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SMALL SYSTEMS TECHNOLOGY INITIATIVE: EVALUATION OF DEMONSTRATION TECHNOLOGIES

Freestone, California Water System

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FINAL REPORT (REVISED):

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Freestone, California Water System

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U.S. Environmental Protection Agency
Office of Ground Water and Drinking Water
Washington, DC 20460

EPA Contract No. 68-C2-0113
Work Assignment 2-14

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EXECUTIVE SUMMARY

The community of Freestone in northern California is serviced by a typical small water system. The system currently provides water to roughly 30 connections and 70 persons, there is no full time operator, the income of the residents is modest at best. Prior to this technology demonstration, the system was also in violation of one or more drinking water quality regulations. The U.S. Environmental Protection Agency has recognized the technical and financial challenges confronting these small water systems and has sought to address these problems through its Small Water System Technology Initiative.

The Freestone Water System was selected for this technology demonstration project because of its water quality problems, an unfiltered surface source with high effluent turbidity and iron, and because of the technology proposed to address these problems, a pre-engineered dual-stage pressure filtration unit. The system was experiencing daily influent turbidity levels during the demonstration period averaging from 4.25 to 22.97 NTU. High and low values for turbidity were recorded at 0.17 and 86.75 NTU.

For this technology demonstration, the performance requirements were as follows: 1) turbidity had to be reduced to levels in accordance with the state Surface Water Filtration and Disinfection requirement of 0.5 NTU in 95 percent of samples taken; 2) the concentration of iron which is also present in the source water had to be reduced to improve taste and odor problems; and, 3) the treatment system must be able to accommodate an increase in production to supply a maximum of 16,560 gallons per day and 30 connections.

The dual-stage pressure filtration treatment technology is designed to operate automatically with minimal operational requirements. In fact, the system was designed to be monitored off site through a telemetry system by a certified California Water Treatment Operator, Grade 2 thereby reducing the time and costs associated with full time operator support. The treatment process is comprised of four steps: coagulation and flocculation by chemical addition; floc removal by a clarifier; filtration; and disinfection by post-chlorination. Chlorine is also used to oxidize soluble iron for subsequent removal. This process proved effective in reducing effluent turbidity levels during the evaluation period to a daily average of 0.11 NTU.

The total capital cost for the installed treatment unit is estimated to be $62,726. The annual O&M expense is estimated to be $9,961 which includes the cost of a contract O&M firm operating the facility and chemicals. The total annualized cost is estimated to be $15,882 which translates to a cost of $7.56 per thousand gallons delivered water. The estimated cost of the dual-stage filtration unit compares favorably to unit costs estimated by the USEPA for a conventional treatment plant (i.e., coagulation/filtration) for a comparably sized system ($13.13 per thousand gallons).

1. INTRODUCTION AND BACKGROUND

The U.S. Environmental Protection Agency (USEPA) is responsible for the development, implementation, and enforcement of regulations mandated under the Safe Drinking Water Act (SDWA). For many water systems, compliance with these regulations will require the installation of new treatment processes or modifications of existing facilities to remove a variety of drinking water contaminants. The installation of custom engineered treatment facilities can be problematic for smaller systems due to cost and operational complexity. Therefore, small water systems are increasingly in need of treatment technologies that provide a simple, cost-effective solution to water quality problems that fit easily into existing treatment and operational configuration.

There are approximately 60 thousand community water supplies nationally, of which nearly two-thirds (roughly 37 thousand) serve populations of 500 or fewer persons. Further, approximately 90 percent of all community water supplies (51 thousand systems) serve populations of 3,300 persons or fewer. These small water systems, especially those serving fewer than 500 persons, are typically comprised simply of a single source (usually a well), a pump, and perhaps, a chlorinator and storage tank. These systems usually do not have a full-time operator to regularly service and maintain the equipment. In addition, the small customer base inhibits the system's ability to generate sufficient financial capital to acquire necessary treatment technologies. In fact, many of these systems are simply not operated as utilities because they are an ancillary part of another business (such as a mobile home park).

The challenge confronting USEPA is how best to induce small water supplies with limited operational and financial capabilities to comply with these regulations and provide their customers with a safe and reliable supply of water. USEPA has estimated the cost to households served by small water systems that must comply with new Federal drinking water regulations may be several hundred dollars per year (USEPA, 1993a). Many small water systems are seeking more cost-effective treatment technologies that will bring them into compliance while minimizing cost increases to their customers.

The Small Systems Technology Initiative described below was instituted by USEPA and the water treatment equipment industry to identify and evaluate alternative technologies that may prove to be cost-effective and practical alternatives to conventionally engineered and constructed treatment systems typically used and considered affordable by larger water supplies.

1.1 Small Systems Technology Initiative

The 1986 amendments to the SDWA mandate USEPA to develop drinking water standards or treatment techniques for 83 different contaminants. In establishing drinking water standards, USEPA is required to designate a best available technology (BAT) for controlling each contaminant regulated under SDWA. A technology must meet certain criteria to be designated as BAT. Specifically, a treatment technology must be:

- demonstrated at field scale;
- compatible with other treatment technologies;
- cost-effective for contaminant removal; and
- affordable to large drinking water utilities.

Best available technologies for small systems, however, may vary from those of large systems.

To stimulate the development of affordable treatment systems for small water systems, the USEPA established an initiative in 1989 to look for innovative, low-cost solutions for complying with Federal and state drinking water regulations. The Small Systems Technology Initiative was designed to build public/private partnerships to promote the identification, development, marketing, approval, and application of simple and inexpensive drinking water treatment technologies for use by water systems serving less than 3,300 persons. Representatives from the American Water Works Association, Water Quality Association, National Association of Water Companies, National Rural Water Association, Association of State Drinking Water Administrators, and a number of equipment manufacturers participated in the initiative.

The demand for quality water in various residential, commercial, and industrial applications such as food processing and metal plating has created a sector of the water treatment industry dedicated to developing smaller scale, packaged technologies. The USEPA felt that these technologies could potentially serve as low cost, low maintenance alternatives for small public water supplies in complying with SDWA-mandated drinking water standards. One significant advantage of packaged systems is the convenience of having the manufacturer or distributor provide an array of services including the delivery and installation of the treatment equipment, providing operational and technical support, and in some circumstances, serving as a source for financing of the purchased equipment.

The USEPA's Small Systems Technology Initiative sought to promote packaged systems through the evaluation of a series of one-year technology demonstration studies involving central and household treatment units at various sites around the country. Only small water systems serving fewer than 500 persons were considered as possible demonstration sites. Selection was based on obtaining sites with a variety of specific contaminant problems and located in different geographic regions in the country. Requests for proposal from water treatment equipment companies to donate process equipment and operational assistance were solicited to identify available treatment technologies. The demonstration studies were conducted under the supervision of USEPA and state regulatory personnel. The objective of these demonstration studies was to evaluate the efficacy and costs of the packaged treatment equipment in removing various drinking water contaminants at typical small systems. Further, the demonstration studies were needed to increase state familiarity with, and willingness to approve these alternative treatment processes.

The village of Freestone, California in Sonoma County was selected as one of these technology demonstration sites. The Freestone Water System was selected in part due to the nature of its water quality, high turbidity and elevated iron and manganese levels, and the technology proposed to remediate this problem, a prefabricated dual-stage pressure filtration system.

In response to the USEPA request for a technology demonstration at the Freestone Water System, Culligan International Company agreed to participate in the installation of a water treatment system. To address the turbidity and microbiological needs of the Freestone Water System, Culligan proposed the installation of its Multi-Tech™ system[1], a dual-stage filtration (DSF) system, which is a pre-engineered, low-cost, packaged water treatment plant. The treatment process installed at Freestone included a telemetry system to provide performance data to the operator situated off-site. The combination of the fully automatic dual-stage filtration system and the telemetry system allowed for limited on-site operator supervision.

1.2 Organization of the Report

This report provides a review of the Freestone technology demonstration project. Section 2, which follows this introduction, provides an overview of the water quality problems confronting the Freestone Water System and the treatment objectives on which this technology was evaluated. Section 3 summarizes the performance data that were collected during the technology demonstration period. Section 4 provides estimates of the cost of the DSF system installed at Freestone. The cost to the consumers as well as a comparative cost analysis of other small system treatment technologies is provided. Finally, Section 5 discusses the institutional arrangements that facilitated the installation of this technology and the roles that key agencies and individuals provided in executing this demonstration.

[1] Multi-Tech™ Filtration System Model MT 24/30. Culligan International Company. Northbrook, IL 60062.

2. DESCRIPTION OF THE FREESTONE, CA WATER SYSTEM

This section of the report provides an overview of the Freestone Water System, water quality conditions before the installation of the DSF system, and a description of the existing treatment facilities and treatment objectives for the technology demonstration.

2.1 System Description

Freestone is a historic village located in rural Sonoma County approximately 50 miles northwest of San Francisco and 15 miles southwest of the city of Santa Rosa. The village itself was created as a railroad water stop and shipping point for lumber used to build the city of San Francisco in the 1860s. The water system was developed by the railroad to supply the steam engines with water and consisted initially of a spring and a storage tank. Other components of the system were added over time, including the distribution system that services the village which was installed sometime around the 1920s. However, there has been no significant rehabilitation of the facilities since its initial development. For the most part, the village has retained its rustic charm, but it now confronts the modern challenges posed by environmental and public health regulations such as those mandated by SDWA. As a result, this small community, as numerous others around the country, must adapt to the changing regulatory climate and find cost-effective and innovative solutions to their water quality problems.

Ownership and responsibility for the Freestone Water System has changed hands since its development. As indicated above, the system was initially capitalized by the railroad company that developed the supply. Control of this system was then assumed by the residents and customers of Freestone who operated the system as an association. However, the declining water quality became problematic for the association which subsequently turned control of the system over to the county in 1989. Sonoma County now has primary responsibility for the operation and maintenance of the water system in Freestone.

The county manages the system as a county service area (CSA #33) and hired a contract operations and maintenance (O&M) firm, Russian River Utility (RRU), to perform routine operation of the system. Improvements and upkeep of the physical structures and distribution system and customer billing activities, however, are performed by county personnel. Prior to the demonstration period, RRU was responsible for activities such as the periodic inspection of the spring collection area and the well, pumps, and storage tanks. In addition, RRU also performed routine servicing to the chlorination facilities and was responsible for the collection of required monitoring samples.

The Freestone Water System presently serves 28 connections and a population of approximately 70, mostly modest income, people. Due to the size of the customer base, the system is classified as a public (i.e., municipal) community water system. During the demonstration period, from April 1, 1992 through March 31, 1993, there were 16 connections, 12 of which served residential customers. The remaining four connections served commercial customers of which three were higher volume users including a restaurant, a nursery, and a spa. The total production requirements of this system averaged approximately 6,000 gallons per day. Freestone customers have also used bottled water for drinking and cooking because of taste (iron) and odor problems.

The primary water supply for this system is a surface spring. The watershed for the spring is essentially wilderness, although a local goat population frequents the spring area. The spring water percolates up through the ground where it collects in a natural trough, and flows down a hillside to a small fabricated dam. The water from the dam is funneled through a halved bleach bottle into a two-inch plastic pipe. The water is then delivered to a series of covered horse troughs where debris is allowed to settle.

Prior to the demonstration project, the water, after leaving the troughs, travelled through a two-inch pipe to a 50,000 gallon concrete storage tank where settling of solids and chlorination took place. The raw water is now diverted to a separate storage tank. This storage tank was covered by a wooden structure, worn and badly in need of repair.

A well, located on private, commercial property (i.e., the nursery) is used as a secondary water source. This groundwater supply is accessed when customer demand exceeds the production of the spring during low flow periods, and when the spring becomes infiltrated with mud and debris during the rainy season. As a result, the well is used more frequently in the winter months when rainfall increases and contributes to water quality problems. The well pumped water upgrade directly into the concrete tank.

The well is typically run for one week each month. The operator starts the well pump during the weekly visit and shuts it down the following week. The well also shuts down automatically when the storage tank is full. Because of the location of the well, adjacent to a pond, it is considered to be a ground water source under the influence of surface water as far as the state regulatory requirements are concerned. Therefore, the ground water source is subject to all requirements of the California Surface Water Filtration and Disinfection Rule (CSWFDR).[2]

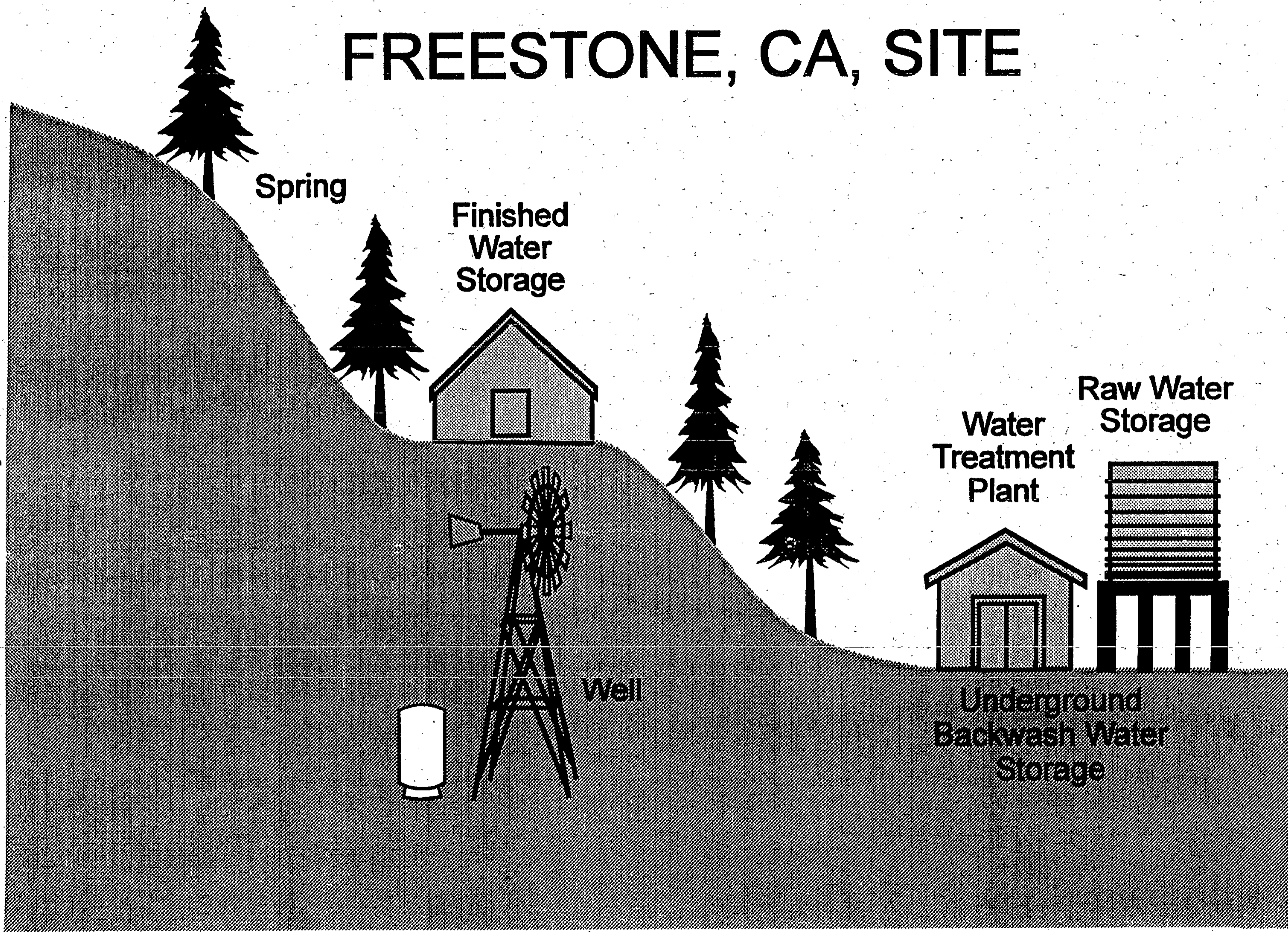
The two water sources combined can produce up to 12 gallons per minute (gpm). The spring produces two to five gpm and the well produces from six to eight gpm.

Exhibit 2-1 is a sketch of the present Freestone Water System, and as it appeared during the demonstration project. The water system consisted of the spring and well sources, the concrete storage tank that is now used as the finished water storage reservoir, and the distribution system. A 10 thousand gallon above-ground redwood tank now serves as a raw water storage reservoir, and is also used to fill the local fire truck since there are no fire hydrants in Freestone. Prior to the demonstration project, there was no treatment plant or underground backwash water storage. The only treatment was a chlorinator that was located adjacent to the 50 thousand gallon concrete storage tank, but has since been removed. Chlorination is incorporated in the new treatment process as a pretreatment for soluble iron and as the final disinfection step post-treatment.

[2] Request for Proposal - CSA #33 (Freestone) Water System, Santa Rosa, CA; U.S. Environmental Protection Agency Low-Cost Small Systems Technology Development Committee (October, 1990).

Exhibit 2-1

FREESTONE, CA, SITE



The county had planned to repair the storage facilities prior to the demonstration project; however, due to funding constraints, these repairs were not undertaken. Since the demonstration project, the county has made repairs and improvements to the facilities.

The water from the concrete storage tank is supplied to Freestone customers through a gravity-fed distribution system, the composition of which is believed to be mainly galvanized steel pipe. The distribution system is relatively old and generally in need of repair and replacement. Flow through much of the system is constricted by accumulated sediment in the pipes. There is also some production loss as a result of leaks in the distribution system, the actual amount of loss could not be accurately gauged until recently since the customers were not metered. Meters have now been installed at each service connection since the end of the demonstration period.

2.2 Influent Water Quality and Treatment Objectives

The factors described above, including the unfiltered surface source, the age of the system, the declining state of the storage and distribution facilities, as well as naturally occurring contaminants, have contributed to the overall quality of water delivered to the Freestone customers. The water system did not comply with the CSWFDR standard for turbidity of 0.5 nephelometric turbidity units (NTU). Because of the high turbidity reported in the system and the unprotected watershed, the potential existed for microbiological contamination, including *Giardia lamblia.*

Extensive influent turbidly data were not available for the Freestone system prior to the demonstration period. However, during the performance evaluation period, influent turbidity levels were monitored on almost a continuous basis, with readings being taken every 15 minutes. These turbidity readings (summarized in Chapter 3) show that during the evaluation period the influent water turbidity levels ranged from a low of 0.17 to a high of 86.8 NTU. The monthly averages (i.e., the mean of the daily averages for each month) for influent turbidity levels ranged from a low of 4.25 NTU to a high of 23.0 NTU with an overall average of 9.29 NTU.

These influent turbidity levels posed a challenge to the unfiltered Freestone Water System. The data available for effluent turbidity levels for the Freestone system, prior to the demonstration period, indicated that the finished water turbidity ranged from 6 to 40 NTU, well above the CSWFDR standard for turbidity of 0.5 NTU. The poor condition of the concrete storage tank housing allowed small animals and birds access to the finished water supply. As a result, the water system did not meet state standards for coliform bacteria regardless of the constant chlorine treatment. In fact, the townspeople were frequently under boil water orders. Further compounding these water quality conditions were the elevated levels of iron in local groundwaters that contributed to taste and odor problems when the well source was used.

Given these water quality conditions, the solution the county chose was to add a filtration system at Freestone that would address both the high turbidity and iron levels in the source water. The county would also upgrade both the storage and distribution systems to prevent contamination of the treated water.

3. PERFORMANCE OF DUAL-STAGE FILTRATION SYSTEM

This section of the report provides an overview of the DSF system, including the water quality requirements and ability of this technology to meet the treatment objectives. In addition, the operation and maintenance requirements of this treatment technology are discussed.

3.1 Performance Requirements

A treatment system at Freestone was required to satisfy the community's turbidity and microbiological requirements. The Freestone Water System did not comply with the CSWFDR and Federal SWTR requirements (40 CFR 141.73) since it was an unfiltered surface water source and the finished water did not meet the standard for turbidity. Prior to this project, the finished water turbidity ranged from 6 to 40 NTU. The system did not meet the standards for coliform bacteria regardless of constant chlorine treatment. As a result, the townspeople were constantly under boil water orders. Given the turbidity levels at Freestone, *Giardia lamblia* and other microbiological contamination were a legitimate concern.

For the Freestone technology demonstration, Sonoma County had several requirements, specifically:

- the treatment system not only provide production capacity to meet the demands of the 16 connections for 6 gpm maximum and 8,640 gpd, but the system had to be expandable to accommodate the projected need of 30 connections and 11.5 gpm maximum and 16,560 gpd;
- constant monitoring of finished water turbidity and chlorine residual; and
- the system had to operate with 100 percent conservation of water in accordance with state regulation.

3.2 Process Description

The DSF system, a prefabricated pressure filtration process, was designed as a treatment for turbidity. The DSF system is a pre-engineered, packaged plant that performs the process steps used in a conventional water treatment plant, including: coagulation, flocculation, clarification, filtration, and disinfection. The DSF system is designed for small communities that do not have full-time operators. DSF units have been installed for filtration in municipal, commercial, and industrial water treatment.

In the DSF system, filtration with proper coagulants has been demonstrated to remove *Giardia* effectively. Colorado State University conducted an independent study of the efficiency of the DSF system for the removal of *Giardia* cysts. In a series of tests (Horn et al., 1988), the DSF system was found to be effective in removing up to 99 percent of *Giardia* cysts under several conditions including low turbidity (i.e., 0.3 to 0.6 NTU), low temperature (0.2°C) samples. Further, these tests found the DSF filtration system to be effective in removing 90 percent of turbidity and 98 percent of coliform bacteria.

The DSF system was installed at Freestone and went on-line on April 1, 1992. The system was designed to meet the water quality needs with 100 percent conservation of water, as well as the current and future water consumption needs of the Freestone community. The DSF system was capable of achieving a maximum flow of 35 gpm or 50,340 gpd.

The DSF system configured for the Freestone Water System started with the diversion of incoming raw water into the raw water storage tank located next to the treatment plant (Exhibit 2-1). The primary source of water was a surface water spring that was gravity fed into the raw water storage tank. The secondary source was well water presumed to be under the influence of surface water since it was a shallow well located near a pond. The well water was pumped into the storage tank and was chlorinated to oxidize the soluble iron and manganese for removal in the DSF system. In addition to the surface and well water, clarified backwash water and rinse water, resulting from compliance with the 100 percent conservation of water requirement, may have been in the raw water storage tank.

From the raw water storage tank, water was gravity fed to a pressure pump on the inlet side of the DSF treatment system. The DSF system used a four-step approach to reduce turbidity. The four steps were as follows:

- coagulation and flocculation of smaller particles by chemical addition;
- floc removal in the clarifier;
- final filtration in the depth filter; and
- disinfection by post-chlorination.

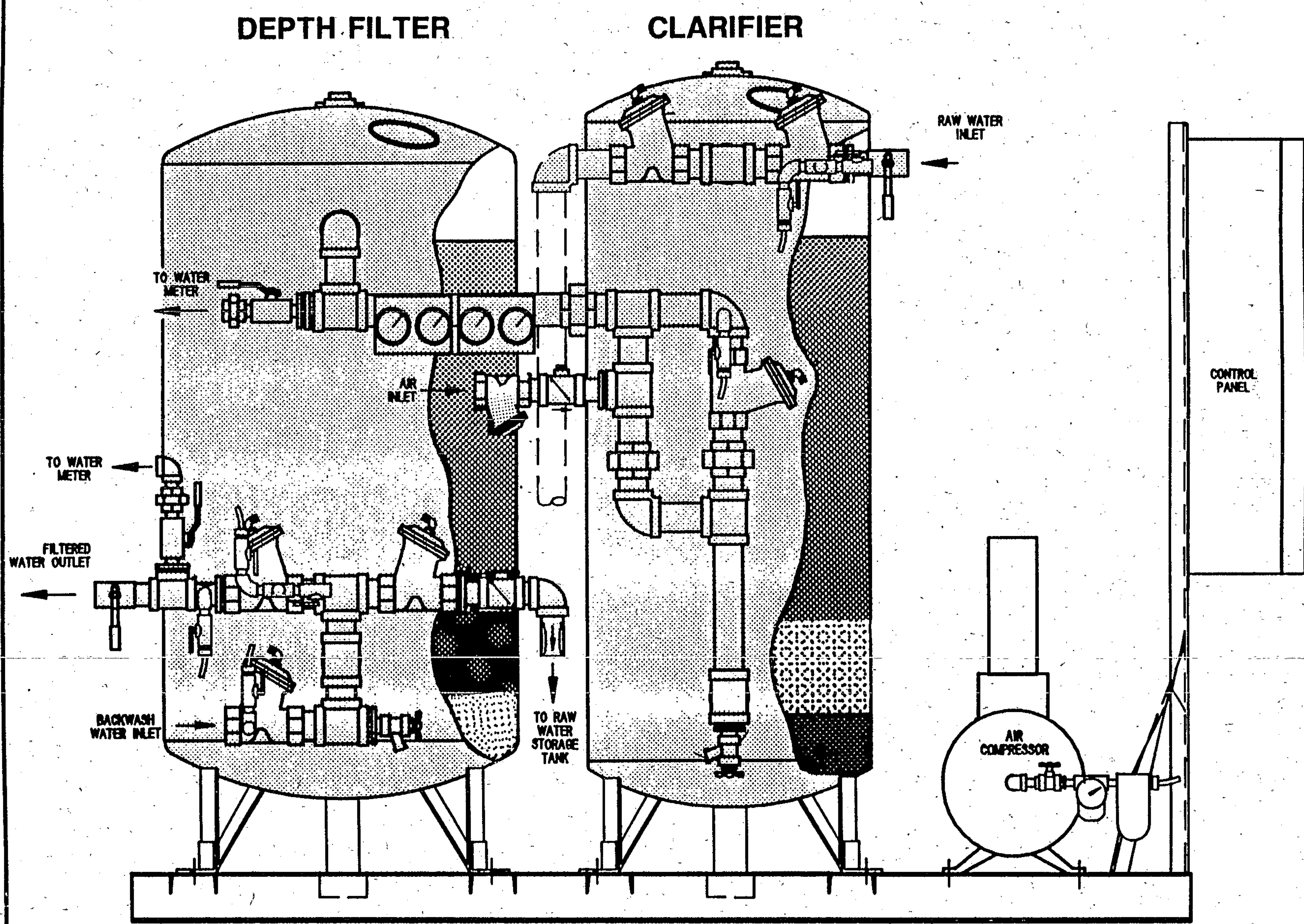
The coagulation and flocculation process involved the injection of chemical aids into the flow stream by chemical feeders. The chemical used in this process was an alum-cationic polymer blend. The chemical feeders were controlled by an in-line flow switch that cycled them on and off based on the water flow. The flow continued through an in-line mixer that mixed the chemicals with the water before entering the clarifier. The flow then passed through the clarifier which is designed to remove suspended solids and reduce turbidity. Clarification occurred as the flocculated particles collided with the media. Exhibit 3-1 presents a cross-sectional view of the DSF system, including a cut away view of the clarifier.

After treatment by the contact flocculator-clarifier, the water passed through a mixed media filter. The water from the clarifier entered the depth filter, as shown in Exhibit 3-1, in which suspended solids were reduced. After this treatment, the water was disinfected with chlorine and forwarded to a concrete water storage tank. An in-line flow switch controlled the cycling of the post-chlorination feeder.

The DSF system backwashes either when the pressure drop across the filters reaches 10 psi or when the finished water turbidity reaches 0.5 NTU. Backwashing was accomplished by flowing finished water back through the DSF system with the water first flowing through the mixed media filter and then through the contact flocculator-clarifier. The contact flocculator-clarifier used an air-assisted backwash to vigorously scour the media. To conserve water, the system was equipped with underground storage tanks in which all backwash and rinse waters were collected and recycled back through the system.

Exhibit 3-1

CULLIGAN® MULTI-TECH™ FILTRATION SYSTEM



Solids from the backwash and rinse waters were allowed to settle in the underground storage tanks. The clarified liquid was fed back through to the raw water storage tank and the settled solids are removed from the underground tanks on a periodic basis for disposal in approved landfills.

Several operational and water quality parameters were monitored during the water treatment process, including: raw and finished water turbidity, chlorine residual, pressure drop, storage tank levels, chemical feed tank levels, flow rate, and total gallons produced. The Freestone Water System was equipped with a telemetry system[3] that enabled these operational and water quality parameters to be transmitted via modem to a facsimile ("fax") machine or to a computer. Transmission of data was scheduled at 12 hour intervals or on alarm. The telemetry system transmitted alarms when operational limits or water quality parameters were exceeded to provide for immediate response by the plant operator. The telemetry process allowed for monitoring of the treatment process without a person on site and reduced the frequency of site visits to verify plant operation.

Influent and finished water turbidities were monitored continuously using on-line turbidity monitors[4]. Data were recorded continuously on chart recorders. In addition, 15 minute interval turbidity data were captured and stored for later transmission via the telemetry systems. The data were transmitted to the local independent Culligan dealer and present operators of the system. The turbidity meters were calibrated in accordance with manufacturer's instructions on a monthly basis and were also validated by comparing samples to laboratory standards on a weekly basis.

Residual chlorine was also monitored continuously via a chlorine analyzer[5]. Fifteen minute interval data were captured and stored for later transmission via the telemetry device. An alarm was sent to the operator if the chlorine residual fell below 0.5 ppm or rose above 3.0 ppm total chlorine at the discharge of the treatment system. The chlorine analyzer was calibrated in accordance with the manufacturer's instructions on a quarterly basis.

As detailed in Exhibit 3-2, the DSF system operated over three thousand hours (181,930 minutes) between April 1, 1992 and March 31, 1993, which was an average of about 250 hours per month. The service flow rate during this time averaged 12 gpm. During the first year of operation, over 2.1 million gallons were produced by the DSF system which averages to about 179 thousand gallons per month. The amount of water used to backwash the system, due to the pressure drop across the filters reaching 10 psi or the finished water turbidity measuring 0.5 NTU, totaled over 235 thousand gallons for the 12 month period.

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[3]Aqua-Status® Telemetry System manufactured for Culligan International Company by Autotrol, Inc.

[4]Hach Model 1720C manufactured by Hach Company

[5]Hach Model CL17 manufactured by Hach Company

Exhibit 3-2

Freestone, CA Water System
Operational and Maintenance Summary

Month	Service Minutes	Service Flow Rate (GPM)	Alum/Polymer		Chlorine (GAL)	Backwash (GAL)	Total Gallons Produced
			Feed (ppm)	Gallons			
April, 1992	9,585	12	No Data	4.5	4.0	1,970	115,074
May	12,225	11	No Data	2.0	4.0	1,930	136,972
June	17,530	11	29.1	2.0	3.0	11,030	197,220
July	12,360	12	30.1	1.0	2.0	860	146,802
August	12,585	12	32.6	3.5	3.0	3,070	151,153
September	11,700	11	33.3	2.5	3.0	2,310	134,659
October	13,065	12	32.9	2.5	4.0	5,270	155,636
November	11,520	12	35.1	3.0	3.0	3,750	133,934
December	12,945	12	41.5	6.0	2.5	28,500	154,847
January, 1993	15,600	12	30.3	5.0	5.5	44,769	190,297
February	25,155	12	30.9	4.5	8.0	86,424	309,417
March	27,660	12	32.5	13.0	11.5	45,421	320,086
Overall Avg.	15,161	12	32.9	4.1	4.5	19,609	178,841
Total	181,930	--	--	49.5	53.5	235,304	2,146,097

Chemical usage was also monitored during the demonstration period. As shown in Exhibit 3-2, alum/polymer feed for the coagulation and flocculation process averaged 32.9 ppm and during the 12 month period 49.5 gallons was consumed. Chlorine usage totaled 53.5 gallons for the first year for both iron reduction and disinfection.

3.3 Finished Water Quality

After start-up, the DSF system was operated and maintained for a full year. The water quality was monitored continuously during this performance period. Influent turbidity, effluent turbidity, and chlorine residual were monitored every fifteen minutes of operation with the results recorded on strip charts. More extensive monitoring was also performed for a variety of water quality parameters on a monthly basis.

Turbidity

Influent and effluent turbidity data for the first year of operation are summarized in Exhibit 3-3. The influent turbidity data demonstrate the variation and magnitude of the raw water turbidity levels. Monthly averages were calculated as the means of the daily averages. Monthly averages of influent turbidity ranged from 4.25 to 23.0 NTU with an overall average of 9.29 NTU. The low and high values are included to provide the range of influent turbidity levels observed for each month. The monthly averages and high and low values are displayed graphically in Exhibit 3-4. Average influent turbidity fluctuated slightly between the months of April and December 1992. The influent turbidity monthly averages and high values for January to March 1993, however, were substantially higher since this period of the year corresponds to the rainy season in which run-off carried debris and silt into the raw water collection area. The well water may also have been affected during the rainy season since it is under the influence of the surface pond.

Monthly averages of effluent turbidity, presented in Exhibit 3-3, ranged from 0.01 to 0.21 NTU with an overall average of 0.11 NTU. Median values ranged from 0.04 to 0.13 NTU. Low and high values illustrate the range of effluent turbidity and are displayed graphically with the monthly averages in Exhibit 3-5. The monthly averages and medians were consistent throughout the first year of operation with a slight rise during the last four months of the demonstration period resulting from the higher than average influent turbidity levels. A graphical comparison of average influent and effluent turbidity levels is presented in Exhibit 3-6.

A higher than expected effluent turbidity level of 3.44 NTU was measured during the month of February, as seen in Exhibit 3-5. The monthly summary report indicated that an operational problem resulted in this higher than expected value. Apparently, a malfunction of the float valve in the finished water storage reservoir resulted in a lower than normal finished water level. The low water level in the finished water tank prevented the system from performing backwashes until sufficient finished water was produced. Since backwashing could not take place, the system was operated in manual mode, overriding safety features and producing finished water with turbidity levels above 0.5 NTU. The effluent turbidity, however, did not exceed the maximum turbidity standard of 5 NTU. The float valve problem was corrected during this episode.

Exhibit 3-3

Freestone, CA Water System
Water Quality Summary

Month	Influent Turbidity (NTU)			Effluent Turbidity (NTU)				Chlorine Residual (ppm)
	Average[1]	Low Value	High Value	Average[1]	Medians[2]	Low Value	High Value	
April, 1992	7.10	2.77	25.1	0.08	0.05	0.02	0.46	1.44
May	8.31	2.46	20.0	0.05	0.05	0.03	0.57	1.25
June	6.25	1.79	26.1	0.10	0.05	0.02	0.78	1.27
July	4.25	1.76	21.3	0.10	0.06	0.01	0.79	1.07
August	4.98	1.77	13.5	0.13	0.03	0.01	0.81	0.71
September	5.94	2.04	14.1	0.05	0.04	0.02	0.62	0.80
October	5.98	1.90	27.3	0.10	0.05	0.01	0.95	0.72
November	6.72	1.37	23.0	0.11	0.09	0.02	0.90	0.52
December	11.1	2.88	20.2	0.14	0.13	0.01	0.57	0.91
January, 1993	16.0	1.27	46.4	0.14	0.11	0.02	0.90	3.36
February	23.0	0.67	86.8	0.21	0.11	0.01	3.44	4.23
March	12.0	0.17	54.7	0.13	0.12	0.01	0.83	2.38
Overall Average[3]	9.29	1.74	31.5	0.11	--	0.02	0.97	1.56

1. Values are means of daily averages.
2. Values are medians of all data in each month.
3. Values are means of monthly averages.

Exhibit 3-4

Influent Water Turbidity

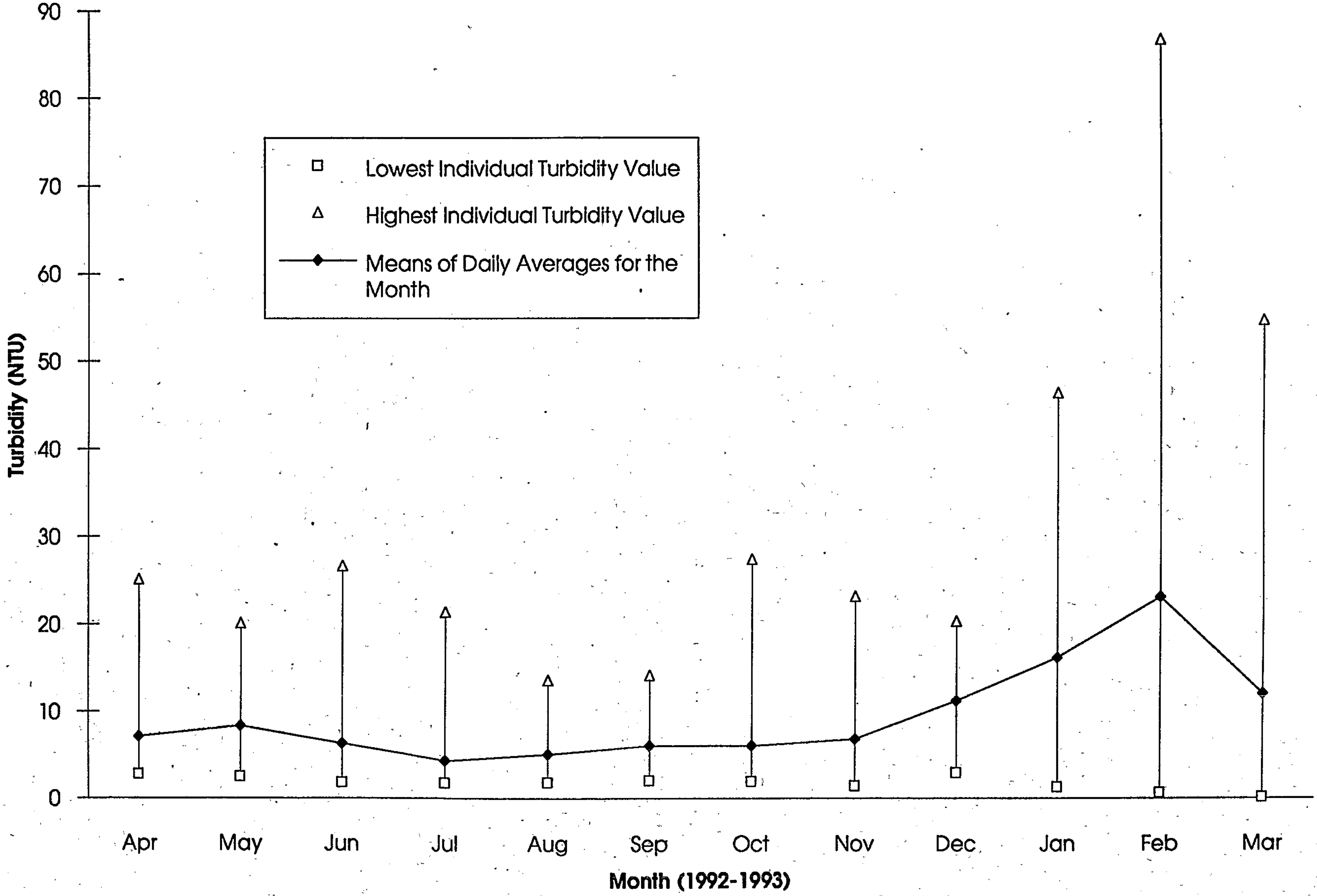


Exhibit 3-5

Effluent Water Turbidity

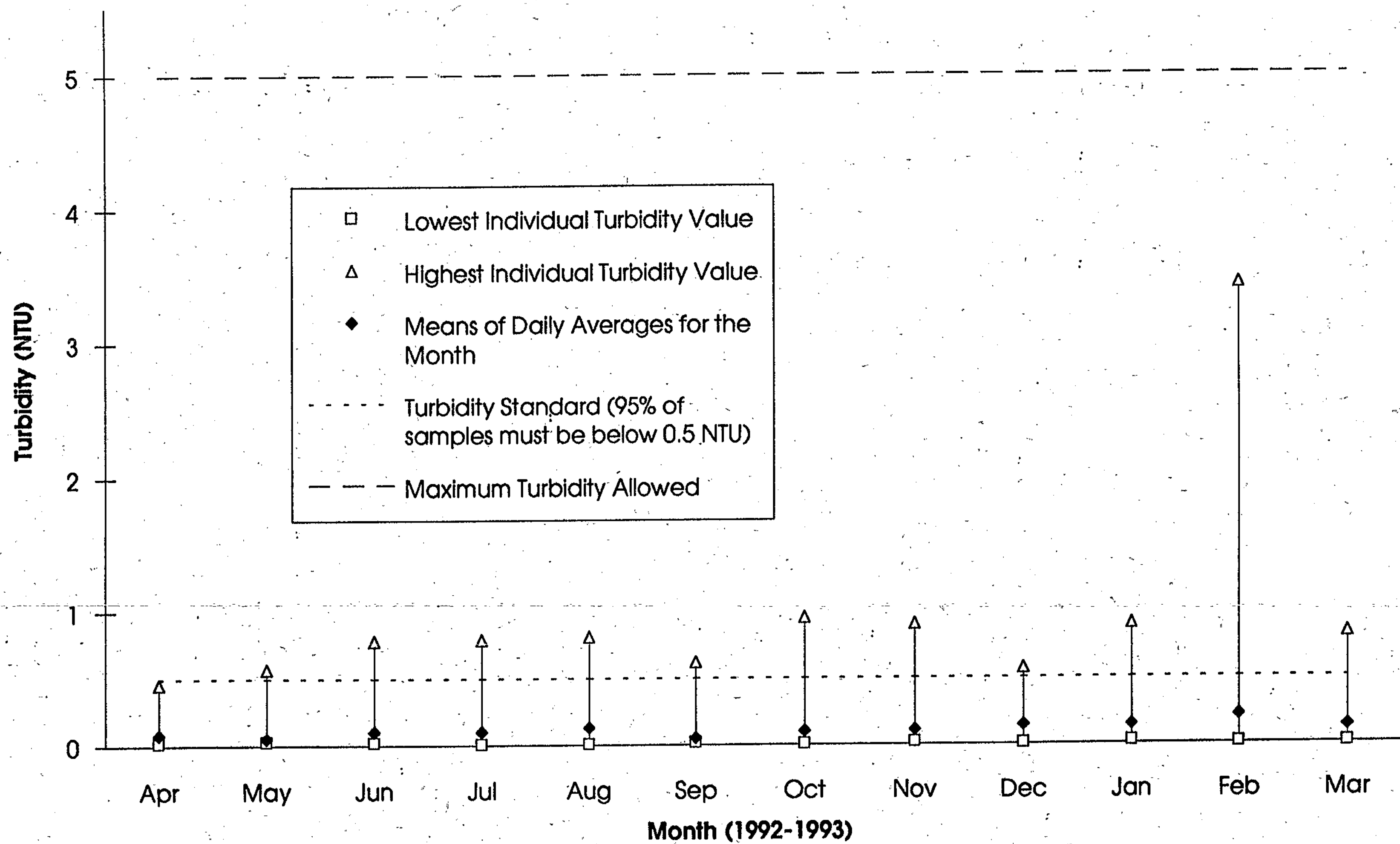
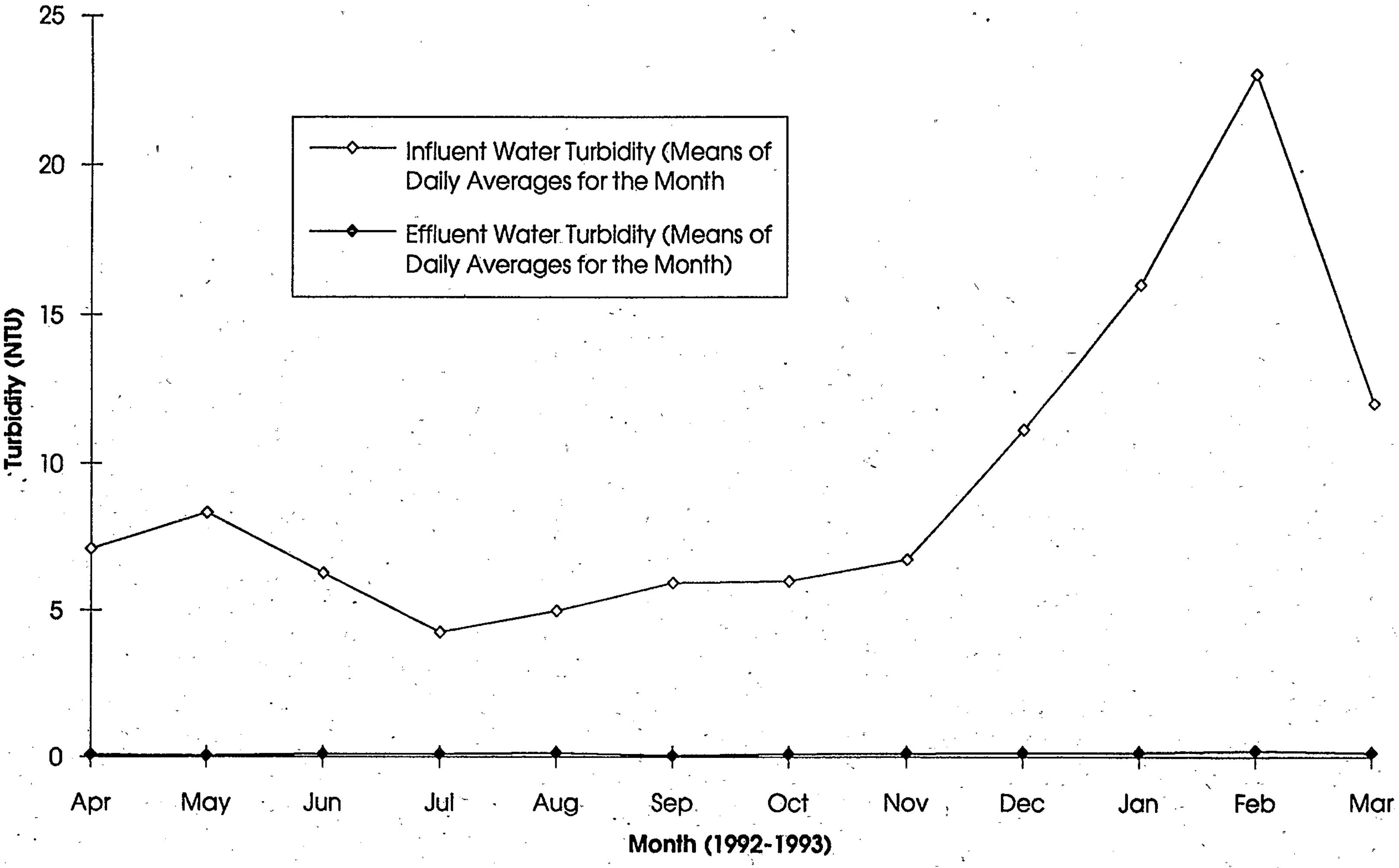


Exhibit 3-6

Influent and Effluent Water Turbidity



The data presented so far has been summaries of monthly averages. These monthly averages, however, do not adequately address the concern for compliance with turbidity standards which are based on percent of total samples. The Federal turbidity standard requires that "the turbidity level of representative samples of a system's filtered water must be less than or equal to 0.5 NTU in at least 95 percent of the measurements taken each month" and "at no time exceed 5 NTU." (40 CFR 141.73) As shown in Exhibit 3-3, during the demonstration period, no single value exceeded 5 NTU.

Exhibit 3-7 presents the turbidity data as percent of samples in each month exceeding the 0.5 NTU standard. During the demonstration period there were four months where the system did not comply with the turbidity regulation. Those months where less than 95 percent of the recorded turbidity levels were greater than 0.5 NTU are August, October, January, and February. In these four months, non-compliance with the turbidity standard was the result of five episodes of operational and mechanical difficulty, four of which were associated with the faulty float valve. As described above, in the month of February the system experienced mechanical problems involving a float value on the finished water tank which resulted in several consecutive turbidity measurements above 0.5 NTU. Similarly, the other months were characterized by other mechanical and operational complications, including scheduled construction involving process and facility improvements which necessitated manual operation of the system until sufficient backwash water was produced.

The detailed turbidity data were analyzed for these four months to describe the range and frequency of observed turbidity levels. The results of this analysis are summarized graphically as cumulative frequency distributions (i.e., ogives) and are included as Appendix A to this report. The analysis shows that the majority of observed effluent turbidity levels fall well below the 0.5 NTU threshold. The mean NTU for these four months ranged from 0.11 to 0.22 NTU. Median effluent NTU ranged from 0.01 to 0.03

Despite these exceedances of the turbidity standard, the DSF system was able to consistently reduce influent turbidity levels to well within the prescribed 0.5 NTU level. To further illustrate the performance of the DSF system, the effluent turbidity for the month of December is plotted versus time in Exhibit 3-8. The month of December was chosen since it had one the of highest monthly averages of influent and effluent turbidity without any mechanical problems or scheduled construction. In the graph, lines are drawn between data points that are taken in secession during the operation of the DSF system. Gaps without points or lines indicate periods when the system was not in operation. The graph shows the cycles of the DSF system which is not provided by averages, medians, or ranges. The graph demonstrates the rise of effluent turbidity levels during operation and as the turbidity reaches 0.5 NTU the unit shuts down to perform the backwashing. After this process, the unit starts back on-line with turbidity levels in the range of 0.01 NTU.

During the period of December 26 to 27, the unit performed multiple backwashing steps as the effluent turbidity continued to climb towards 0.5 NTU. On December 4 and 7, the effluent turbidity levels exceeded 0.5 NTU, reaching 0.56 and 0.54 NTU, respectively. Discussions with the manufacturer's engineers involved in the design of the DSF system noted that these levels are within the tolerance of the instrumentation used to monitor the turbidity levels and that the system may be in the process of backwashing as these data were being recorded.

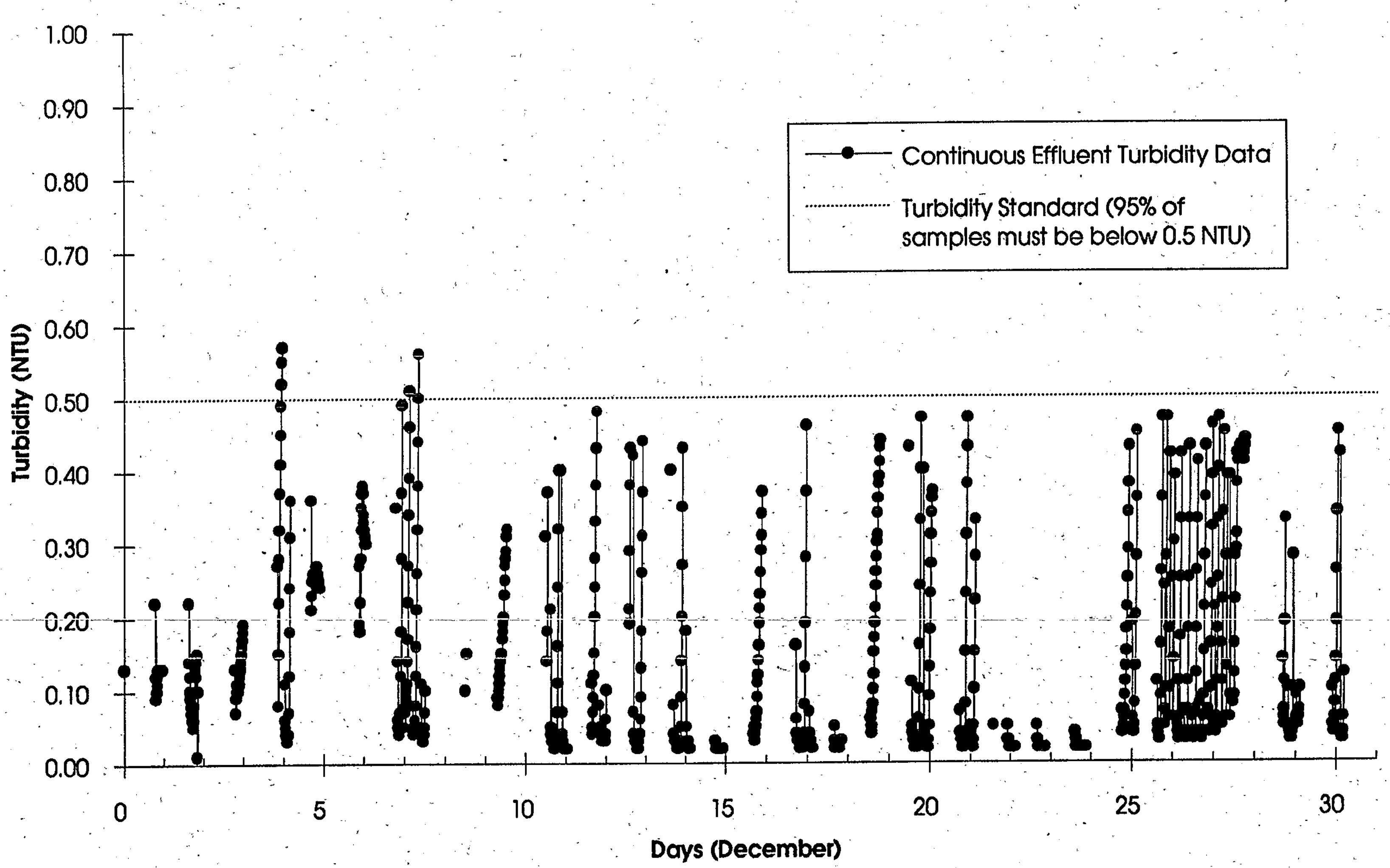
Exhibit 3-7

Summary of Turbidity Measurements

Month	Number Samples	No. Samples >0.5 NTU	% Samples <0.5 NTU	% Samples >0.5 NTU
April 1992	639	0	100.0%	0.0%
May	556	1	99.8%	0.2%
June	1,109	34	96.9%	3.1%
July	759	25	96.7%	3.3%
August	738	58	92.1%	7.9%
September	678	1	99.9%	0.1%
October	857	78	90.9%	9.1%
November	595	2	99.7%	0.3%
December	859	5	99.4%	0.6%
January 1993	1,039	84	91.9%	8.1%
February	1,626	144	91.1%	8.9%
March	1,773	18	99.0%	1.0%
Totals	11,228	450	96.0%	4.0%

Exhibit 3-8

Effluent Turbidity for the Month of December



The influent and effluent turbidity levels during the demonstration period, for those months where there were no mechanical or operational difficulties, demonstrated the ability of the DSF system to reduce turbidity levels below 0.5 NTU during periods of low and high influent turbidity levels. With adequate water quality control mechanisms in place (i.e., alarms), the system proved to be effective in controlling effluent turbidity levels without the presence of a full-time operator.

Chlorine Residual

The Freestone Water System used chlorine as a disinfectant. A chlorine residual was maintained for residence time in the distribution system. During the demonstration period, the chlorine residual leaving the treatment plant and entering the distribution system were recorded at 15 minute intervals. As shown in Exhibit 3-3, monthly averages ranged from 0.71 to 4.23 ppm with an overall average of 1.56 ppm. Exhibit 3-9 presents graphically the monthly averages for chlorine residual. The increased levels of chlorine residual during the months of January to March, at the request of county and state officials, reflect the concern of microbiological contamination during the period of high turbidity, high surface water usage, and the general condition of the finished water tank and the distribution system.

Chlorine residual was also monitored in the distribution system by Russian River Utility during the demonstration period. Grab samples were tested on-site for chlorine residual using test kits. Chlorine residual was measured 94 times in the distribution system during the demonstration period with levels ranging from less than detection to 3.0 ppm. Of the 94 samples, 83 had chlorine residuals above 0.1 ppm. The chlorine residual levels leaving the treatment plant and maintained in the distribution system have diminished the threat of microbiological contamination in the Freestone distribution system.

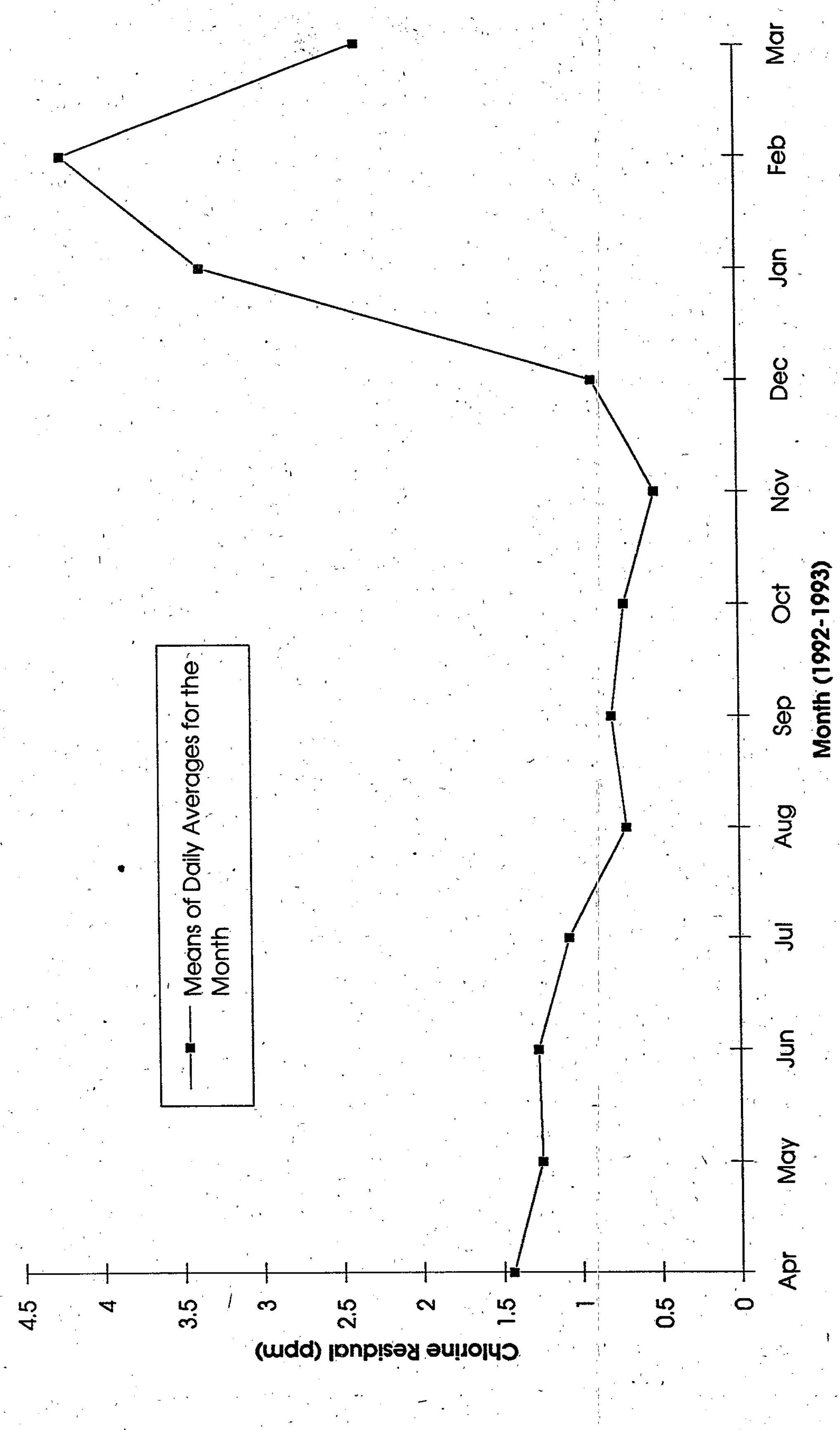
The condition of the distribution system, including the finished water storage tank, was the primary reason for maintaining elevated levels of chlorine residual during the demonstration period. Specifically, the poor condition of the finished water storage tank provided opportunities for surface water run-off into the tank during a rainfall. Further, small animals were able to gain entry into the tank housing. Since the demonstration period, improvements have been made to the Freestone Water System which include the relining of the concrete storage tank and replacement of the storage tank housing. As a result, the threat of microbiological contamination was reduced and the chlorine residual is now able to be maintained at lower, more consistent levels in the distribution system.

Microbiologicals

Russian River Utility had primary responsibility for the distribution system serving the townspeople of Freestone during the demonstration period and was responsible for monitoring the microbiological contaminants. Total coliforms and *Escherichia coli* are indicator organisms of fecal pollution. Total coliforms and *E. coli* levels were monitored in the distribution system throughout the first year of operation. Grab samples were taken on-site and sent to a state laboratory for analysis.

Exhibit 3-9

Chlorine Residual Entering Distribution System: Monthly Averages



Total coliforms were found to be absent in 25 analyses and present in 5 analyses. *E. coli* was absent in all 14 analyses conducted. These levels of microbiological contamination were a large improvement over the levels prior to the installation of the DSF system. The reduction of turbidity levels, the presence of a chlorine residual, and the absence of fecal coliforms resulted in the reduction of the threat of microbiological contamination. As a result, the boil water orders that the townspeople of Freestone were almost constantly under, were lifted shortly after the DSF system went into operation. The improvements made to the Freestone Water System since the demonstration period, including the replacement of the finished water storage tank housing, should help to further reduce the threat of microbiological contamination.

Other Effluent Water Quality Parameters

As part of the technology demonstration, monitoring of additional water quality parameters was performed. These analyses were conducted 11 times during the demonstration period by the manufacturer's laboratory which is certified by the State of Illinois Environmental Protection Agency (Certification Number 100213 for inorganic analyses). All analyses followed the methods outlined in the USEPA's document: *Method for Chemical Analysis of Water and Wastes* (EPA 600/4-79-020). Additional parameters analyzed and summarized in Exhibit 3-10, included: iron, manganese, pH, calcium, magnesium, sulfate, conductivity, sodium, chloride, nitrate/nitrite, and bicarbonate.

Iron was the only other water quality parameter measured that was substantially affected during the demonstration period. Influent iron levels ranged from 0.37 to 1.27 ppm with an average of 0.65 ppm. Effluent iron levels were all below the detection limit of 0.05 ppm. The DSF system did not have a substantial effect on any of the other water quality parameters analyzed.

Waste Handling

Two underground storage tanks collected the backwash waters where solids were allowed to settle. After settling, the clarified water was returned to the raw water storage tank. These tanks were examined after the one year demonstration period and not enough solids were present to justify removal. When removal is warranted, the solids will be disposed of in an approved landfill.

3.4 Operation and Maintenance Requirements

The Freestone Water System was operated and maintained during the demonstration period by Russian River Utility under a contract with Sonoma County. Russian River was responsible for the operation and maintenance of the water system outside of the treatment facility, including the collection of required microbiological samples. The manufacturer's responsibilities were limited to the operation and maintenance of the DSF process and the collection and review of the telemetry readings from the turbidimeters and chlorine analyzer. The actual operation and maintenance of the DSF system during the demonstration period was performed by Mr. James Fisher, an independent dealer for the manufacturer in Santa Rosa. Mr. Fisher is a certified State of California Water Treatment Plant Operator Grade 2 and is factory-trained in the operation and

Exhibit 3-10

Freestone, CA Water System Additional Water Quality Summary

Date	Iron (ppm)		Manganese (ppm)		pH		Calcium (ppm)		Magnesium (ppm)		Sulfate (ppm)	
	Influent	Effluent	Influent	Effluent	Influent	Effluent	Influent	Effluent	Influent	Effluent	Influent	Effluent
1/20/92	0.68	N/A	0.05	N/A	6.4	N/A	16.1	N/A	7.6	N/A	12.0	N/A
4/1/92	0.57	<0.05	<0.02	0.04	7.7	7.5	13.9	14.6	6.2	5.8	10.0	16.0
4/28/92	0.40	<0.05	0.12	0.14	7.7	7.7	20.1	20.3	10.3	10.6	7.0	14.0
5/28/92	0.37	<0.05	0.02	0.04	7.7	7.6	15.4	15.7	7.6	7.7	14.0	16.0
6/5/92	0.51	<0.05	0.03	<0.02	7.6	7.5	17.3	16.1	8.1	7.7	24.0	21.0
7/1/92	0.64	<0.05	0.06	0.02	7.6	7.4	16.5	16.7	7.2	7.6	14.0	17.0
9/23/92	0.57	<0.05	0.03	0.03	7.6	7.4	14.3	11.7	7.2	7.1	11.0	17.0
11/5/92	1.03	<0.05	0.05	0.02	7.7	7.3	16.6	13.0	7.2	7.5	8.0	23.0
12/9/92	0.77	<0.05	0.11	0.10	7.7	7.5	16.6	17.5	8.5	9.3	13.0	21.0
1/26/93	1.27	<0.05	0.20	0.14	7.5	7.3	17.5	17.0	7.2	7.2	18.0	24.0
3/10/93	0.38	<0.05	0.15	0.05	7.7	7.7	22.1	20.8	15.5	11.5	8.0	12.0
Average	0.65	<0.05	0.08	0.06	7.5	7.5	16.9	16.3	8.4	8.2	12.6	18.1

Date	Conductivity (µMHO/cm)		Sodium (ppm)		Chloride (ppm)		Nitrate/Nitrite (ppm)		Bicarbonate (HCO_3) (ppm)	
	Influent	Effluent	Influent	Effluent	Influent	Effluent	Influent	Effluent	Influent	Effluent
1/20/92	296	N/A	29.3	N/A	42.6	N/A	<0.05	N/A	85.4	N/A
4/1/92	241	195	25.0	27.0	31.2	34.1	<0.05	<0.05	65.8	61.0
4/28/92	403	290	48.0	46.0	45.4	45.5	<0.05	<0.05	140.3	136.4
5/28/92	268	216	24.0	25.5	33.1	32.7	<0.05	<0.05	81.7	75.6
6/5/92	288	223	28.0	27.5	36.9	36.9	<0.05	<0.05	78.6	76.9
7/1/92	293	296	26.5	31.6	35.5	38.3	<0.05	<0.05	76.9	76.9
9/23/92	266	276	24.2	25.9	29.8	32.5	<0.05	<0.05	81.7	76.9
11/5/92	279	289	28.0	33.0	33.9	33.7	<0.05	<0.05	88.6	72.0
12/9/92	287	298	24.5	23.5	27.0	28.9	<0.05	<0.05	95.2	87.8
1/26/93	262	262	21.2	20.3	25.4	22.7	<0.05	<0.05	79.3	73.2
3/10/93	389	380	43.0	41.9	44.5	40.3	<0.05	<0.05	153.7	144.0
Average	297	273	29.2	30.2	35.0	34.6	<0.05	<0.05	93.4	88.12

service of the DSF system. In addition to the services provided by Mr. Fisher, the manufacturer of the DSF system, provided background support and expertise during this demonstration period.

Mr. Fisher has now assumed full operational responsibility for the entire Freestone Water System having recently entered into a contract with Sonoma County. In addition to maintaining the DSF system, Mr. Fisher's contract with Sonoma County requires the following services be provided:

- routine servicing of the treatment facilities;
- maintenance of wells, pumps, tanks, and supply facilities;
- testing and monitoring of water sources, and performing weekly checks on chlorine residuals;
- maintain customer accounts and prepare budget requests to county;
- recordkeeping, reporting, and public notification;
- handling of customer service complaints;
- emergency service and repairs;
- leak detection; and
- microbiological testing.

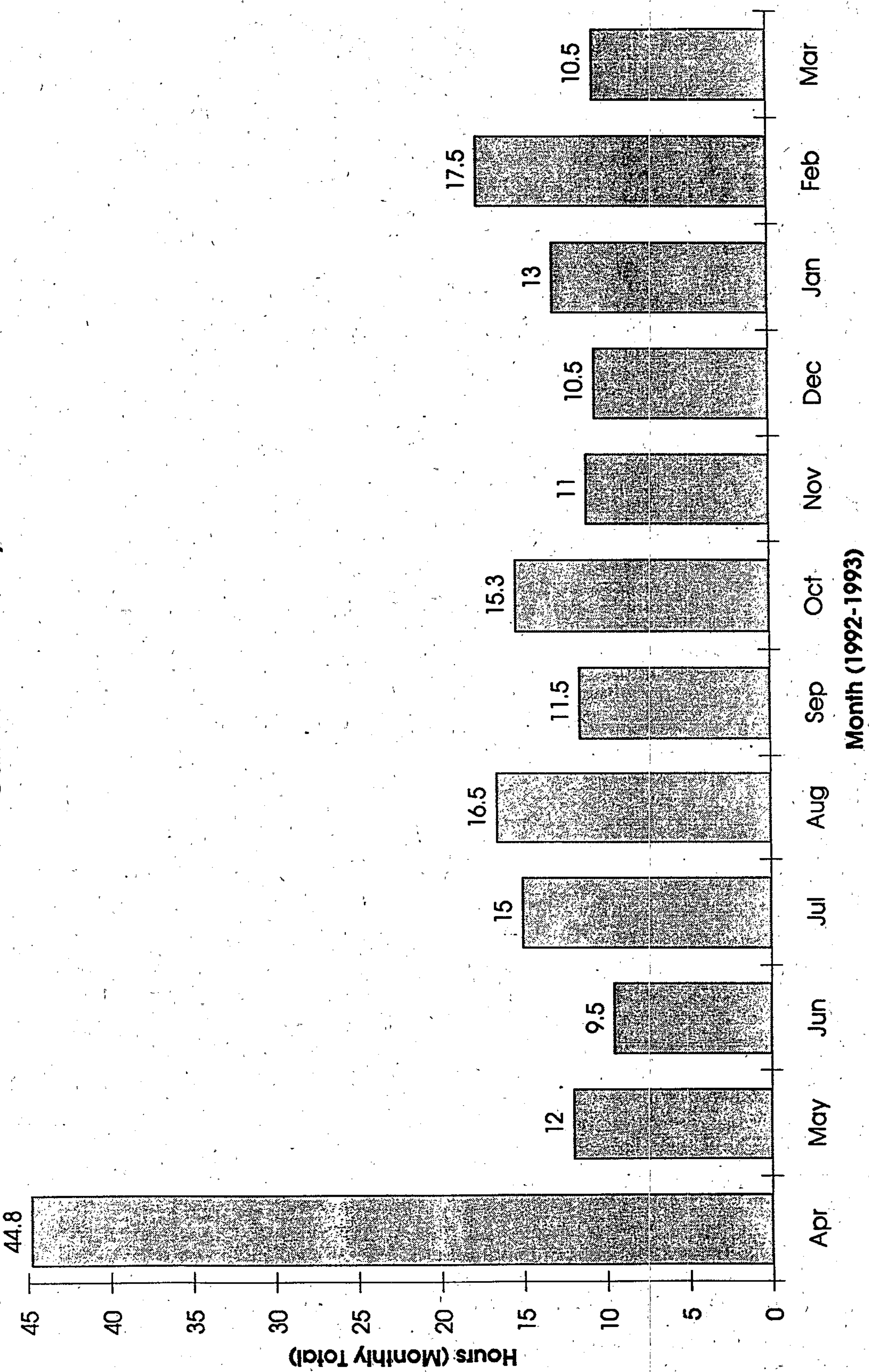
The DSF system installed at Freestone is designed to operate automatically and is maintained as needed and in accordance with the manufacturer's instructions. System backwashing is automatic and conducted according to pre-set guidelines. The telemetry system allows transmission of operational and monitoring information to Mr. Fisher's office in Santa Rosa. Parameters monitored include raw and finished water turbidity, chlorine residual, pressure drop, storage tank levels, chemical feed tank levels, flow rate, and total gallons produced. If parameter limits are exceeded, notification is automatically sent over the telemetry system as an alarm to Mr. Fisher's office.

The combination of the automated features of the DSF and the use of the telemetry system allowed for less frequent visits to the water system by the operator. During the demonstration period, weekly site visits were adequate to perform maintenance, fill chemical tanks, and examine the condition of the system.

Exhibit 3-11 displays the operation and maintenance (O&M) labor hours for the 12 month demonstration period. The number of hours for the first year totaled 187.1 hours, including travel time, with monthly totals ranging from 9.5 to 44.8 hours (Exhibit 3-2). The latter amount, however, reflects start-up hours during the first month of operation. Round trip travel time to and from the site requires 40 minutes per visit. The average of the monthly totals was 15.6 hours. The number of operator hours per month has since been reduced and is currently averaging only 6.5 to 8, including travel time.

Exhibit 3-11

O&M Labor Hours by Month



4. PROJECT COSTS

This section summarizes the total capital and operations and maintenance (O&M) costs to the Freestone Water System to install and operate the DSF system. The estimated costs for the DSF system are based on the reasonable market value, since the equipment was donated to the citizens of Freestone. The costs to the Freestone customers for this treatment facility were also estimated and summarized below.

4.1 Baseline Costs

As previously discussed, prior to the installation of the DSF system, the Freestone Water System consisted of little more than chlorination of water collected from a natural spring and a well which was stored in a concrete tank for subsequent distribution. The O&M requirements were minimal because of the rudimentary nature of the facilities, and involved mainly cleaning of the collection area, inspection of the chlorinator, bacteriological monitoring, and general upkeep of the treatment and distribution systems. The Freestone Water System was operated by an outside contractor, Russian River Utility, under an O&M contract with Sonoma County.

Exhibit 4-1 is a summary of O&M expenses for the year immediately preceding the installation of the DSF system. These expenses exceeded $6,600 for the 1990-1991 Fiscal Year. Of this total, routine maintenance by the contractor accounted for $6,200, while $200, $140, and $115 were spent on laboratory fees, chemicals, and miscellaneous expenditures, respectively.

The cost of service to the individual Freestone customer was $35 per month which is collected by the county. The customers were also billed an annual debt service fee of approximately $300 per connection, irrespective of water consumption. This surcharge was used to cover payment on a $85,000 low-interest loan the community undertook for general system rehabilitation and repair, developing a new well source, and other construction activities which had occurred prior to this demonstration project. The combination of these two costs translates to an effective water rate of about $60 per month per connection. This flat-rate fee structure has been in effect for over four years since the county assumed control of the operation and management of the system.

4.2 Cost of the Dual-Stage Filtration System

Comparing the cost of water treatment across small systems is complicated by site specific factors, raw water quality, and the general condition of each system prior to the installation of a treatment process. These system-specific factors can contribute to wide variations in the ultimate cost a system incurs for treatment. In addition, there are a variety of accounting procedures employed by water systems. Some systems may report cost elements as fixed and variable, while other systems report elements as capital and O&M. Often an expense that is reported as a capital expense by one system may be considered an O&M expense by another.

Exhibit 4-1
Operating Costs Prior To Installation of DSF[1]
Fiscal Year 1990-1991

Month	Standard Contract Fees	Additional Services by Contractor	Chemicals	Laboratory Fees	Total
July	$550		$37	$192	$778
August	$550				$550
September	$550				$550
October	$550	$115			$665
November	$550		$25		$575
December	$550		$28		$578
January	$550				$550
February	$550				$550
March	$450				$450
April	$450				$450
May	$450				$450
June	$450		$48		$498
Annual Total	$6,200	$115	$139	$192	$6,646

[1] Electrical Costs are not included due to unavailability of data

Exhibit 4-2
Cost Breakdown for Freestone Water Treatment System
In Current Dollars

Cost Components	Freestone Configuration
Capital Costs	
Building	$5,000
Treatment Equipment	$21,625
Freight	$864
Installation	$2,755
Start Up	$3,500
Other *Includes telemetry system air compressor, chemical feed well supply, chlorine monitor, and flowmeter package*	$10,843
Water Storage *Raw and finished*	$6,294
Waste Handling *includes tank and pump*	$6,845
Engineering	$5,000
Total Capital	$62,726
Annualized capital @ 7% over 20 years	$5,921
Operation and Maintenance Costs	
Routine O&M	
Service contract	$4,080
Telephone	$960
Electrical	$1,416
Water sampling and analysis	$348
Parts	$400
Total Annual Routine O&M	$7,204
Variable O&M	
Chemicals (disinfectant and coagulant)	$531
Replacement Costs (annual contribution)	

Component	Estimated Replacement Cost	Estimated Life (Years)	Freestone Configuration
Anthracite	$320	4	$64
Cullsorb	$260	8	$26
Feed Pumps	$2,080	5	$312
Raw Water Pump	$2,080	5	$312
Backwash Pump	$2,232	5	$335
Turbidimeter	$4,660	5	$699
Chlorine Monitor	$3,190	5	$479

Total Annual Replacement Costs	$2,226
Total Annual O&M and Replacement Costs	$9,961
Total Annual Costs (Capital + O&M)	**$15,882**

To compare cost elements across water systems and accounting procedures, the USEPA Small Systems Initiative Cost Reporting Committee has developed a standard cost reporting framework which is presented as Appendix B. The cost of the DSF system, as displayed in Exhibit 4-2 and discussed in the following paragraphs, are presented within the outlines of this framework. Cost estimates are presented for the specific treatment system designed and installed at Freestone.

Capital Costs

The standard DSF package treatment plant is comprised of the following capital equipment:

- a dual-stage pressure filtration package treatment plant;
- a chemical feed system for disinfection and coagulation chemicals;
- a continuous monitoring turbidimeter, equipped with a strip chart recorder set to monitor and record effluent quality; and
- an in-line mixer.

In addition to the standard configuration, the Freestone treatment configuration required various equipment upgrades and support equipment to meet system-specific water quality, waste disposal, and aesthetic objectives. The additional components of the installed treatment system at Freestone included:

- a constructed building to shelter the DSF;
- an additional chemical feed system for the backup raw water supply well;
- an air compressor;
- a telemetry system;
- a continuous monitoring chlorine meter;
- a flowmeter package;
- level control systems for the raw water and finished water storage tanks; and
- and a backwash storage tank and control system.

Below is a detailed discussion of these individual components and the associated capital cost as defined by the USEPA's Cost Reporting Committee.

Building - The treatment plant is located next to the fire station which was built to resemble an old-time fire house. The typical physical structure necessary to house a DSF or other packaged treatment system is a simple prefabricated metal shed with electrical and plumbing connections and a concrete slab foundation. For the Freestone site, the DSF system required a 10 by 20 foot structure to house the system. Since Freestone is an historic district with strict architectural design and aesthetic standards, the county constructed a wooden residential-looking building, complete with drywall and a shingled roof. In addition, the building was soundproofed at the residents request to suppress noise that might emanate from the treatment equipment. These additional architectural features were erected at additional expense to the county. Since these architectural requirements are beyond those required to house a typical DSF system, the manufacturer contributed $5,000 towards the cost of construction for this upgraded facility, which is the equivalent cost of a prefabricated steel structure. Sonoma County covered the additional expense for the design and construction of the upgraded facility. Therefore, $5,000 for building construction was used in this cost estimation.

Treatment Equipment - The standard DSF packaged plant and associated equipment donated by the manufacturer totaled $21,625. The components and associated costs are as follows: DSF ($12,500), chemical feed for surface supply ($3,065), influent and effluent turbidimeters and recorders ($5,760 total, or $2,880 each), and in-line mixer ($300).

Freight - The cost to ship all associated components to the job site from the manufacturer's headquarters in Northbrook, Illinois was $864.

Installation - Installation for the standard system and components totaled $2,755. The bulk of these charges ($2,000) were associated with the installation of the DSF system; while the chemical feed surface supply, turbidity meters and recorders, and in-line mixer accounted for $480, $500, and $25, respectively.

Start Up - A flat fee of $3,500 was required for system start up. Start up usually consists of a visit by a representative of the manufacturer to ensure the equipment is installed correctly and the process is operating according to design specifications. Typical tasks performed as part of system start up are training sessions for operators, including an explanation of the equipment's capabilities and a demonstration of operational requirements, as well as a general inspection to ensure a quality installation.

Other Treatment Equipment - The installation at Freestone contained numerous upgrades to the standard package plant. These upgrades and associated installation fees amounted to $10,843. The breakdown of the individual costs of the upgrades are as follows: chemical feed for well supply (valued at $825 plus $160 for installation labor), air compressor ($905 plus $125), chlorine monitor ($3,190 plus $125), flowmeter package ($2,995 plus $60), telemetry system ($770 plus $187.50), and telemetry software ($1,500).

The telemetry system and software were donated by Autotrol, Inc. As with all other contributed items, costs were calculated at fair market value (i.e., at the manufacturer's list price). A second telemetry system was also installed at Freestone for the purpose of sending the water quality information to the manufacturer's headquarters in Illinois. However, since the end of the demonstration, the extra line was redirected to the local system operator. Since the data were required only for research purposes and not plant operation, the cost of the second telemetry system is not included.

Water Storage - The cost for water storage improvements totaled $6,294. Improvements to the raw water storage tank amounted to $5,010. The raw water pump and control system cost $2,730 plus $250 for installation. The level control system for the raw water tank amounted to $1,780 plus $250 for installation. The finished water storage tank level control accounted for $1,284 ($1,034 for the components and $250 for installation). An existing raw water storage tank, while not required to operate the DSF system, was upgraded from its previous use for fire protection to a storage tank suitable for incorporation into the treatment system. Because water storage requirements are site specific, the costs associated with purchasing a new tank were not included in this report.

Waste Handling - Freestone is required by county law to maintain a "zero water waste" operation, that is, a treatment process where there is 100 percent water conservation, and therefore, no waste of treated water. The only waste is the sludge from the settling and backwash operations. To maintain this "zero water waste" operation, a backwash holding tank was needed. A standard above-ground tank is normally required. Again, for aesthetic reasons, Freestone chose to install an underground waste storage system consisting of septic tanks. The manufacturer contributed $3,600, an amount sufficient to cover the cost of an above-ground tank, which was used for this cost estimation. In addition, a backwash reclaim pump was installed at a cost of $2,995 plus $250 for installation labor. Thus, the total costs for waste handling was $6,845.

Engineering - Culligan personnel expended time and effort for the various site specific design engineering needs of Freestone which has been valued at $5,000. Compared to custom designed and constructed treatment plants, the design costs of packaged plants are relatively low. The design costs for packaged plants are incorporated into the overall cost of the technology and can be spread over a large number of production units, thereby reducing the per unit design cost. As a result, this off-the-shelf technology represents a cost savings to the water system. A consulting engineer can be used to prescribe an operationally sound and complete treatment process that is essentially pre-designed and pre-built.

For the Freestone demonstration site, engineering costs for the treatment decision are difficult to discern because they are grouped together with distribution system improvements and the feasibility studies. However, Sonoma County estimated that $100,000 was saved in water treatment equipment and related costs due to the use of the package plant.

Total Capital Costs - The total capital costs for the Freestone installation were estimated to be $62,726.

Annualized Capital Costs - Assuming a 20 year system life and a 7 percent annual interest rate, the annualized capital cost for installation of the complete Freestone treatment system amounts to $5,921.

Operation and Maintenance (O&M) Costs

The estimated cost to operate and maintain this facility are detailed below according to the specifications of the USEPA's Cost Reporting Committee.

Routine O&M - The annual expense for routine O&M was estimated to total $7,204 and includes the cost of the service contract between Sonoma County and the current operator which is fixed at $340 per month, or $4,080 per year.

The independent Culligan dealer and operator of the DSF system made weekly visits to the plant, even though these visits are not required for operation of the treatment plant. The purpose of the visits was to collect grab samples for turbidity and chlorine residual. The telemetry system provides sufficient information regarding the system's performance to enable the operator to monitor the water quality off-site and therefore spend less time conducting site visits. On average 13 labor hours per month (excluding system start-up) were spent during the demonstration period, which included the travel time between the operators office in Santa Rosa and Freestone of approximately 40 minutes per trip. Since the demonstration period, only 8 hours per month (including travel time) have been needed to maintain the system. Therefore, labor costs are calculated to range from $26 to $43 per hour. It is important to note that this figure also includes the costs of the chemicals and instruments for the chlorine and turbidity grab samples, which are typically passed through to the county.

Additional water sampling and analysis costs amount to $348 per year. Monthly samples for microbiological contaminants are analyzed at the state lab at a cost of $19 each, while quarterly tests for iron are $30 each. Electrical costs averaged $118 per month during the demonstration period, totalling $1,416 for the year. Costs for items such as buffer solution for the chlorine monitor, light sources for the turbidimeters, and other similar items are estimated to be $400 per year.

The telephone line for the telemetry system costs $80 per month, or $960 per year, that is due to the long distance call from Freestone to the manufacturer's independent dealer in Santa Rosa. The telephone line costs were paid for by the manufacturer during the demonstration period and are now passed through to the county.

Variable O&M (Treatment Chemicals) - Chemical costs were $531 for the demonstration period. Coagulant usage averaged approximately 4 gallons per month at a cost of $9 per gallon. Chlorine usage averaged around 4.5 gallons per month at a cost of $1.60 per gallon. Since the demonstration period, chemical usage has decreased slightly to 2.5 gallons per month for the coagulant, and 3.5 gallons per month for chlorine.

Replacement Costs - The cost to replenish filter media or replacement of worn equipment is estimated to be approximately $2,226 per year for the Freestone system. Exhibit 4-2 lists the estimated replacement cost and life expectancy of each major component. Average annual costs in current dollars were calculated by averaging the total expected cost for each component over twenty years. For example, Anthracite, with an expected life of 4 years, would be replaced 4 times (in years 5, 9, 13, and 17). This value was multiplied by the replacement cost, $320, to yield a total expenditure of $1,280 over the life of the system. Averaging over the 20 year expected life yields an annual value of $64.

Total Annual O&M Costs - Routine O&M, variable (chemical), and replacement costs total $9,961 for the Freestone installation.

<u>Other Unaccounted Costs</u>

A major need for the Freestone Water System is an upgrade of the distribution system. Although the condition of the distribution system ultimately affects water quality, it is considered to be an additional infrastructure expense that would be required in the absence of treatment and is not included in this presentation. Only the capital and O&M expense for the DSF system were taken into account. The county is, however, currently renovating the distribution system.

Total Annual Costs

The total annual capital and O&M expense for installation and operation of the Freestone treatment plant is estimated to be $15,882.

4.3 Customer/Household Costs

During the demonstration period, 16 connections were served and consumed approximately 2.1 million gallons of water. The specifications for the demonstration site required a system that could meet the future demands of 30 connections and treat approximately 6 million gallons per year. Prior to the installation of the DSF system, customers paid an effective rate of $60 per month for water. However, the residents purchase bottled water for their drinking and cooking needs at additional household expense. For example, a two-person household consuming two liters of drinking water per day, at an assumed average cost of one dollar per gallon bottle, would spend over $30 per month on bottled water.

For the 16 connections served during the demonstration period, the total annual cost of $15,882 translates to a cost per connection of approximately $83 per month, or almost $1,000 per year. With the system expansion to 30 connections, the monthly cost per connection would decrease to $44.

Exhibit 4-3 summarizes the cost per unit production (i.e., per 1,000 gallons of delivered water). Production costs are calculated by dividing the total annual cost of the Freestone Water System ($15,882) by the annual volume (actual and projected) of water treated. The reported consumption for the Freestone Water System of 2.1 million gallons per year yields a total cost of $7.56 per 1,000 gallons delivered. These costs will decrease to $3.20 per 1,000 gallons delivered water assuming the future demand of 6 million gallons annually is reached.

4.4 Comparative Cost Analysis

Demonstrating the effectiveness of pre-designed packaged treatment plants in minimizing the capital and O&M expense to small systems was a critical element of this technology demonstration. For compliance purposes, small system technologies must be as effective as other approved technologies in removing drinking water contaminants while also providing a lower cost alternative to conventionally design-constructed plants. Exhibit 4-4 shows the results of a comparative analysis of the cost of the Freestone dual-stage filtration system to recent USEPA cost estimates for two very small (i.e., serving fewer than 500 people) system filtration options. The USEPA estimates represent the costs for conventionally engineered and constructed coagulation/filtration and slow sand filtration plants with production capability sufficient to meet the requirements of a system serving 25 to 100 people. Comparisons to coagulation/filtration and slow sand filtration were made because they are two technologies regarded as effective treatment alternatives for small systems.[6] Additionally, this comparison allows examination of the potential cost differences between design-constructed facilities and packaged treatment plants.

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[6] The high influent turbidity recorded at Freestone may have obviated the use of slow sand filtration; however, it is still considered a common treatment alternative for small water systems and was included as a point of comparison.

Exhibit 4-3

Projected Unit Treatment Costs

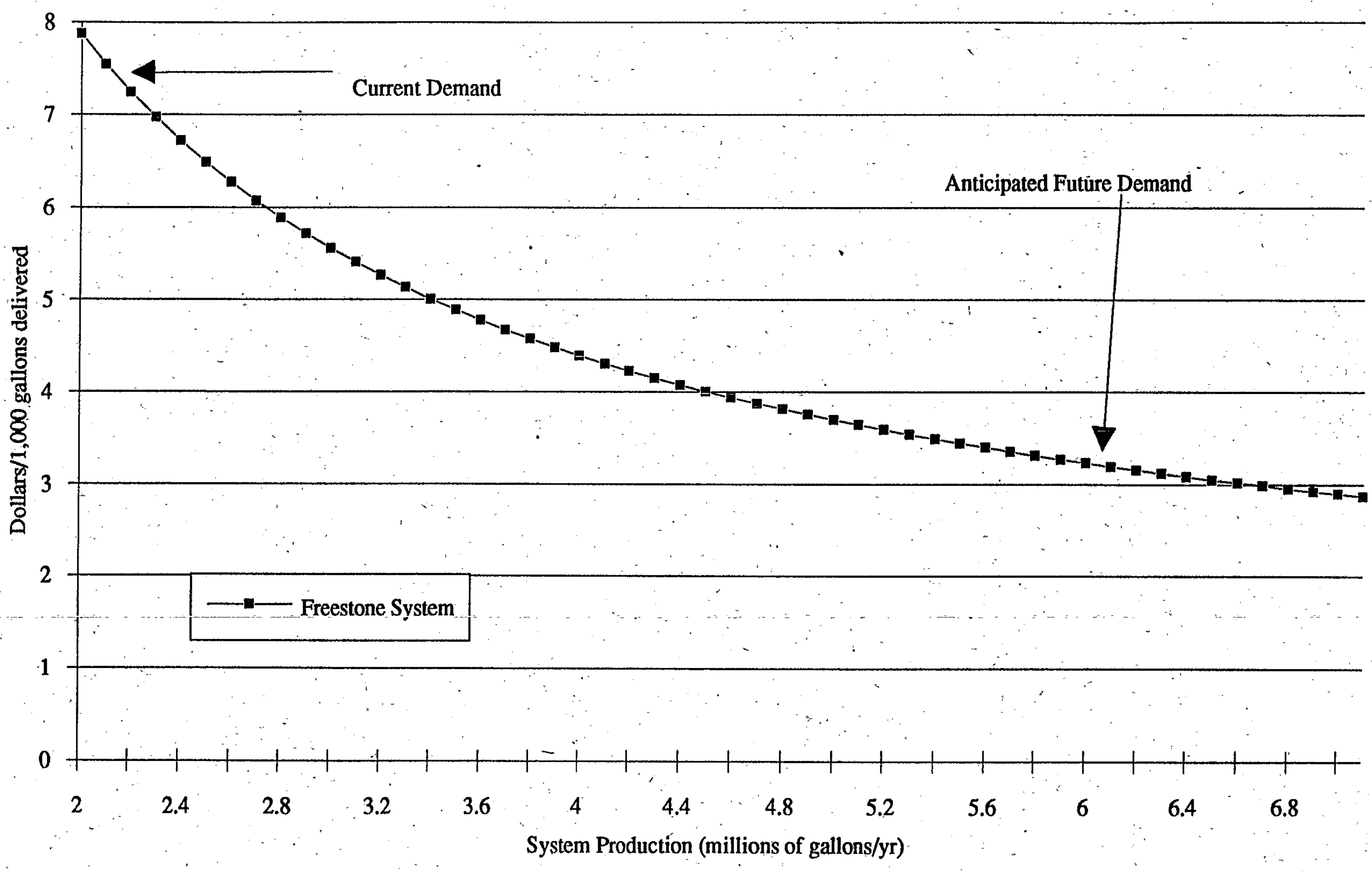

Exhibit 4-4
Cost Comparison of Alternative Treatment Systems

Cost Component	Manufacturer Estimates	EPA Estimates for Constructed Facility	
	Freestone DSF System	Coagulation/ Filtration	Slow Sand Filtration
Capital Costs	$62,726	$79,557	$58,475
Annual O&M Costs	$9,961	$20,058	$14,630
Total Annual Costs	$15,882	$27,568	$20,150
Production Costs ($/1000 gal. delivered)	7.56	13.13	9.59

It should be noted, however, that slow sand filtration was never considered in any of the feasibility studies prepared for Freestone because of the variability in turbidity levels and the need to reduce iron and manganese concentrations in the source water.

The comparative cost analysis was performed assuming yearly production of 2.1 million gallons, the amount recorded during the demonstration period. Compared to the USEPA estimates, the capital cost for the Freestone system are about 30 percent lower than that estimated for a coagulation/filtration system, and approximately seven percent greater when compared to the slow sand filtration plant. However, in both cases, the O&M costs for the DSF system were significantly lower (50 to 100 percent) than the USEPA's estimates for the constructed facilities.

On an annual cost basis, the USEPA's estimates for the constructed facility filtration alternatives (annualization performed assuming a 20 year life of the equipment and a 7 percent discount rate), and corresponding production costs, are 10 to 75 percent greater than the Freestone packaged treatment system. As previously mentioned, Sonoma County estimated that over $100,000 was saved in water treatment equipment and related costs due to the use of the package plant instead of the custom designed system originally planned for this small community.

5. EVALUATION OF INSTITUTIONAL AND PROGRAMMATIC ARRANGEMENTS

This section describes the role that the manufacturer, the O&M firm, and each of the various government agencies played in facilitating the successful completion of the technology demonstration at the Freestone Water System. Other regulatory and programmatic issues are presented and discussed.

5.1 Role of the Principal Players

The principal parties involved in this technology demonstration project included: the USEPA; the California Department of Public Health; the Sonoma County Department of Public Health; the manufacturer, Culligan International Company; and the independent Culligan dealer in Santa Rosa that operated the DSF system during the demonstration period. The principal contributions that each made to this project are described below.

Federal and State Regulatory Agencies

The role of the USEPA in the Freestone Water System technology demonstration was primarily to organize the demonstration project and to analyze and report on the results. Within the State of California, the Department of Health Services (DHS) has regulatory enforcement responsibility for public water supplies. Freestone, which uses an unfiltered surface source with high turbidity levels, was in violation of the CSWFDR. The role of the DHS, therefore, was to ensure that approved technologies were applied to address the water quality problems and to provide technical assistance as necessary to achieve system compliance.

The DHS district office was familiar with the special problems presented by Freestone. This small community is similar to many others across the state that are in need of financial and technical assistance. Mr. David Clark and Ms. Leah Walker of DHS had knowledge of USEPA's Small Systems Technology Demonstration Initiative, the latter while employed with Sonoma County, and recommended that Freestone participate as a demonstration site. Both the county and customers of Freestone agreed to serve as a test site.

The primary obstacle to the application of a pressure filtration treatment system at Freestone was that California did not list this technology as one of the four state-approved technologies for compliance with the CSWFDR requirements. The four approved technologies included: conventional treatment (i.e., coagulation/sedimentation/filtration); direct filtration; diatomaceous earth; and slow sand filtration. California law requires one year of successful demonstration and reporting, to develop a history of performance, before the technology can be considered approved and applied within the state. For a small community like Freestone, using an unapproved technology would represent a severe financial risk if the technology is ultimately deemed unsuccessful. The state allowed the use of the DSF system in this instance since the manufacturer's proposal was accepted on the basis of their no-cost guarantee. Specifically, if the treatment was determined to be ineffective, the manufacturer would have been responsible for the cost to dismantle and remove the equipment.

The state also showed flexibility in accepting the experience of the manufacturer's independent dealer, but did stipulate that the operator of this treatment facility must be certified Grade 2 before granting approval. The operator was able to obtain the required certification after successfully completing instruction at a local community college. Further state involvement was apparently limited to normal review of the operational plan.

Sonoma County

The Sonoma County Department of Public Works (DPW) had responsibility for the overall operation of the water system in Freestone. For this demonstration project, the county's primary function was to facilitate the connection of the DSF system to the existing system configuration. As indicated above, Freestone's water quality problems stem in part from the poor condition of the system's ageing infrastructure, which made the supply vulnerable to bacteriological intrusion. The county was responsible for providing infrastructure improvements to the collection, storage, and distribution systems to provide a reasonable set of baseline water quality conditions for evaluating the performance of the DSF system. During the demonstration period, the county was not able to make all the necessary improvements. As a result, operational problems resulted and higher than average effluent turbidity and chlorine residual levels were recorded in four months during the demonstration period. Recently, county work crews have completed improvements to the finished water storage tank. These improvements are expected to result in reduced threat of microbiological contamination.

In addition, the county had the responsibility for coordinating activities between the operator of the water system, Russian River Utility, the operator of the treatment facility, the manufacturer, the DHS, and USEPA. As indicated above, it was county staff (Leah Walker) that recommended this site for the technology demonstration.

Manufacturer and Operator

During the demonstration period, the manufacturer was responsible for the design and installation of the treatment technology and the collection and analysis of the system performance data. The operation and maintenance of the DSF unit was performed by the manufacturer's independent dealership in Santa Rosa. As indicated above, the state required a Grade 2 certification to operate the Freestone Water System and the DSF unit. Before this demonstration project, Mr. Fisher was not certified at that grade, although he had 15 years of experience in the installation and maintenance of water treatment equipment. Initially, Mr. Fisher attempted to obtain a concession from the state to substitute years of experience for formal training. However, the state did not grant the concession. Mr. Fisher was able to attend classes at a local community college that provided the requisite technical training. He was able to fulfill the state certification requirements and receive his Grade 2 certification prior to the April 1992 start-up date for this demonstration project.

The manufacturer and operator also prepared the Operations Plan for the treatment facility which is required by the state for approval and permitting. The manufacturer also provided monthly summary documentation of the performance of the DSF system to the appropriate county, state, and Federal agencies involved in this technology demonstration.

The principle contributions of the manufacturer involved donating staff time and equipment and assuming the risk of performance. Since the DSF system was not a state approved technology, the equipment contribution provided an opportunity to collect the necessary monitoring and performance data to demonstrate the effectiveness of small scale, packaged technologies. This technology is now more likely to be approved for application in numerous other communities with similar water quality and financial and operational problems throughout the state. The current operator of the Freestone system has been able to forge a successful relationship with the county and customers of Freestone which will lead to a greater confidence in the water supply.

The contribution of the Aqua-Status telemetry system was also a unique feature of this technology demonstration. This telemetry equipment and computer software, which transmits performance data to the off-site operator via computer modem, allowed both the operator and the manufacturer to continuously monitor the performance of the DSF system and to identify and resolve problems quickly without having to maintain a full-time presence at the facility. The telemetry system provide an affordable technological alternative to having a full time operator which is costly for small systems.

5.2 Consideration of Alternative Treatment Configuration

Demonstrating the effectiveness of pre-designed packaged treatment plants, and specifically pressure filtration units, in minimizing the capital and O&M expense to small systems is a critical element of this technology evaluation. For compliance purposes, these small system technologies must be as effective as other approved technologies. For unfiltered surface systems with high turbidity, conventionally engineered treatment facilities such as a coagulation/filtration system are an accepted alternative since these processes have been field tested and shown to be effective. One drawback to conventional treatment plants, however, is the level of operator training and skill required to adequately maintain this type of treatment process. This technology requires operator experience that is typically above the capabilities of many small systems.

Slow sand filtration is another commonly used treatment alternative for small systems. This technology, however, is more suited to higher quality source water with turbidity levels of 5 NTU or less (USEPA, 1993). The turbidity levels observed in the Freestone water supply exceeded 5 NTU. As a result slow sand filtration was not considered for Freestone.

5.3 Post-Demonstration System Improvements

The demonstration period for this technology was April 1, 1992 to March 31, 1993. During this period there were problems with the existing Freestone Water System infrastructure and operational procedures that affected the quality of water both entering the treatment plant and delivered to the customers. The three major components of the system, the spring source collection area, the finished water storage tank, and the distribution system required substantial rehabilitation. The county has recently completed repairs to the spring collection area. The finished water tank has also been relined and new housing was constructed to prevent the possibility of microbiological contamination from small animals and birds. The distribution system is also undergoing repair.

The county has installed meters at each connection to monitor customer usage. The application of meters also allowed the county to revise its flat rate structure to a rate that is now based on consumption. The use of metering and a consumption-based rate will provide the county with an improved capability to monitor system demand and to develop better estimates of future production and revenue requirements which is integral to proper system planning.

Finally, because of the improvements to the system, the county has now been able to connect more residents to the system as demonstrated by the increase in the number of connections since the demonstration period from 16 to 30. This increase in the customer base will allow for greater sharing of the cost burden across customers which should contribute to a lower cost per household for these water quality improvements.

6. CONCLUSIONS

This technology demonstration has provided an opportunity for both government regulatory agencies and the regulated community to observe the performance of the dual-stage pressure filtration system provided by Culligan International Company. The DSF system proved successful in reducing effluent turbidity to levels below the required 0.5 NTU standard. There were four months in which the system would have been determined to be out of compliance with fewer than 95 percent of turbidity readings below 0.5 NTU. In each of these months, the trouble could be traced to a faulty float valve on the finished water storage reservoir preventing backwashing of the filter media or to construction at the finished water storage reservoir. These operational and mechanical problems have been addressed since there have been no reported violations of the turbidity requirements since the demonstration period ended.

The reduction in effluent turbidity and the presence of a chlorine residual has substantially reduced the risk of microbiological contamination. The DSF system has also proved to be effective in reducing concentrations of iron present in the water which improved the taste and odor of the water.

This demonstration has also provided Sonoma County the opportunity to make further drinking water infrastructure improvements. The spring raw water collection area and reservoir have been rehabilitated, the finished water storage tank has been drained, cleaned, relined and new housing provided to protect the tank from natural elements and animal infestation. The distribution system is also being upgraded which will reduce the need to maintain elevated chlorine residual levels to ensure that finished water is not subject to further microbiological contamination.

The DSF system, compared to a fully constructed engineered treatment system, has shown to have minimal O&M requirements and is designed to operate automatically. The telemetry system allows the performance of the treatment system to be monitored off site reducing the need for a full time, on-site operator which significantly reduces the cost to small, financially constrained water systems.

The annual cost of the DSF system to Freestone customers based on consumption (2.1 million gallons) and the number of connections (16) during the demonstration period is estimated to be $83 per month per connection. With system expansion to accommodate 30 connections, the cost per connection would decrease to $44. The system also has the capacity to expand production and to serve additional customers which could ultimately reduce household costs even further. More importantly, the installation of the meters at Freestone will allow the cost of this system to be spread more equitably across users based on relative consumption, which should reduce costs to the lower volume users. Because of the lower capital cost for this packaged treatment system, the system is also able to significantly reduce its financing costs and reduce the debt obligation which its customers must incur.

The estimated cost for the installation and operation of the DSF system has been determined to be considerably lower than a custom engineered system. The cost of the DSF system installed at Freestone was compared to USEPA cost estimates for a constructed conventional treatment system, a generally accepted and approved small system treatment option.

This cost comparison showed that the total annual expense for the DSF system was considerably lower compared to the coagulation/filtration system despite the upgraded components that were included in the final Freestone treatment package. The cost of installation and operation of a coagulation/filtration process is estimated to be $13.13 per thousand gallons delivered water compared to the DSF system that was estimated to cost Freestone $7.56 per thousand gallons.

The efforts of staff from the California Department of Health Services and the Sonoma County Department of Public Works demonstrated that solving the problems of small water systems requires a planned and concerted effort to adequately address the specific needs of the water supply. The manufacturer provided invaluable technical assistance, in addition to the risk incurred in donating both time and equipment to this technology demonstration. The manufacturer was sensitive to the needs of the community and the requirements of state and county regulations and procedures and demonstrated that addressing water quality problems requires more than simply the application of technology.

The State of California showed great flexibility in allowing this demonstration project to take place since the technology involved had not yet received state approval. Typically, the state requires a period of pilot testing prior to approving full scale installation. In this case, however, the state recognized the tremendous potential that this technology offers to address the filtration needs of small systems. Based on the data collected during this demonstration, the state has decided to include the DSF on the list of "acceptable" alternative technologies and will be granted credit for 2-log removal for giardia. The list will be provided to state district engineers for general circulation. The DSF, however, will be included on the list with a restriction placed on the quality of the source water. Specifically, a turbidity limit will be imposed on the DSF that allows for its application in situations where influent turbidity is no greater than that observed for Freestone.

In conclusion, this technology demonstration project provided USEPA the opportunity to observe a successful and integrated approach to solving small water system compliance problems that involved both the application of an innovative technology and the restructuring of the water system. In assuming control of the system, the county was in a better position to negotiate an O&M contract to attract a technically qualified firm to operate the system since there are several other small systems in Sonoma County with similar financial or technical problems. The manufacturer was able to demonstrate the effectiveness of the DSF treatment process in improving Freestone's water quality. The net result of this demonstration project is that small systems such as Freestone are now able to access technologies which provide operationally sound and cost-effective alternatives to achieve compliance with water quality standards.

7. REFERENCES

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USEPA, 1993b. "Very Small Systems Best Available Technologies Cost Document"; USEPA Office of Ground Water and Drinking Water, September 1993b.

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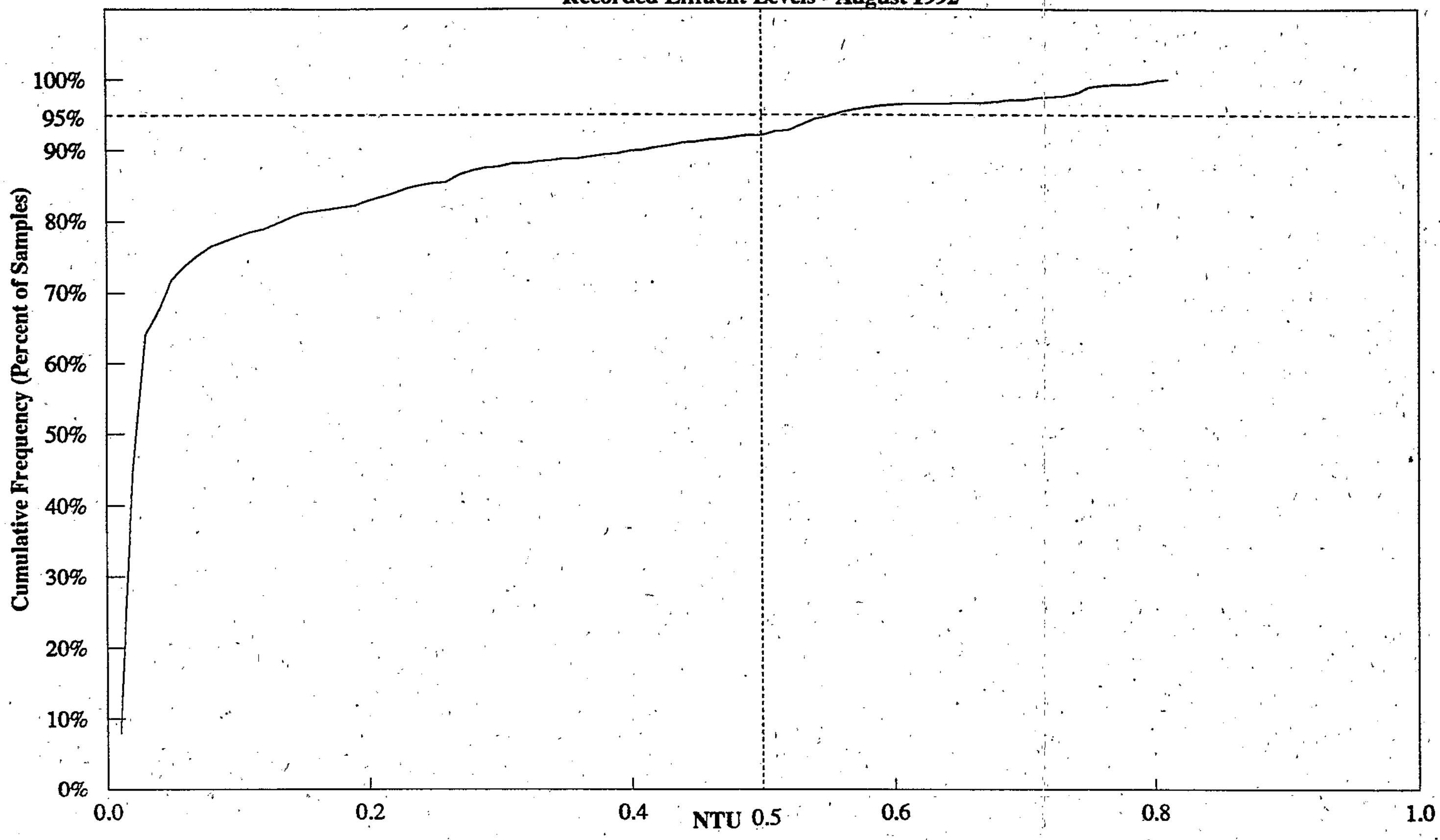
APPENDIX A

CUMULATIVE FREQUENCY DISTRIBUTIONS OF RECORDED NTU LEVELS

Exhibit A-1

Ogive of the Distribution of Turbidity Levels

Recorded Effluent Levels - August 1992

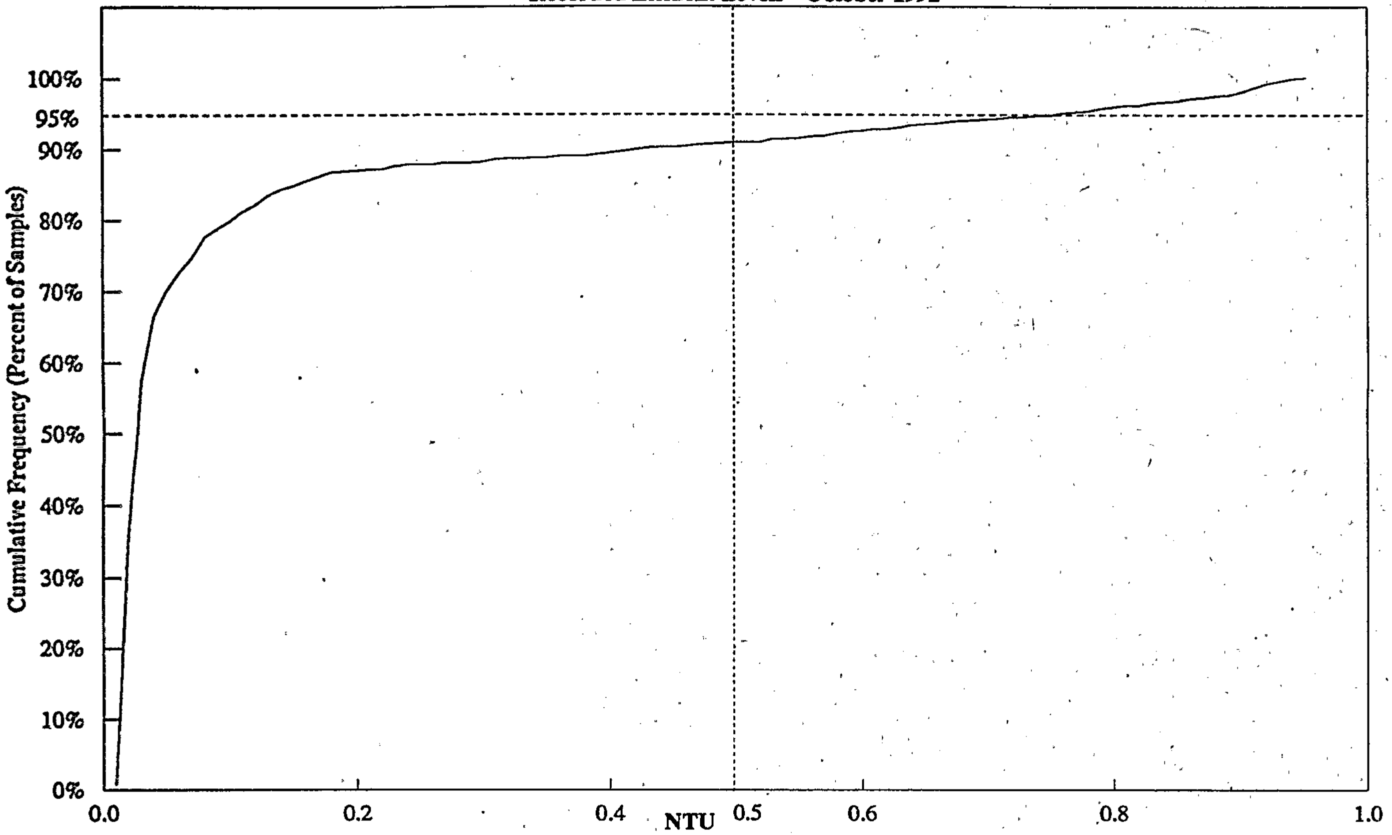


Summary Statistics	
No. Observations	738
No. Obs. > 0.5 NTU	58
% Obs. > 0.5 NTU	7.9 %
Mean Turbidity	0.11 NTU
Median Turbidity	0.03 NTU
Minimum Value	0.01 NTU
Maximum Value	0.81 NTU

Exhibit A-2

Ogive of the Distribution of Turbidity Levels

Recorded Effluent Levels - October 1992

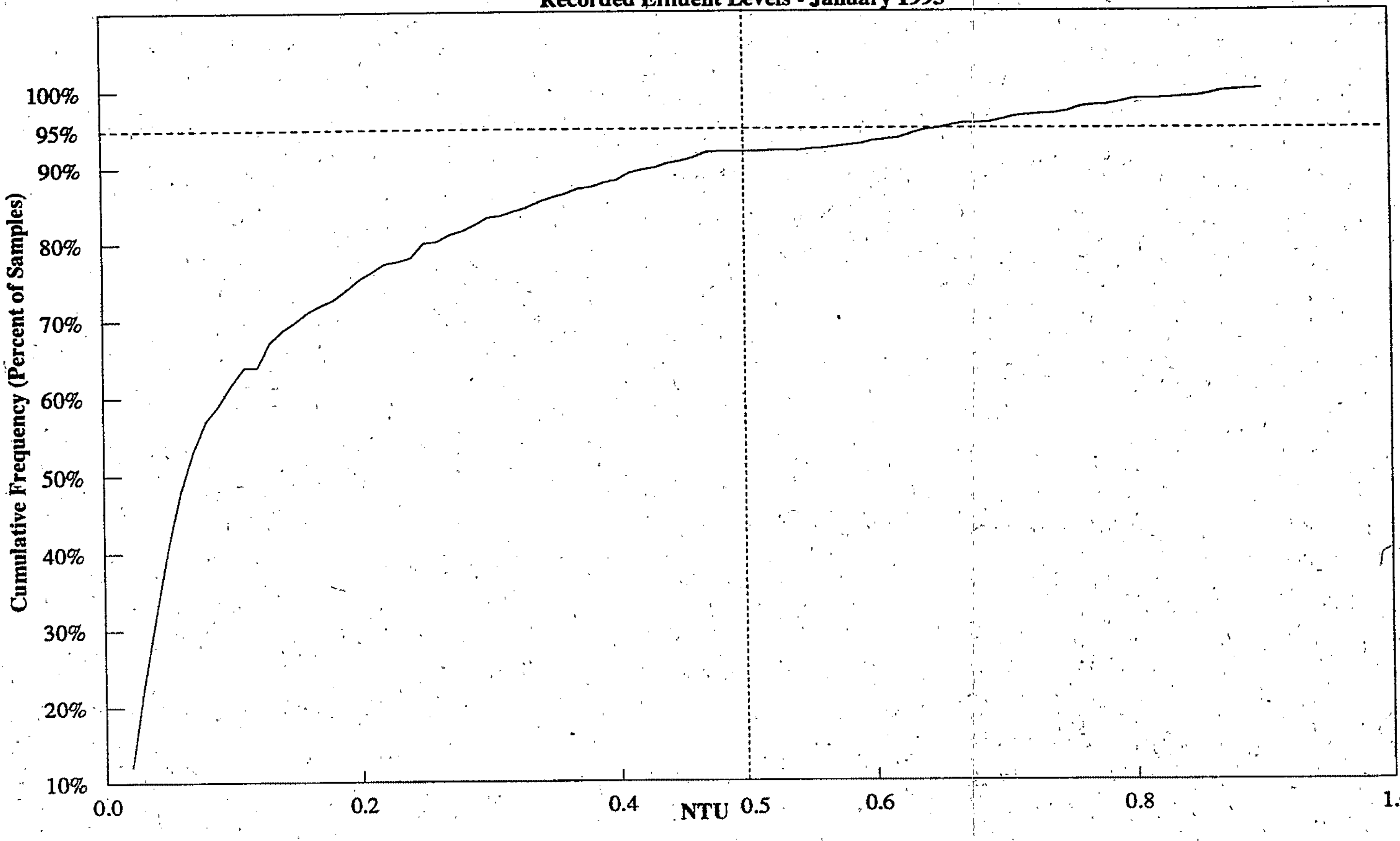


Summary Statistics	
No. Observations	857
No. Obs. > 0.5 NTU	78
% Obs. > 0.5 NTU	9.1 %
Mean Value	0.12 NTU
Median Value	0.03 NTU
Minimum Value	0.01 NTU
Maximum Value	0.95 NTU

Exhibit A-3

Ogive of the Distribution of Turbidity Levels

Recorded Effluent Levels - January 1993

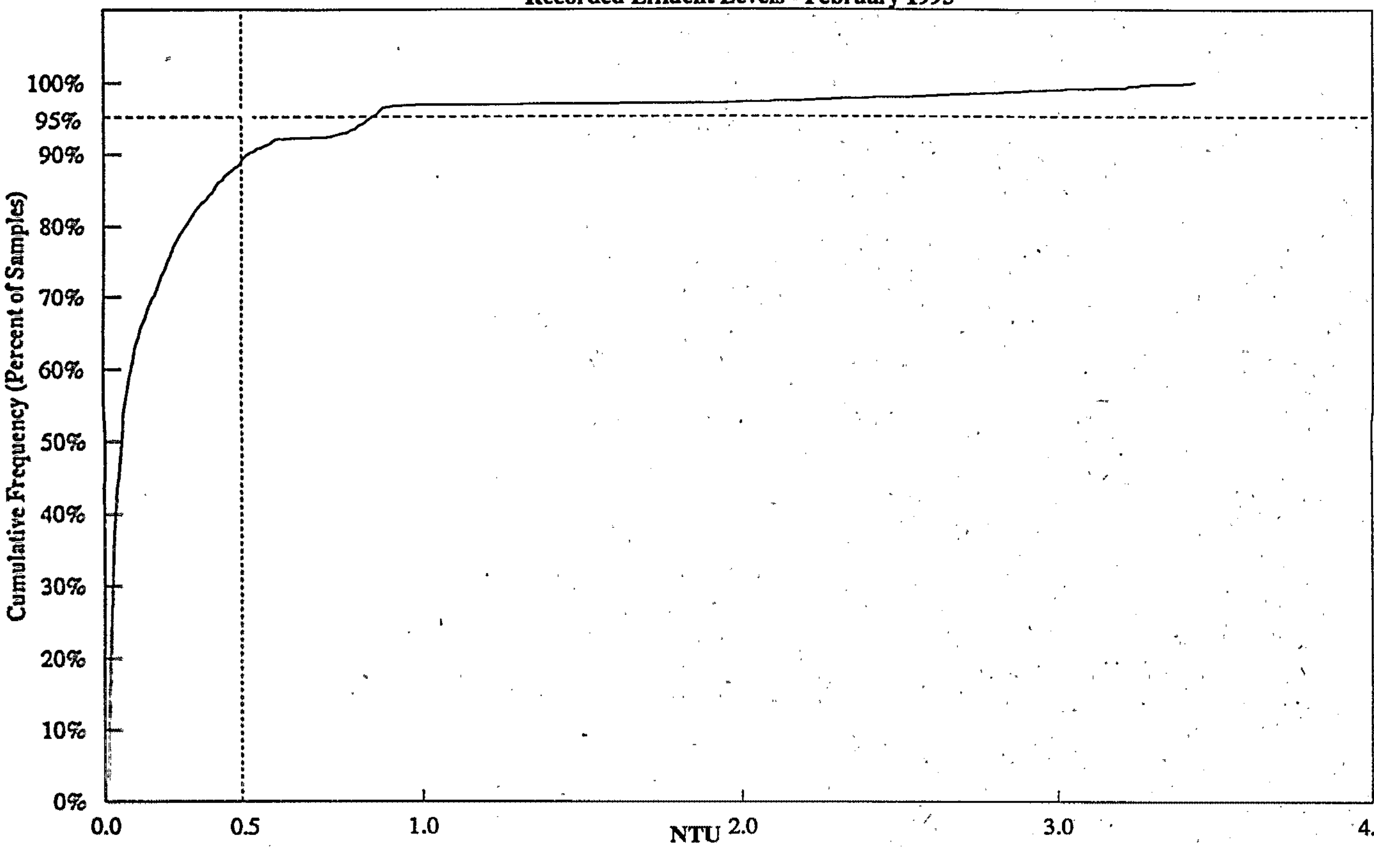


Summary Statistics	
No. Observations	1039
No. Obs. > 0.5 NTU	84
% Obs. > 0.5 NTU	8.1 %
Mean Value	0.16 NTU
Median Value	0.02 NTU
Minimum Value	0.02 NTU
Maximum Value	0.90 NTU

Exhibit A-4

Ogive of the Distribution of Turbidity Levels

Recorded Effluent Levels - February 1993



Summary Statistics	
No. Observations	1626
No. Obs. > 0.5 NTU	144
% Obs. > 0.5 NTU	8.9 %
Mean Value	0.22 NTU
Median Value	0.01 NTU
Minimum Value	0.01 NTU
Maximum Value	3.44 NTU

APPENDIX B

SMALL SYSTEMS TECHNOLOGY INITIATIVE: COST REPORTING FORMAT

Alternate Treatment Technology Costs

GENERAL INSTRUCTIONS

1. Please remember that this cost survey requests information relative **only to alternative treatment technology**. Please do not include capital or operation and maintenance costs for other portions of your water system. If separate costs are not available, please estimate them to the best of your ability and denote "est." next to the appropriate costs.

2. If a requested item was not part of your project, please write "NA" after the item.

3. Please include under "other" any additional items in each category that are not specifically listed.

4. If specific costs for each item within a given category are not available, but total costs are available, please list the total cost anyway. If possible, please indicate under "other" the items that are included in the lump sum amount.

5. If you do not have the information available in the cost units that are indicated, please provide any cost information that you may have. For example, if you do not know the cost of a treatment chemical per thousand gallons of water treated, please provide the monthly or annual cost for the chemical and the unit cost for that chemical.

6. Please add additional information on other sheets if necessary.

GENERAL QUESTIONS

1. How many hours per day does your treatment system operate?

_______ average
_______ maximum

2. What is the capacity of your treatment system in gallons per minute?

_______ gpm

3. Please indicate how much time

a. your operator(s) spends operating and maintaining the treatment equipment (hours/month):

_______ average
_______ maximum

b. a contracted service person spends operating and maintaining the treatment equipment (hours/month):

_______ average
_______ maximum

Alternate Treatment Technology Costs

CAPITAL COSTS

I Sitework

Land acquisition .... $ ______

Excavation & clearing .... $ ______

Roads .... $ ______
Permits .... $ ______

Sewer ....$ ______

Other (please describe) ____
____
____
________________ .... $ ______

TOTAL SITEWORK COSTS .... $ ______

II Building

Physical structure .... $ ______

Landscaping .... $ ______

Furniture .... $ ______

Permanent fixtures .... $ ______

Painting .... $ ______

Other (please describe) ____
____
____
________________ .... $ ______

TOTAL BUILDING COSTS .... $ ______

III Process piping, HVAC, plumbing and electrical

Process & interconnecting piping (if not included in IV, V & VI below) .... $ ______

HVAC .... $ ______

Plumbing (other than process piping) .... $ ______

Electrical .... $ ______

Other (please describe) ____
____
________________ .... $ ______

TOTAL PIPING, HVAC, PLUMBING AND ELECTRICAL COSTS .... $ ______

IV Treatment equipment

Equipment and instrumentation .. $ ______

Equipment warranty (if not included above) .... $ ______

Freight .... $ ______

Installation .... $ ______

Start-up costs .... $ ______

Lab apparatus .... $ ______

Safety apparatus .... $ ______

Other (please describe) ______

____

____

______________ .... $ ______

TOTAL TREATMENT EQUIPMENT COSTS ...... $ ______

V Water storage (materials and installation/construction)

Raw water .... $ ______

Finished water .... $ ______

Other (please describe) ____

____

______________ .... $ ______

TOTAL STORAGE COSTS .... $ ______

VI **Waste handling** (materials and installation/construction)

Backwash .... $ ______

Sludge (if separate from back-
wash) .... $ ______

Other (please describe) ____
____
________________ .... $ ______

TOTAL WASTE HANDLING COSTS .... $ _____

VII **Contractor** (costs other than those included above)

Project coordinator .... $ ______

Other (please describe) ____
____
________________........... $ ______

TOTAL CONTRACTOR COSTS .... $ ______

VIII **Engineering**

Survey .... $ ______

Studies and reports .... $ ______

Plans .... $ ______

Other (please describe) ____
____
________________........... $ ______

TOTAL ENGINEERING COSTS............... $ ______

IX Miscelleneous

Legal .... $ ______

Insurance .... $ ______

Title .... $ ______

Acquisition of financing .... $ ______

Supervision of construction by owner .... $ ______

Other (please describe) ____

____

________________ .... $ ______

TOTAL MISCELLANEOUS COSTS .... $ ______

•••••••••••••

TOTAL CAPITAL COSTS .... $ __________

TOTAL GRANT FUNDS RECEIVED
(if applicable) .... $ ________

TOTAL ANNUAL PAYMENTS .... $ _________

What is the interest rate and term of your loan?
______ % for ______ years

OPERATION AND MAINTENANCE COSTS

I **Fixed treatment costs** (average annual costs unless otherwise indicated. These are routine costs that can be expected each year. Please do not include replacement of major components such as pumps, chemical feed equipment, filter sand etc. Replacement of minor treatment components like cartridge filters or replacement/ regeneration of activated carbon **should be** included, however. Chemical costs are **not** included here, they are listed later under variable treatment costs).

A. Routine O & M

Operator salaries + fringe ..... $ ______

Average operator salary + fringe ______ $/hr

Office supplies .... $ ______

Telephones .... $ ______

Insurance .... $ ______

Electrical .... $ ______

Fuel .... $ ______

Travel .... $ ______

Training .... $ ______

Building maintenance .... $ ______

Service contracts .... $ ______

Water sampling & analysis ...... $ ______

Parts .... $ ______

Lubricants .... $ ______

Other (please describe) ____

____

________________ .... $ ______

TOTAL ANNUAL ROUTINE O&M COSTS .... $ ______

B. Replacement.

(Please list the estimated life of major **treatment** equipment components such as filter sand and anthracite, process pumps, chemical feed equipment, ion exchange media, instrumentation etc. Please also estimate the cost of repair or replacement.)

	Component	Est. life	Est. repl. cost
1.			
2.			
3.			
4.			
5.			
6.			

If possible, please indicate the total annual replacement cost below. What interest rate was used? _____ %

TOTAL ANNUAL REPLACEMENT COSTS .... $ _____

II **Variable costs** (Variable costs are those that vary with the amount of water treated, e.g. treatment chemicals, power costs for pumping and disposal of sludge. Please include whatever costs are available if you cannot provide the specific information requested.)

A. Chemical costs

Chemical Name	Average Dose (ppm)	Size of Containers (100 bags etc.)	Average Cost per year
________	________	________	________
________	________	________	________
________	________	________	________
________	________	________	________
________	________	________	________
________	________	________	________

Total chemical costs per thousand gallons (if available) .... $ _______

B. Power costs

What is your current unit power cost for your treatment and pumping equipment ($/kwh etc.)?

____

____

Is there a demand charge? (yes/no)
If yes, how much?

____

What is your average monthly (or annual) cost for power for your treatment and pumping equipment?

$ ________ per month/year

C. Waste disposal (sludge, brine etc.)

Please describe the estimated volume or weight of sludge produced annually and any costs associated with treatment if those costs are not included elsewhere.

____

____

____

____