assure compliance with these policies and procedures, the Federal Highway Administration should periodically review and monitor the State program for regulation and control of safety rest area water systems. Since surveillance of safety rest area water systems is the maintenance responsibility of the State highway department, the Federal Highway Administration should assure that such maintenance complies with State health standards. It is recommended that this be an integral part of the annual review of the State highway department's maintenance program for interstate highways.

[1] "Policy and Procedure Memorandum 90-3", U.S. Department of Transportation, Federal Highway Administration, April 10, 1973, 10 pp.

Participants

DRINKING WATER SYSTEMS ALONG FEDERAL INTERSTATE HIGHWAYS

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Appendices

APPENDIX A

SANITARY SURVEY FORMS USED IN STUDY

ENVIRONMENTAL PROTECTION AGENCY

Office of Water Programs
Division of Water Hygiene

INDIVIDUAL WATER SUPPLY SURVEY QUESTIONNAIRE

Card 1

NAME ______________________ SAMPLE NO. ☐☐☐☐☐☐ (1)

ADDRESS ______________________ YEAR ☐☐ (8)

Col. ______________________

I. THE SOURCE

9 A. Spring ☐(1); Well ☐(2); Surface Source ☐(3); Cistern ☐(4)

10 B. On-premise ☐(1); Off-premise ☐(2) (distance: ______________________)

11 C. Ground Water from: Sand/Gravel ☐(1); Limestone ☐(2); Sandstone ☐(3); Other Formation ☐(4) Specify ______________; Unknown ☐(5)

12 D. Construction: By Contractor ☐(1); Owner/Occupant ☐(2); Other ☐(3); Unknown ☐(4)

II. A. SPRING

13 1. Flowing ☐(1); Non-Flowing ☐(2); Intermittent ☐(3)

14 2. Encasement: Brick, Block, or Stone ☐(1); Reinforced Concrete ☐(2); Other ☐(3)

15 General Condition: Good ☐(1); Fair ☐(2); Poor ☐(3)

16 3. Surface Drainage Controlled? Yes ☐(1); No ☐(2)

17 4. Adequate Fencing around spring? Yes ☐(1); No ☐(2)

18 5. Water withdrawn with: Power Pump ☐(1); Hand Pump ☐(2); Bucket ☐(3); Gravity Flow ☐(4); Other ☐(5)

19-20 6. Estimated Minimum Capacity: ☐☐ GPM
Numeric

B. WELL

21 1. Dug ☐(1); Driven ☐(2); Jetted ☐(3); Bored ☐(4); Drilled ☐(5)

2. Dug Well:

22 Acceptable lining to 10' or more? Yes ☐(1); No ☐(2)

23 Acceptable cover? Yes ☐(1); No ☐(2)

24 Masonry or other jointe lining, sealed: Yes ☐(1); No ☐(2); Unknown ☐(3)

25 Reconstructed, sealed and filled: Yes ☐(1); No ☐(2)

26 General condition: Good ☐(1); Fair ☐(2); Poor ☐(3)

3. Other Types of Walls:

27-28 a. Casing: Diameter: ☐☐ inches, I.D.
Numeric

Col.

29 Steel or Black Iron ☐1; Galvanized Iron or Steel ☐2; Plastic ☐3; Masonry or Ceramic ☐4; Other ☐5

30 Joints Screwed Coupling ☐1; Joints Welded ☐2; Unknown ☐3.

31 Wall thickness, Std. or better? Yes ☐1; No ☐2

b. Depths:

32-34 Ground surface to bottom of well: ☐☐☐ Ft.

35-37 Ground surface to bottom of casing: ☐☐☐ Ft.
Numeric

c. Formation Seal:

38 Cement grout seal from depth of 5 to 10' up to surface ☐1; 10 to 20' up to surface ☐2; Fine sand (natural) seal 10 to 20' up to surface ☐3; Puddled clay seal 5 to 20' up to surface ☐4; No apparent formation seal between casing and earth ☐5; Concealed (buried) formation grout seal reported ☐6; Unknown ☐7

d. Sanitary Well Seal:

39 Water tight cover? Yes ☐1; No ☐2

40 Well exposed to flooding by surface water? Yes ☐1; No ☐2

e. Well Pit

41 Pit around well? Yes ☐1; No ☐2

42 Pit has acceptable cover? Yes ☐1; No ☐2

43 Pit drains to open air? Yes ☐1; No ☐2

44 Pit drains to drain line or sewer? Yes ☐1; No ☐2

45 Possible to flood pit in any way? Yes ☐1; No ☐2

46 Pitless adapter? Yes ☐1; No ☐2

47 Pitless adapter with top of well buried or below ground level: Yes ☐1; No ☐2

48 f. Well "Filter" or Screen*

Open hole ☐1; Perforated or slotted pipe ☐2; Gravel Pack ☐3; Sand (well) point or screen of horizontal, endless slot type ☐4; Other type of screen ☐5

49 g. Age of Well: <2 yrs. ☐1; 2-5 yrs. ☐2; 6-10 yrs. ☐3; 11-20 yrs. ☐4; >20 yrs. ☐5

50 C. PUMP AT SOURCE: Yes ☐1; No ☐2; Bucket ☐3

51 1. Hand pump ☐1; "Shallow well" (Low-Lift) Jet or Centrifugal pump ☐2; "Deep well"(Hi-Lift) Jet Pump ☐3; Submersible pump ☐4; Piston Pump ☐5; None ☐6

*Not to be confused with "filter" or strainer attached to suction inlet of pump.

Col.

I. PHYSICAL QUALITY OF WATER

9 1. Colored ☐1; Turbid ☐2; Clear ☐3; Contains sand ☐4

10 2. Taste: Good ☐1; Fair ☐2; Poor* ☐3 ____________________

11 3. Evidence of iron or manganese problem: Yes ☐1; No ☐2

12 4. Water Softener in regular operation: Yes ☐1; No ☐2

13 5. Other water conditioner devices used: Yes ☐1; No ☐2

J. PUBLIC AGENCY INTERESTS**

14 1. Has any public agency inspected this supply at any time within the last two years? Yes ☐1 **____________________ ____________________; No ☐2; Unknown ☐3

15 2. Has bacteriological analysis ever been made on the water? Yes ☐1; Date ________,** ____________________ ____________________; No ☐2; Unknown ☐3

16 a. If "yes", was the water found "safe"? Yes ☐1; No ☐2

17 b. If "no" (under 2a), were corrections recommended? Yes ☐1; No ☐2

18. c. Were corrections made? Yes ☐1; No ☐2

19 d. After corrections were made, was water retested? Yes ☐1 **____________________; No ☐2

20 3. Did the owner, before attempting any construction at the source or before using the source, consult any agency about its suitability? Yes ☐1 **____________________ ____________________; No ☐2

21 4. Have any chemical analyses ever been made on the water? Yes ☐1 Date ________, ** ____________________ ____________________; No ☐2; Unknown ☐3

K. USER'S PREFERENCE

22 1. User prefers: Present supply ☐1; Another or improved individual supply ☐2; A public supply ☐3

23-25 ☐☐☐ 2. Reason(s) for Preference: Lower cost ☐1; Better tasting water ☐2; Softer water ☐4; Independence ☐8; More reliable source ☐16; Safer ☐32; More convenient ☐64; Other ☐128

L. PRESENT CONSUMPTION

26 1. Number of dwelling units using system ☐

27-30 2. Number of persons using system. Adults ☐☐ ; Children ☐☐

31 3. Is water shortage ever experienced: Yes ☐1 ** ____________________ ____________________; No ☐2

80 CARD NUMBER 2

* Identify if possible

** Identify agency

Col.

52 2. Pump never breaks suction ☐1; Sometimes breaks suction ☐2

53 3. With existing pump, source delivers: <3 GPM ☐1; 3-5 GPM ☐2; 5-10 GPM ☐3; 10-20 GPM ☐4; >20 GPM ☐5

D. SURFACE SOURCE (Stream; Lake)

54 1. Perennial ☐1; Intermittent ☐2

55 2. Upstream: Human activity currently on watershed? Yes ☐1; No ☐2

56 3. Delivery: Flow by pumping ☐1; By gravity ☐2

E. CISTERN

57 1. Catchment Area: Rooftops ☐1; Ground surface paved or covered with impermeable material ☐2

58 2. Ground Area Only: Fenced ☐1; Signs posted ☐2; Unprotected ☐3

59 3. Cistern Construction: Above ground ☐1; Below ground ☐2;

60 Brick or Stone ☐1; Concrete ☐2; Wood ☐3; Steel ☐4

61 General Condition: Good ☐1; Fair ☐2; Poor ☐3

62 4. Device for discarding first water? Yes ☐1; No ☐2

63 5. Cistern Protection: Screened against rodents, birds? Yes ☐1; No ☐2

64 6. Cleaning: Does cistern have drain which permits cleaning and flushing to waste? Yes ☐1; No ☐2

65 Does cistern need cleaning now? Yes ☐1; No ☐2

F. WATER TREATMENT

66 1. Sedimentation: Yes ☐1; No ☐2

67 2. Filtration Through: Sand ☐1; Other Medium ☐2

68 3. Chlorination: Automatic ☐1; Manual ☐2

69 4. Softening: Yes ☐1; No ☐2

70 5. Other: Yes ☐1 (Describe)______________________; No ☐2

71 G. STORAGE (All Sources): Yes ☐1; No ☐2

72 1. Pressure tank ☐1

73 2. Other storage: Elevated or Ground Level ☐1; Below ground level ☐2

74 3. Construction: Steel ☐1; Brick, block or stone ☐2; Concrete ☐3; Wood ☐4; Plastic ☐5; Other ☐6

75 4. General Condition: Good ☐1; Fair ☐2; Poor ☐3

76 H. DELIVERY

76 1. Water flows to point of use by hand pumping ☐1; Power pumping ☐2; Gravity ☐3; Hand carry ☐4

80 CARD NUMBER 1; CARD 2 - Dup. 1-8

APPENDIX B

Calculation of Annual Surveillance Cost

Surveillance

Assume 1 man-day will be required per supply for the following activities:

—Field surveys

—Construction surveillance

—Informal on-the-job-training

Average annual estimated personnel costs for surveillance

$12,000	salary
2,500	fringe benefits
2,000	travel
500	office supplies
500	office space
2,500	⅓ secretary
$20,000	

Assuming 225 man-days equals 1 man-year, one person can provide surveillance over

$$\frac{225 \text{ man-days per year}}{1 \text{ man-day per system}} = \frac{225 \text{ systems}}{\text{year}}$$

The average cost per system will then be:

$$\frac{\$20,000}{225} = \$89 \text{ per year}$$

Chemical Surveillance

	Man-Days Per Sample	Frequency of Analysis	Man-Days Per Annum
Wet Chemistry	.65	Triennial	.22
Trace Metals	.65	Triennial	.22
Radiochemical	1.2	Triennial	.40
Total			.84

$$\frac{.84 \text{ man-days } (\$20,000/\text{year})}{225 \ \frac{\text{man-days}}{\text{year}}} = \$75/\text{year}$$

Bacteriological Surveillance

Assuming the cost per bacteriological analysis, including postal

cost = $5 per sample, then

$$2 \text{ samples/months} \times 12 \text{ months/year} \times \$5/\text{sample}$$
$$= \$120/\text{year}$$

$$\$89 + \$75 + \$120 = \$284/\text{year}$$

APPENDIX C

CALCULATION OF NUMBER OF SYSTEMS

During the field and planning stages of this study it was estimated that there was approximately 1 commercial service facility for every 5 miles of Interstate Highway. Federal Highway Administration sources[1] report that there are approximately 42,481 miles of Interstate Highway in the United States. Other FHWA sources[2] report a total of 1044 safety rest areas along rural and urban Interstate Highways. However, the same source indicates that only 59% of the safety rest areas have drinking water facilities. Therefore, the number of water systems serving the traveling public along Interstate Highways is estimated as follows:

$$\frac{42{,}481 \text{ miles}}{\frac{5 \text{ miles}}{\text{systems}}} + 1044 \text{ systems } (0.59) = 9115 \text{ water systems}$$

In the study[2] just mentioned, a total of 69 safety rest areas were surveyed for a 32 hour study-period during the summer of 1969. During the study period a total of 70,536 individuals made use of drinking water facilities at the 60 rest areas, therefore, it is estimated that

$$70{,}536 \text{ people} \times \frac{24 \text{ hour}}{32 \text{ hour}} \times \frac{1044\ (0.59) \text{ systems}}{60 \text{ systems}} = 540{,}000$$

people per day use the drinking water facilities at safety rest areas in the United States. Therefore, it is expected that well over one million people per day use the drinking water facilities at both commercial service facilities and safety rest areas.

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[1] Title 23, U.S. Code, Highways—Section 104 (b) 5—Interstate System Estimate of Cost to Complete the System for Apportioning Funds for Fiscal Year 1972.

[2] "Summary of the 1969 National Rest Area Usage Study and the 1970 Update of the Rest Area Inventory", U.S. Department of Transportation, Federal Highway Administration, May 1971, 75 pp.

APPENDIX D

RESULTS OF LABORATORY ANALYSES

SPECIAL WATER SUPPLY STUDY

VA. INTERSTATE

LABORATORY ANALYSES

SERIAL NUMBER	TURBIDITY	COLOR	ODOR	TOTAL DISSOLVED SOLIDS	CHLORIDE	SULFATE	NITRATE	M.B.A.S.	SELENIUM	BORON	FLUORIDE	CYANIDE	URANYL ION	PH
11502	.10	2		333.0	84.0	24.9	3.7	.009	.004		.25			
11503	.20	2		179.0	9.9	24.9	2.6	.004	.004		.31			7.7
11504	5.50*	7		297.0	23.0	24.9	19.2	.011	.004		.10			7.5
11505	.10	3		406.0	96.0	24.9	9.0	.015	.004		.11			7.6
11506	.20	2		201.0	9.9	24.9	3.8	.004	.004		.20			7.8
11507	.10	2		295.0	17.5	35.0	2.4	.005	.004		.11			7.7
11515	.10	2		394.0	31.5	24.9	11.0	.010	.004		.30			
11516	.10	2		306.0	9.9	24.9	5.0	.004	.004		.30			7.8
11517	.10	2		263.0	9.9	24.9	14.0	.006	.004		.50			7.7
11518	.10	2		344.0	10.5	24.9	6.6	.006	.004		.45			7.7
11519	.20	2		151.0	10.4	24.9	1.4	.005	.004		.09			7.7
11520	.10	2		202.0	9.9	24.9	1.6	.004	.004		.28			7.8
11521	.40	2		330.0	9.9	46.0	4.2	.004	.004		.12			7.6
11529	.70	1		290.0	21.0	24.9	4.7	.007	.004		.09			
11530	.10	2		238.0	9.9	24.9	9.0	.004	.004		.09			7.6
11531	.10	2		267.0	24.0	24.9	6.8	.008	.004		.09			7.7
11532	.10	2		315.0	60.0	24.9	6.0	.012	.004		.09			7.6
11533	.30	1		166.0	9.9	26.0	.9	.004	.004		.10			7.6
11534	.30	2		370.0	9.9	24.9	.9	.004	.004		.14			7.8
11541	.10	1		108.0	12.0	25.0	1.2	.005	.004		1.10			
11542	2.00	2		237.0	11.0	33.0	.9	.004	.004		.90			7.6
11543	.20	2		416.0	14.0	90.0	.9	.006	.004		1.70			7.9
11547	.80	2		180.0	14.0	27.0	.9	.004	.004		.10			
11548	.20	1		315.0	9.9	24.9	22.0	.008	.004		.11			7.7
11549	.10	2		353.0	9.9	50.0	.9	.004	.004		1.50			7.9
11550	.10	1		404.0	76.0	24.9	6.2	.010	.004		.12			7.6
11551	.10	2		165.0	9.9	24.9	5.0	.004	.004		.20			7.8
11556	.10	2		346.0	9.9	24.9	2.4	.004	.004		.38			
11559	.10	3		329.0	9.9	24.9	.9	.004	.004		.70			7.8
11560	.20	2		233.0	11.0	24.9	8.6	.006	.004		.17			7.8
11561	.10	1		194.0	72.0	115.0	11.6	.012	.004		.14			7.6
11562	.10	1		303.0	9.9	24.9	9.4	.004	.004		.53			7.7
11563	.10	1		331.0	27.5	24.9	13.5	.012	.004		.17			7.7
11571	.30	1		416.0	9.9	24.9	.9	.004	.004		.38			
11572	.10	1		477.0	150.0	24.9	10.2	.032	.004		.47			7.6
11573	.10	2		365.0	35.0	35.0	.9	.006	.004		.59			7.8
11574	.10	1		532.0*	70.0	35.0	58.0*	.033	.004		.37			7.6
11575	.20	1		283.0	12.5	24.9	5.2	.004	.004		.24			7.8
11576	.10	3		388.0	9.9	50.0	6.3	.004	.004		.40			7.7

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SPECIAL WATER SUPPLY STUDY

VA. INTERSTATE

LABORATORY ANALYSES

SERIAL NUMBER	TURBIDITY	COLOR	ODOR	TOTAL DISSOLVED SOLIDS	CHLORIDE	SULFATE	NITRATE	M.B.A.S.	SELENIUM	BORON	FLUORIDE	CYANIDE	URANYL ION	PH
MAXIMUM	5.50	7		632.0	150.0	115.0	58.0	.033	.004	.000	1.70	.000	.000	7.9
MINIMUM	.10	1		108.0	9.9	24.9	.9	.004	.004	.000	.09	.000	.000	7.5
AVERAGE	.36	1		303.1	26.9	31.7	7.1	.007	.004	.000	.35	.000	.000	

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SPECIAL WATER SUPPLY STUDY

KS. INTERSTATE LABORATORY ANALYSES

SERIAL NUMBER	TURBIDITY	COLOR	ODOR	TOTAL DISSOLVED SOLIDS	CHLORIDE	SULFATE	NITRATE	M.B.A.S.	SELENIUM	BORON	FLUORIDE	CYANIDE	URANYL ION	PH
11833	.22	4		1112.0*	22.0	227.0	1.9	.004	.015$	.242	.05			7.7
11834	.27	4		632.0*	17.8	126.0	1.3	.004	.004	.228	.07			7.9
11835	.15	4		404.5	4.9	58.0	.3	.003	.004	.172	.08			8.0
11836	.22	4		695.5*	27.0	174.0	1.4	.003	.004	.149	.06			7.6
11837	.47	4		540.0*	33.0	40.0	.2	.003	.004	.182	.05			7.8
11843	4.00	4		2680.0*	158.0	820.0*	5.8	.004	.004	1.490*	1.12			7.6
11844	6.30*	4		902.0*	25.0	106.0	6.2	.003	.004	.126	1.00			7.5
11845	.35	4		668.4*	8.0	100.0	2.0	.002	.004	.099	.60			7.5
11846	3.20	4		609.5*	11.0	53.5	1.6	.003	.004	.126	.86			7.8
11847	9.00*	4		553.0*	7.8	31.0	6.7	.003	.004	.109	.55			7.8
11848	.90	4		497.0	4.9	37.5	5.6	.003	.004	.192	.55			7.9
11849	33.00*	65*		993.0*	4.9	430.0*	1.8	.005	.004	.366	1.12			7.4
11850	14.00*	4		1095.0*	7.8	385.0*	1.6	.004	.004	.192	.72			7.4
11853	.15	4		283.0	5.5	9.3	15.9	.002	.004	.099	.07			7.7
11854	.50	4		262.5	4.9	6.9	8.9	.003	.004	.109	.06			7.6
11861	.37	4		726.5*	25.0	111.0	45.3*	.003	.004	.222	1.15			7.6
11862	.39	4		580.5*	12.5	133.0	11.5	.003	.004	.233	.72			7.6
11863	.37	4		390.0	32.0	71.0	5.0	.003	.004	.186	.50			8.2
11864	.22	4		918.3*	33.0	188.0	24.8	.003	.006	.194	.55			7.6
11865	.27	4		2267.0*	276.0*	183.0	.0	.002	.004	.718	3.05 $			7.9
11866	.26	4		1461.0*	124.0	174.0	1.3	.004	.004	.332	.82			7.7
11867	.22	4		411.5	4.9	25.0	25.7	.003	.004	.133	.75			7.6
11868	.32	4		732.6*	13.0	155.0	24.8	.003	.004	.133	.68			7.5
11877	.35	4		542.5*	19.0	105.5	15.6	.003	.004	.172	.72			7.5
11878	.83	4		622.0*	19.0	67.0	15.6	.003	.004	.202	.44			7.6
11879	.30	4		612.2*	33.5	43.0	5.8	.003	.004	.149	.40			7.5
11880	.14	4		2762.5*	25.0	650.0*	1.8	.003	.004	.980	1.29			7.5
11881	1.60	4		296.4	36.5	68.0	2.1	.003	.004	.149	1.40			7.7
11882	.38	4		2841.7*	30.0	700.0*	1.6	.001	.004	1.080*	1.40			7.5
11883	.27	4		526.0*	26.0	103.0	15.0	.003	.004	.116	.57			7.9
11884	.23	4		539.0*	33.5	67.5	8.0	.003	.004	.149	.65			7.9
11885	.25	4		426.5	60.0	63.0	.5	.003	.004	.113	.52			7.8
13222	.22	4		743.0*	26.0	158.0	28.6	.003	.004	.099	.98			7.6
13223	.33	4		520.5*	13.0	90.5	58.6*	.003	.004	.127	.45			7.5
13224	.16	4		266.5	4.9	9.3	1.9	.003	.004	.099	.60			7.4
13225	.26	4		909.5*	18.2	330.0*	.0	.002	.004	.617	1.28			7.7
13226	.42	4		2024.0*	140.0	375.0*	.0	.003	.004	.750	.48			7.5
13227	3.00	4		1647.0*	88.0	425.0*	.0	.004	.004	.750	2.03			7.7
13228	.17	4		165.0	4.9	26.3	24.0	.002	.004	.099	.50			7.4
13229	.32	4		215.5	5.5	22.0	31.0	.003	.004	.099	.42			7.1

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SPECIAL WATER SUPPLY STUDY

KS. INTERSTATE

LABORATORY ANALYSES

SERIAL NUMBER	TURBIDITY	COLOR	ODOR	TOTAL DISSOLVED SOLIDS	CHLORIDE	SULFATE	NITRATE	M.B.A.S.	SELENIUM	BORON	FLUORIDE	CYANIDE	URANYL ION	PH
MAXIMUM	33.00	65		2841.7	276.0	820.0	58.6	.005	.015	1.490	3.05	.000	.000	8.2
MINIMUM	.14	4		165.0	4.9	6.9	.0	.001	.004	.099	.05	.000	.000	7.1
AVERAGE	2.12	5		879.4	36.2	173.6	10.2	.003	.004	.294	.73	.000	.000	

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SPECIAL WATER SUPPLY STUDY

OR. INTERSTATE

LABORATORY ANALYSES

SERIAL NUMBER	TURBIDITY	COLOR	ODOR	TOTAL DISSOLVED SOLIDS	CHLORIDE	SULFATE	NITRATE	M.B.A.S.	SELENIUM	BORON	FLUORIDE	CYANIDE	URANYL ION	PH
11744	.18	4		65.5	4.9	.9	.3	.001	.004	.099	.13			6.8
11746	.23	4		45.5	5.0	2.8	5.8	.001	.004	.099	.03			6.6
11748	.20	4		38.5	4.0	.9	.8	.001	.004	.099	.05			6.4
11750	.22	5		180.5	10.8	.9	17.7	.002	.004	.099	.03			7.4
11751	.23	4		173.0	12.0	1.3	2.3	.001	.004	.099	.07			7.6
11752	.57	4		170.5	10.3	.9	.0	.001	.004	.099	.11			7.5
11753	.45	4		317.0	49.0	.9	.0	.001	.004	.099	.22			7.6
11754	.50	4		528.5*	88.0	.9	.2	.002	.004	.136	.05			7.4
11755	5.70*	8		1423.0*	220.0	.9	1.1	.003	.004	.144	.08			5.7
11756	11.00*	15		1996.5*	370.0*	2.9	.0	.002	.004	.099	.09			7.5
11757	.18	4		1364.5*	325.0*	.9	.2	.002	.004	.099	.18			7.8
11767	.21	4		180.5	10.6	3.5	1.8	.001	.004	.099	.11			7.5
11768	.32	4		147.5	9.0	3.0	4.7	.001	.004	.099	.11			7.3
11769	.15	4		154.0	12.5	2.5	5.2	.001	.004	.099	.15			7.5
11770	.18	4		371.0	28.0	9.3	.0	.002	.004	.099	.15			7.9
11771	.80	4		211.5	13.4	.9	.2	.002	.004	.132	.72			7.3
11772	2.20	8		220.5	9.0	.9	.3	.003	.004	.126	.18			7.2
11773	2.80	15		266.5	7.2	1.1	.3	.003	.004	.187	.25			7.6
11774	.28	4		286.5	28.0	4.9	.4	.003	.004	.242	.17			7.6
11783	.13	4		566.0*	125.0	9.6	1.5	.003	.004	.625	.38			7.6
11784	.24	4		303.0	42.4	36.0	1.6	.002	.004	.695	.34			7.8
11785	.12	4		506.0*	100.0	5.4	.9	.002	.004	.420	.21			7.7
11786	.15	4		1344.5*	250.0	8.9	.8	.002	.004	1.442*	.33			7.4
11787	.43	4		2401.0*	320.0*	10.0	.9	.003	.004	1.440*	.42			7.1
11788	.36	4		482.5	69.0	20.5	1.6	.002	.004	.695	.22			7.7
11789	.08	4		189.0	16.2	5.3	3.1	.003		.152	.20			7.8
11797	.75	4		520.5*	13.2	110.0	1.5	.003	.004	.126	.10			7.5
11798	.13	4		243.0	25.0	7.6	1.2	.003	.004	.584	.11			7.8
11799	.22	4		208.0	7.5	.9	2.1	.003	.004	.099	.04			7.3
11804	.22	4		234.5	39.0	13.3	.9	.003	.004	.731	.21			7.6
11805	.80	4		441.5	8.9	44.0	1.8	.004	.004	.143	.25			7.3
11806	.23	4		453.0	100.0	6.6	1.6	.004	.004	.523	.21			7.8
11807	5.10*	8		79.5	5.5	1.6	.9	.002	.004	.099	.08			6.9
11812	.70	4		192.5	22.5	2.8	1.7	.002	.004	.156	.14			7.6
11813	1.10	4		317.5	16.0	19.0	3.9	.002	.004	.099	.75			7.4
11814	.32	4		242.0	11.5	13.7	.9	.003	.004	.104	.18			7.8
11815	.16	4		147.5	8.0	4.2	30.2	.003	.004	.099	.67			7.3
11816	1.00	8		161.5	80.0	9.1		.003	.004	.099	.65			7.6
11826	1.40	4		47.0	4.9	1.6	2.0	.002	.004	.100	.09			7.4
11827	.12	4		187.5	6.0	1.7	23.1	.002	.004	.099	.09			7.2

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SPECIAL WATER SUPPLY STUDY

OR. INTERSTATE LABORATORY ANALYSES

SERIAL NUMBER	TURBIDITY	COLOR	ODOR	TOTAL DISSOLVED SOLIDS	CHLORIDE	SULFATE	NITRATE	M.B.A.S.	SELENIUM	BORON	FLUORIDE	CYANIDE	URANYL ION	PH
MAXIMUM	11.00	15		2401.0	370.0	110.0	30.2	.004	.004	1.442	.75	.000	.000	7.9
MINIMUM	.08	4		38.5	4.0	.9	.0	.001	.004	.099	.04	.000	.000	5.7
AVERAGE	1.00	4		436.6	62.2	9.3	3.0	.002	.003	.269	.21	.000	.000	

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WATER SUPPLY STUDY

LABORATORY ANALYSES

SERIAL NUMBER	TURBIDITY	COLOR	ODOR	TOTAL DISSOLVED SOLIDS	CHLORIDE	SULFATE	NITRATE	M.B.A.S.	SELENIUM	BORON	FLUORIDE	CYANIDE	URANYL ION	PH
MAXIMUM	33.00	65		2841.7	370.0	820.0	58.6	.033	.015	1.490	3.05	.000	.000	8.2
MINIMUM	.08	1		38.5	4.0	.9	.0	.001	.004	.000	.04	.000	.000	5.7
AVERAGE	1.17	4		541.7	41.9	71.9	6.8	.004	.004	.189	.43	.000	.000	

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VA. - INTERSTATE

LABORATORY ANALYSES

SERIAL NUMBER	SPECIFIC CONDUCTANCE	BARIUM	ARSENIC	CHROMIUM	SILVER	COPPER	MANGANESE	LEAD	IRON	COBALT	CADMIUM	ZINC	NICKEL	MERCURY	COLIFORM TOTAL	FECAL
11502	603	.160	.004	.000	.000	.025	.000	.012	.029	.000	.000	.690	.000	.0004	0	0
11508															0	0
11503	374	.070	.004	.000	.000	.025	.000	.000	.014	.008	.000	1.500	.000	.0004	0	0
11509															0	0
11504	567	.060	.004	.000	.000	.025	.008	.000	.180	.000	.000	1.000	.000	.0004	0	0
11510															0	0
11514															99999$	6$
11505	741	.060	.004	.000	.000	.054	.000	.000	.072	.000	.000	1.010	.000	.0004	2$	0
11511															0	0
11506	395	.049	.004	.000	.000	.034	.000	.000	.058	.000	.000	.920	.000	.0004	0	0
11512															0	0
11507	504	.160	.004	.000	.000	.054	.000	.000	.014	.000	.000	1.750	.000	.0004	3$	0
13749															0	0
11515	689	.120	.004	.000	.000	.025	.008	.000	.020	.013	.003	3.400	.000	.0004	0	0
11522															0	0
11516	530	.120	.004	.000	.000	.016	.000	.000	.021	.008	.000	2.000	.000	.0004	0	0
11523															0	0
11517	464	.070	.004	.000	.000	.082	.008	.000	.230	.000	.000	1.090	.000	.0004	0	0
11524															3$	0
11518	618	.130	.004	.000	.000	.025	.000	.000	.022	.000	.000	3.700	.000	.0004	0	0
11525															0	0
11519	367	.050	.004	.000	.000	.370	.000	.000	.022	.000	.000	.770	.000	.0004	0	0
11526															0	0
11520	296	.050	.004	.000	.000	.140	.000	.000	.022	.000	.000	.025	.000	.0004	0	0
11527															0	0
11521	541	.140	.004	.000	.000	.016	.008	.000	.043	.000	.000	.720	.000	.0004	7$	0
11528															3$	0
11529	556	.060	.004	.000	.000	.034	.004	.000	.029	.000	.000	.950	.000	.0004	21$	1$
11535															42$	1$
11530	435	.049	.004	.000	.000	.016	.000	.000	.036	.000	.000	.920	.000	.0004	5$	0
11536															8$	0
11531	494	.049	.004	.000	.000	.054	.004	.000	.022	.000	.000	1.200	.000	.0004	1	0
11537															1	0
11532	587	.049	.004	.000	.000	.025	.004	.000	.029	.000	.000	1.900	.000	.0004	0	0
11538															0	0
11533	278	.140	.008	.000	.000	.016	.270*	.000	.065	.000	.000	1.010	.000	.0004	0	0
11534	685	.300	.004	.000	.000	.016	.044	.000	2.420*	.000	.000	.460	.000	.0004	0	0
11540															0	0
11541	190	.049	.004	.000	.008	.074	.000	.000	.200	.000	.000	.009	.000	.0004	0	0
11544															0	0
11542	328	.090	.004	.000	.000	.042	.130*	.000	1.000*	.006	.000	.087	.000	.0004	0	0
11545															0	0

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SERIAL NUMBER	SPECIFIC CONDUCTANCE	BARIUM	ARSENIC	CHROMIUM	SILVER	COPPER	MANGANESE	LEAD	IRON	COBALT	CADMIUM	ZINC	NICKEL	MERCURY	COLIFORM TOTAL	COLIFORM FECAL
11543	671	.090	.004	.000	.000	.084	.160*	.000	.250	.000	.000	.120	.000	.0004	0	0
11546															0	0
11547	300	.170	.004	.000	.000	.031	.280*	.000	.730*	.006	.000	.330	.000	.0004	0	0
11552															0	0
11548	598	.060	.004	.000	.000	.042	.078*	.000	.200	.000	.000	7.400*	.000	.0004	0	0
11553															0	0
11557															0	0
11549	624	.090	.004	.000	.000	.021	.000	.000	.034	.006	.000	1.400	.000	.0004	1	0
11554															0	0
11550	769	.050	.004	.000	.000	.026	.000	.000	.180	.006	.000	1.900	.000	.0004	33$	0
11555															41$	0
11551	338	.049	.004	.000	.000	.021	.000	.000	.013	.000	.000	.250	.000	.0004	0	0
11556															0	0
11558	640	.080	.004	.000	.000	.021	.000	.000	.020	.000	.000	1.050	.000	.0004	0	0
11564															0	0
11559	609	.049	.004	.000	.000	.021	.000	.000	.073	.000	.000	.540	.000	.0004	0	0
11565															0	0
11560	447	.049	.004	.000	.000	.011	.000	.000	.013	.000	.000	.660	.000	.0004	0	0
11566															0	0
11561	936	.150	.004	.000	.000	.021	.000	.000	.034	.000	.000	.910	.000	.0004	0	0
11567															0	0
11562	546	.100	.004	.000	.000	.042	.000	.000	.050	.006	.001	2.950	.000	.0004	2$	0
11568															1	0
11570															0	0
11563	588	.050	.004	.000	.000	.031	.000	.000	.042	.000	.000	.190	.000	.0004	0	0
11569															0	0
11571	738	.230	.004	.000	.000	.140	.000	.000	.020	.000	.000	.200	.000	.0004	0	0
11577															0	0
11572	880	.100	.004	.000	.000	.063	.000	.065$	.027	.000	.000	.150	.000	.0004	0	0
11578															1	0
11573	634	.170	.004	.000	.000	.026	.011	.000	.024	.000	.000	.370	.000	.0004	0	0
11579															0	0
11574	1248	.170	.004	.000	.000	.011	.006	.014	.027	.000	.000	.200	.000	.0004	71$	0
11580															52$	0
11575	530	.090	.004	.000	.000	.042	.006	.000	.034	.000	.000	.510	.000	.0004	0	0
11581															0	0
11576	676	.140	.004	.000	.000	.031	.009	.000	.053	.000	.000	.200	.000	.0004	1	0
11582															0	0
MAXIMUM	1248	.300	.008	.000	.008	.370	.280	.065	2.420	.013	.003	7.400	.000	.0004	99999	[illegible]
MINIMUM	190	.049	.004	.000	.000	.011	.000	.000	.013	.000	.000	.009	.000	.0004	0	[illegible]
AVERAGE	275	.048	.002	.000	.000	.023	.012	.001	.079	.000	.000	.555	.000	.0001	1253	[illegible]

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KS. INTERSTATE LABORATORY ANALYSES

SERIAL NUMBER	SPECIFIC CONDUCTANCE	BARIUM	ARSENIC	CHROMIUM	SILVER	COPPER	MANGANESE	LEAD	IRON	COBALT	CADMIUM	ZINC	NICKEL	MERCURY	COLIFORM TOTAL	COLIFORM FECAL
11875															0	0
13222	1100	.049	.004	.000	.000	.040	.000	.000	.012	.000	.000	.016	.000	.0004	13$	0
13230															0	0
13223	797	.600	.004	.000	.000	.570	.000	.000	.036	.000	.000	.180	.000	.0004	0	0
13231															0	0
13224	375	.049	.004	.000	.000	.057	.080*	.000	.012	.000	.000	.540	.000	.0004	0	0
13232															0	0
13225	1425	.049	.004	.000	.000	.032	.000	.000	.140	.000	.000	.054	.000	.0004	230$	0
13233															150$	0
13226	2760	.049	.004	.000	.000	.024	.480*	.000	.500*	.012	.002	.015	.004	.0004	0	0
13234															0	0
13227	2525	.049	.004	.000	.000	.011	.220*	.000	1.700*	.006	.000	.440	.000	.0004	0	0
13235															1	0
13228	224	.100	.004	.000	.000	.170	.000	.000	.030	.000	.000	.043	.000	.0004	0	0
13236															0	0
13229	274	.200	.004	.000	.000	.120	.000	.000	.018	.000	.000	.050	.000	.0004	0	0
13237															0	0
11833	1218	.120	.004	.000	.003	.104	.000	.020	.014	.000	.000	.067	.011	.0004	0	0
11838															0	0
11834	911	.240	.004	.000	.003	.029	.300*	.000	3.000*	.008	.000	.220	.006	.0004	1	0
11839															0	0
11835	610	.130	.004	.000	.000	.017	.015	.000	.020	.008	.000	.033	.000	.0004	970$	0
11840															950$	0
11836	940	.049	.004	.000	.000	.013	.011	.000	.025	.000	.000	.005	.000	.0004	0	0
11841															1	0
11837	820	.320	.015*	.000	.000	.000	.740*	.000	5.800*	.000	.000	.320	.011	.0004	0	0
11842															0	0
11843	3700		.004	.006	.003	.064	.110*	.050	2.000*	.016	.001	1.100	.011	.0004	0	0
11844	1118	.120	.004	.000	.000	.080	.040	.030	3.900*	.012	.000	.940	.011	.0004	1	1$
11845	887	.220	.004	.006	.000	.025	.013	.000	1.200*	.012	.000	2.850	.011	.0004	1	1$
11846	722	.140	.004	.000	.000	.033	.024	.000	1.800*	.008	.000	1.700	.006	.0004	0	0
11847	852	.200	.004	.006	.003	.160	.032	.120$	2.200*	.008	.000	.770	.008	.0004	0	0
11848	700	.150	.004	.000	.000	.041	.022	.000	1.500*	.000	.000	.540	.006	.0004	0	0
11849	1145	.150	.004	.006	.000	.009	2.200*	.000	3.500*	.016	.000	.057	.017	.0004	0	0
11851															0	0
11850	1300	.150	.004	.006	.000	.017	.650*	.000	2.200*	.016	.000	.260	.017	.0005	0	0
11852															0	0
11853	395	.150	.004	.000	.000	.009	.003	.000	.082	.000	.000	1.200	.000	.0004	0	0
11855															0	0
11854	373	.420	.004	.000	.003	.056	.032	.060$	.590*	.000	.000	4.700	.000	.0004	0	0
11856															12$	0
11861	1076	.100	.004	.000	.000	.075	.000	.000	.030	.000	.000	.120	.000	.0004	0	0

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KS. INTERSTATE LABORATORY ANALYSES

SERIAL NUMBER	SPECIFIC CONDUCTANCE	BARIUM	ARSENIC	CHROMIUM	SILVER	COPPER	MANGANESE	LEAD	IRON	COBALT	CADMIUM	ZINC	NICKEL	MERCURY	COLIFORM TOTAL	COLIFORM FECAL
11869															0	0
11862	737	.049	.004	.000	.000	.130	.000	.000	.063	.000	.000	.076	.000	.0004	0	0
11870															0	0
11863	523	.049	.004	.000	.000	.009	.003	.000	.082	.000	.000	1.200	.000	.0004	0	0
11871															0	0
11864	1425	.049	.004	.000	.000	.560	.000	.000	.008	.000	.000	.050	.000	.0004	320$	0
11872															0	0
11865	3840	.049	.004	.000	.000	.025	.008	.000	.250	.000	.000	.410	.000	.0004	2$	0
11873															1	1$
11866	2430	.049	.004	.000	.000	.040	.150*	.000	.230	.000	.000	.054	.000	.0004	0	0
11874															0	0
11867	577	.300	.004	.000	.000	.011	.000	.000	.210	.000	.000	.360	.000	.0004	0	0
11868	1008	.200	.004	.000	.000	.093	.000	.000	.150	.000	.000	.040	.004	.0004	0	0
11876															0	0
11877	736	.100	.004	.000	.000	.032	.008	.000	.042	.000	.000	.120	.004	.0004	1	1$
11886															2$	0
11878	1010	.200	.004	.000	.000	.025	.000	.000	.008	.000	.000	.034	.000	.0004	0	0
11887															0	0
11879	883	.200	.004	.000	.000	.032	.000	.000	.036	.000	.000	.240	.000	.0004	0	0
11888															0	0
11880	2710	.049	.004	.012	.005	.011	.028	.070$	.030	.012	.001	.360	.021	.0004	12$	0
11889															11$	0
11881	442	.100	.004	.000	.000	.004	.020	.000	.430*	.000	.000	.019	.000	.0004	0	0
11890															0	0
11882	2850	.049	.004	.028	.005	.102	.028	.090$	.620*	.012	.001	4.200	.025	.0004	0	0
11891															0	0
11883	765	.049	.004	.000	.000	.093	.000	.000	.210	.000	.000	.054	.000	.0004	0	0
11892															0	0
11884	800	.050	.004	.000	.000	.004	.000	.000	.210	.000	.000	.099	.000	.0004	1600$	29$
11893															2500$	25$
11885	600	.200	.004	.000	.000	.004	.720*	.000	.300	.000	.000	.054	.000	.0004	0	0
11894															0	0
MAXIMUM	3840	.600	.015	.028	.005	.570	2.200	.120	8.200	.016	.002	4.700	.025	.0005	2500	29
MINIMUM	224	.049	.004	.000	.000	.000	.000	.000	.008	.000	.000	.005	.000	.0004	0	0
AVERAGE	643	.074	.002	.000	.000	.039	.080	.005	.529	.001	.000	.318	.002	.0002	91	0

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OR. INTERSTATE LABORATORY ANALYSES

SERIAL NUMBER	SPECIFIC CONDUCTANCE	BARIUM	ARSENIC	CHROMIUM	SILVER	COPPER	MANGANESE	LEAD	IRON	COBALT	CADMIUM	ZINC	NICKEL	MERCURY	COL FORM TOTAL	COL FORM FECAL
11744	43	.049	.004	.000	.000	.023	.000	.000	.092	.000	.000	.044	.000	.0010	0	0
11747															0	0
11745															33$	0
11748	29	.049	.004	.000	.000	.140	.008	.000	2.100*	.000	.000	.100	.000	.0004	33$	0
11746	56	.049	.004	.000	.000	.031	.008	.000	.092	.000	.000	.087	.000	.0004	0	0
11749															0	0
11750	250	.049	.004	.000	.006	.031	.008	.000	.030	.000	.000	.260	.000	.0004	0	0
11758															0	0
11751	276	.049	.004	.000	.006	.008	.004	.000	.012	.000	.000	.290	.000	.0004	0	0
11759															0	0
11753	542	.049	.004	.000	.012	.008	.058*	.000	.470*	.000	.000	.430	.000	.0004	0	0
11761															0	0
11754	749	.049	.004	.000	.018	.008	.320*	.000	.790*	.000	.000	.240	.000	.0004	1	0
11762															1	0
11755	1925	.049	.004	.000	.006	.110	.012	.000	1.540*	.012	.000	.420	.007	.0004	0	0
11763															0	0
11756	2760	.049	.004	.000	.006	.016	.110*		1.610*	.012	.000	.620	.007	.0004	0	0
11764															0	0
11757	2500	.049	.004	.000	.000	.016	.000	.000	.066	.000	.000	.016	.000	.0004	0	0
11765															0	0
11766															0	0
11752	269	.049	.004	.000	.006	.008	.065*	.000	.520*	.000	.000	.120	.000	.0004	0	0
11760															0	0
11767	250	.049	.004	.000	.000	.008	.000	.000	.041	.000	.000	.024	.000	.0004	0	0
11775															0	0
11768	175	.049	.004	.000	.000	.120	.000	.000	.060	.000	.000	.390	.000	.0004	0	0
11776															0	0
11769	175	.049	.004	.000	.000	.008	.000	.000	.024	.000	.000	.170	.000	.0004	0	0
11777															0	0
11770	526	.049	.004	.000	.000	.110	.016	.000	.024	.000	.000	.069	.000	.0004	0	0
11778															0	0
11771	300	.049	.004	.000	.000	.031	.360*	.000	1.310*	.000	.000	.180	.000	.0004	0	0
11779															0	0
11772	305	.049	.004	.000	.000	.023	.320*	.000	2.310*	.000	.000	2.000	.000	.0004	0	0
11780															0	0
11773	389	.200	.020*	.000	.000	.016	.650*	.000	3.000*	.000	.000	.026	.000	.0004	0	0
11781															0	0
11774	445	.200	.004	.000	.000	.023	.170*	.000	.420*	.000	.000	.100	.000	.0004	0	0
11782															0	0
11783	1020	.049	.004	.000	.000	.190	.020	.000	.036	.000	.000	.110	.000	.0004	0	0
11790															0	0
11784	519	.049	.004	.000	.000	.023	.069*	.000	.054	.000	.000	.099	.000	.0004	0	0

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OR. INTERSTATE LABORATORY ANALYSES

SERIAL NUMBER	SPECIFIC CONDUCTANCE	BARIUM	ARSENIC	CHROMIUM	SILVER	COPPER	MANGANESE	LEAD	IRON	COBALT	CADMIUM	ZINC	NICKEL	MERCURY	COLIFORM TOTAL	COLIFORM FECAL
11791															0	0
11785	1090	.049	.004	.000	.000	.061	.027	.000	.013	.000	.000	.120	.000	.0004	0	0
11792															0	0
11786	1925	.049	.004	.000	.006	.031	.020	.000	.120	.007	.003	.100	.016	.0004	0	0
11793															0	0
11787	3280	.100	.004	.000	.006	.053	.027	.000	.700*	.016	.004	.280	.021	.0004	0	0
11794															0	0
11788	875	.049	.004	.000	.000	.016	.050	.000	.380*	.007	.004	.160	.016	.0004	0	0
11795															0	0
11789	318														0	0
11796															0	0
11797	805	.200	.004	.000	.000	.046	.082*	.000	1.900*	.016	.003	.870	.016	.0004	0	0
11800															0	0
11798	405	.600	.004	.000	.000	.046	.090*	.000	.042	.000	.000	.110	.000	.0004	0	0
11801															0	0
11803															0	0
11799	334	.049	.004	.000	.000	.031	.000	.000	.130	.000	.000	.170	.000	.0004	0	0
11802															0	0
11804	500	.049	.004	.000	.000	.031	.020	.000	.100	.000	.000	.560	.000	.0004	0	0
11808															0	0
11805	688	.100	.004	.000	.000	.160	.200*	.000	.600*	.000	.000	.091	.026	.0004	5$	
11809															0	0
11806	855	.200	.004	.000	.000	.038	.070*	.000	.150	.000	.000	.094	.000	.0004	1	0
11810															0	0
11807	80	.049	.004	.000	.000	.038	.012	.040	.110	.000	.000	8.000*	.000	.0004	0	0
11811															0	0
11812	299	.049	.004	.000	.000	.016	.020	.000	.190	.000	.000	.058	.000	.0004	0	0
11817															0	0
11822															0	0
11813	520	.400	.004	.000	.000	.031	.031	.000	.600*	.000	.000	.210	.000	.0004	0	0
11818															0	0
11814	380	.049	.004	.000	.000	.038	.061*	.000	.030	.000	.000	.120	.000	.0004	0	0
11819															0	0
11823															0	0
11815	214	.049	.004	.000	.000	.076	.000	.000	.036	.000	.000	.860	.000	.0004	0	0
11820															0	0
11824															21$	0
11816	202	.049	.004	.000	.000	.017	.120*	.000	.640*	.000	.000	.075	.000	.0004	0	0
11821															0	0
11825															0	0
11826	44	.049	.004	.000	.000	.170	.008	.000	.076	.000	.000	.160	.000	.0004	0	0
11828															0	0

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OR. INTERSTATE

LABORATORY ANALYSES

SERIAL NUMBER	SPECIFIC CONDUCTANCE	BARIUM	ARSENIC	CHROMIUM	SILVER	COPPER	MANGANESE	LEAD	IRON	COBALT	CADMIUM	ZINC	NICKEL	MERCURY	COLIFORM TOTAL	COLIFORM FECAL
11830															29$	7$
11827	206	.049	.004	.000	.000	.017	.000	.000	.013	.000	.000	1.300	.000	.0004	0	0
11829															0	0
MAXIMUM	3280	.600	.020	.000	.018	.190	.650	.040	3.000	.016	.004	8.000	.026	.0010	33	7
MINIMUM	29	.049	.004	.000	.000	.008	.000	.000	.012	.000	.000	.016	.000	.0004	0	0
AVERAGE	304	.040	.001	.000	.000	.021	.034	.000	.234	.000	.000	.219	.001	.0001	1	0

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LABORATORY ANALYSES

SERIAL NUMBER	SPECIFIC CONDUCTANCE	BARIUM	ARSENIC	CHROMIUM	SILVER	COPPER	MANGANESE	LEAD	IRON	COBALT	CADMIUM	ZINC	NICKEL	MERCURY	COLIFORM TOTAL	COLIFORM FECAL
MAXIMUM	3840	.600	.020	.028	.018	.570	2.200	.120	8.200	.016	.004	8.000	.026	.0010	99999	29
MINIMUM	29	.049	.004	.000	.000	.000	.000	.000	.008	.000	.000	.005	.000	.0004	0	0
AVERAGE	398	.053	.002	.000	.000	.027	.041	.002	.273	.001	.000	.361	.001	.0001	444	0

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