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Point-of-Use or Point-of-Entry Treatment Options for Small Drinking Water Systems

Prepared For:

U.S. Environmental Protection Agency
Office of Ground Water and Drinking Water
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This document provides public water systems and States with the Environmental Protection Agency's (EPA's) current policy on point-of-use and point-of-entry devices used for compliance. The statutory provisions and EPA regulations presented in this document contain legally binding requirements. This document is not a regulation itself, nor does it change or substitute for those provisions and regulations. Thus, it does not impose legally binding requirements on EPA, States, or public water systems. This guidance does not confer legal rights or impose legal obligations upon any member of the public.

While EPA has made every effort to ensure the accuracy of the discussion in this guidance, the obligations of the regulated community are determined by statutes, regulations, or other legally binding requirements. In the event of a conflict between the discussion in this document and any statute or regulation, this document would not be controlling.

The general descriptions provided here may not apply to a particular situation based upon the circumstances. Interested parties are free to raise questions and objections about the substance of this guidance and the appropriateness of the application of this guidance to a particular situation. EPA and other decision-makers retain the discretion to adopt approaches on a case-by-case basis that differ from those described in this guidance where appropriate.

POU can refer to several different types of units: plumbed-in units; plumbed-in units with separate faucets for the POU device; faucet-attached units; and faucet-connected counter top units. This document focuses on plumbed-in units with separate faucets for the POU device. Such units are typically installed under the kitchen sink so as to provide convenient use for drinking and cooking water. Separate faucets allow for the use of untreated water for washing and cleaning, thus helping to reduce operating costs of the treatment device.

Mention of trade names or commercial products does not constitute endorsement or recommendation for their use.

This is a living document and may be revised periodically without public notice. EPA welcomes public input on this document at any time.

This document reflects the comments received from stakeholders on the March 2002 draft and has undergone peer review by experts in the field of POU and POE devices.

The term "State" as used in this document means both State and Primacy Agency.

Point-of-Use or Point-of-Entry Treatment Options for Small Drinking Water Systems

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Exhibits

Abbreviations

μg/l	Micrograms per Liter
μm	Micron Meter
AA	Activated Alumina
ANSI	American National Standards Institute
AwwaRF	American Water Works Association Research Foundation
AX	Anion Exchange
BAT	Best Available Technology
CCl_4	Carbon Tetrachloride
CCR	Consumer Confidence Report
CFR	Code of Federal Regulations
cfm	Cubic Foot per Minute
cfu	Colony Forming Units
$CHCl_3$	Chloroform
cm	Centimeter
CTA	Cellulose Triacetate
CWS	Community Water System
CX	Cation Exchange
DBA	Diffused Bubble Aeration
DNR	Department of Natural Resources
EBCT	Empty Bed Contact Time
EPA	United States Environmental Protection Agency
GAC	Granular Activated Carbon
GFH	Granular Ferric Hydroxide
gpd	Gallons per day
gpm	Gallons per minute
HFTF	High-flow Thin-film
HPC	Heterotrophic Plate Count
IOC	Inorganic Chemical
IX	Ion Exchange
kgal	1,000 gallons
MCL	Maximum Contaminant Level
meq	Milliequivalents
MGD	Millions of Gallons per Day
mg/L	Milligrams per Liter
ml	Milliliter

NPDWR	National Primary Drinking Water Regulation
NSF	National Sanitation Foundation
NTU	Nephelometric Turbidity Units
O&M	Operation and Maintenance
PCE	Tetrachloroethylene
pCi/L	picoCuries per Liter
POE	Point-of-Entry
POTW	Public Owned Treatment Works
POU	Point-of-Use
ppb	Parts per Billion
ppm	Parts per Million
psi	Pounds per Square Inch
PTA	Packed Tower Aeration
PWS	Public Water System
RCRA	Resource Recovery and Conservation Act
RO	Reverse Osmosis
SDWA	Safe Drinking Water Act
SDWIS	Safe Drinking Water Information System
SOC	Synthetic Organic Chemical
SSCT	Small System Compliance Technology
TCA	1,1,1-trichloroethane
TCE	Trichloroethylene
TDS	Total Dissolved Solids
TSS	Total Suspended Solids
TTHM	Total Trihalomethanes
UL	Underwriters Laboratories Inc.
UV	Ultraviolet Light
VOC	Volatile Organic Chemical
WHO	World Health Organization
WIA	Wattenburg Improvement Association
WQCD	Colorado Water Quality Control Division
WQA	Water Quality Association

Point-of-Use or Point-of-Entry Treatment Options for Small Drinking Water Systems

1. Introduction

The challenges facing small public water systems (PWSs) (systems serving 10,000 people or fewer) were a major focus of the 1996 Amendments to the Safe Drinking Water Act (SDWA). One way Congress sought to help systems meet these challenges was by explicitly allowing systems to install point-of-use (POU) and point-of-entry (POE) treatment devices to achieve compliance with some of the maximum contaminant levels (MCLs) established in the National Primary Drinking Water Regulations (NPDWRs) (Section 1412(b)(4)(E)(ii) of SDWA).

POU and POE treatment devices rely on many of the same treatment technologies that have been used in central treatment plants. However, while central treatment plants treat all water distributed to consumers to the same level, POU and POE treatment devices are designed to treat only a portion of the total flow. POU devices treat only the water intended for direct consumption (drinking and cooking), typically at a single tap or limited number of taps (Exhibit 1.1), while POE treatment devices are typically installed to treat all water entering a single home, business, school, or facility (Exhibit 1.2). The cost savings achieved through selective treatment may enable some systems to provide more protection to their consumers than they might otherwise be able to afford. Ultimately, POU or POE treatment devices may be an option for PWSs where central treatment is not affordable.

POU can refer to several different types of units: plumbed-in units; plumbed-in units with separate faucets for the POU device; faucet-attached units; and faucet-connected counter top units. This document focuses on plumbed-in units with separate faucets for the POU device. Such units are typically installed under the kitchen sink so as to provide convenient use for drinking and cooking water. Separate faucets allow for the use of untreated water for washing and cleaning, thus helping to reduce operating costs of the treatment device. It should be emphasized that when such a unit is installed for purposes of compliance with a contaminant regulation, the regular kitchen faucet itself (as well as any other faucet in the house) should only be used for cleaning and washing purposes. Water for cooking or drinking should come only from the tap with the POU device.

This guidance outlines the technical, operational, and managerial issues involved in implementing a POU or POE treatment strategy. It describes the types of contaminants that can and cannot be treated with POU and POE devices and offers recommendations on how to select, install, operate, maintain, and monitor this equipment. This guidance document is intended for small community water systems (CWSs), but non-community water systems also may find information in this document useful.

Additional information on POU and POE devices is also available from the National Sanitation Foundation on its web site at www.nsf.org.

Exhibit 1.1: Typical POU Installation

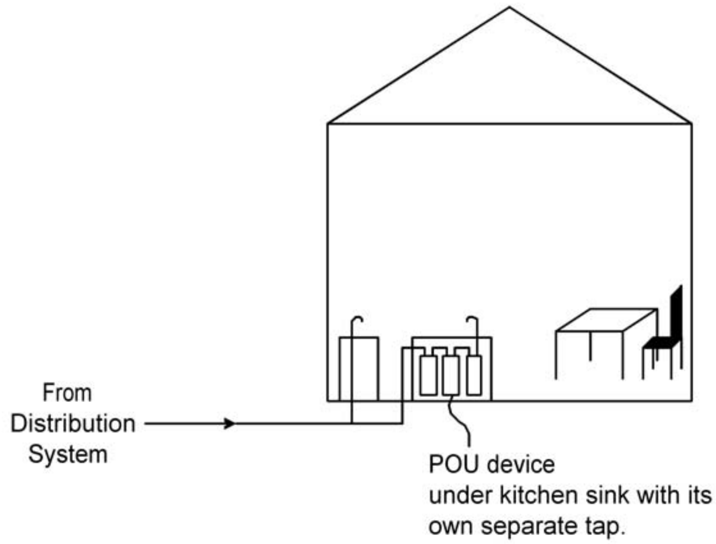
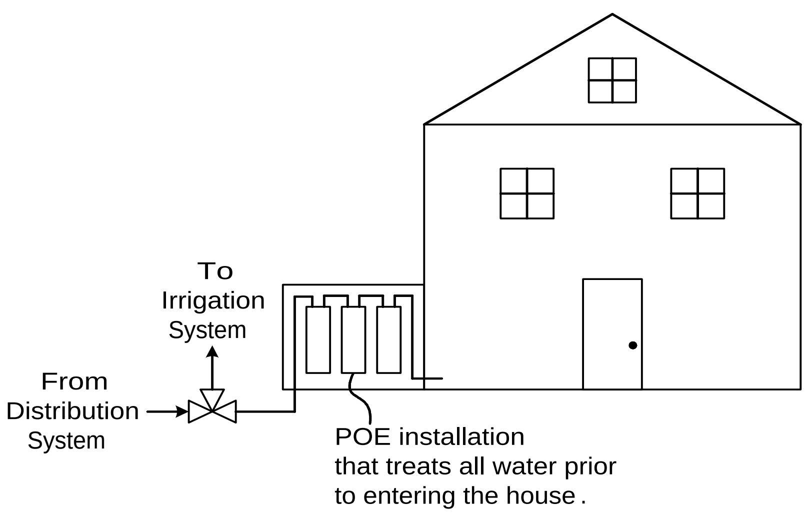


Exhibit 1.2: Typical POE Installation



This document is organized into six remaining chapters and eight appendices as follows:

Chapter 2. Existing Regulations. This chapter provides information on existing regulations that pertain to POU and POE devices. Applicable sections of SDWA and Title 40 of the Code of Federal Regulations (40 CFR) are presented and discussed.

Chapter 3. POU and POE Treatment Technologies. This chapter discusses POU and POE treatment technologies that are either listed in a final rule, listed in a proposed rule, or identified by EPA as a small system compliance technology (SSCT).

Chapter 4. Cost Considerations and Benefits of a POU or POE Treatment Strategy. This chapter briefly discusses the cost considerations and benefits a system may realize when implementing a POU or POE treatment strategy. For more detailed information on costs, refer to *Cost Evaluation of Point-of-Use and Point-of-Entry Treatment Units for Small Systems* (EPA, 2006).

Chapter 5. Implementation Considerations for POU and POE Devices- State and Local Regulations. This chapter presents system considerations, such as pilot studies, monitoring frequency, disposal permits, and other issues related to a POU and POE treatment strategy. The system should consult State and local regulatory personnel to identify regulations, requirements, or permits that may need to be addressed in order to implement a POU or POE treatment strategy.

Chapter 6. Site-specific Considerations for POU and POE Devices. This chapter will present issues the system should consider to effectively implement a POU or POE treatment strategy, such as public education, device selection, installation, liability, logistics and administration, and costs.

Chapter 7. Case Studies. This chapter contains case studies from systems throughout the country that have implemented a POU or POE treatment strategy. These case studies are presented to provide other systems with information on how to successfully implement a POU or POE treatment strategy.

Appendix A. Small System Compliance Technologies. This appendix lists the approved compliance technologies for small systems for arsenic and radionuclides.

Appendix B. Potential Funding Sources for the Implementation of a POU or POE Compliance Strategy. This appendix presents information on funding sources and contact information for different funding sources.

Appendix C. Model Ordinance Language for a System Implementing a POU or POE Compliance Strategy. This appendix contains model ordinance language a system may want to adopt for a POU or POE treatment strategy.

Appendix D. Sample Access and Maintenance Agreement. This appendix contains a sample access agreement systems may want to use to obtain access to private dwellings and facilities.

Appendix E. Sample Monitoring Log for POU or POE Devices. This appendix contains a sample monitoring log systems may want to use to document monitoring of POU and POE devices.

Appendix F. Sample Maintenance Log for POU or POE Devices. This appendix contains a sample maintenance log systems may want to use to document maintenance activities on POU and POE devices.

Appendix G. Sample Public Education Notice for Systems Using POU Devices for Nitrate Removal. This appendix contains a sample public education flyer that a system could use when POU devices are installed for nitrate removal.

Appendix H. Sample Public Education Notice for Systems Using POU Devices for Chronic Contaminant Removal. This appendix contains a sample public education flyer that a system could use when POU devices are installed for chronic contaminants besides nitrate.

2. Federal Requirements for POU/POE

Federal requirements establish a national basis for implementing a POU or POE treatment strategy. The most fundamental of these requirements are found in the 1996 Amendments to the Safe Drinking Water Act (SDWA) that are discussed below. Also important are existing federal regulations, which are discussed in Section 2.2.

2.1 Safe Drinking Water Act

To ensure the protection of public health, Section 1412(b)(4)(E)(ii) of SDWA regulates the design, management, and operation of POU and POE treatment units used to achieve compliance with an MCL. Key provisions of this section of SDWA are summarized in bold and italics as follows:

1. ***The statute prohibits EPA from listing any POU treatment units as an affordable technology to achieve compliance with an MCL or treatment technique for a microbial contaminant or an indicator of a microbial contaminant.*** However, the Act is silent on the use of POE devices to achieve compliance with microbial contaminants or indicators.

2. ***POU and POE units must be owned, controlled, and maintained by the PWS or by a contractor hired by the PWS to ensure proper operation and maintenance of the devices and compliance with MCLs.*** This provision does not require the PWS staff to perform all maintenance or management functions; the PWS can contract out these tasks. However, it does emphasize that the PWS retains final responsibility for the quality and quantity of the water provided to the service community and must closely monitor all contractors. Further, the PWS may not delegate its responsibility for the operation and maintenance of installed POU or POE devices to homeowners as part of a compliance strategy.

3. ***POU and POE units must have mechanical warnings to automatically notify customers of operational problems.*** Each POU or POE treatment device installed as part of a compliance strategy must be equipped with a warning device (*e.g.*, alarm, light, etc.) that will alert users when their unit is no longer adequately treating their water. Alternatively, units may be equipped with an automatic shut-off mechanism to meet this requirement.

4. ***If the American National Standards Institute (ANSI) has issued product standards for a specific type of POU or POE treatment unit, then only those units that have been independently certified according to these standards may be used as part of a compliance strategy.*** ANSI has adopted the standards for POU and POE devices developed by National Sanitation Foundation (NSF) International, formerly known as the National Sanitation Foundation. See Section 5.7 for more information on standards.

2.2 Federal Regulations

Existing Federal statutory language is not meant to be exhaustive, and Federal regulations do not address all aspects of system requirements that need to be considered when implementing a POU or POE treatment strategy. Therefore, systems are strongly encouraged to consult State and local regulatory personnel to obtain information on additional State and local requirements (see Chapter 5).

2.2.1 40 CFR Section 141.100 - Criteria and Procedures for PWSs Using POE Devices

40 CFR Section 141.100 (July 2005 Edition) addresses POE devices and contains language similar to that in SDWA. However, 40 CFR Section 141.100 is specific to POE devices only and ***does not*** address POU devices. This section of the rules states that POE devices may be used for MCL compliance if they meet the following criteria:

Systems should check with State and local regulatory agencies to determine if any State or local regulations exist for POU and POE devices. State and local regulations could exist that would preclude the use of some or all POU or POE devices. See Exhibit 5.1 in Chapter 5 for more information.

- ***It is the responsibility of the PWS to operate and maintain the POE treatment system.*** This section of the rule coincides with SDWA language and again establishes the requirement that the PWS is responsible for the POE device.

- ***The PWS must develop and obtain State approval for a monitoring plan before POE devices are installed for compliance. Under the plan approved by the State, POE devices must provide health protection equivalent to central water treatment. "Equivalent" means that the water would meet all NPDWRs and would be of acceptable quality similar to water distributed by a well-operated central treatment plant. In addition to the volatile organic chemicals (VOCs), monitoring must include physical measurements and observations such as total flow treated and mechanical condition of the treatment equipment.*** When a POE device is used for compliance with an MCL, the system must develop a monitoring plan that addresses the contaminant of concern and obtain State approval of the monitoring plan prior to installing the POE device. The monitoring plan should include frequency of monitoring for the contaminant of concern and number of units to be monitored. For instance, the system may propose to monitor every POE device during the first year for the contaminant of concern and then monitor one-third of the units annually, each on a rotating schedule, such that each unit would be monitored every three years. Also, the POE devices must provide health protection equivalent to central water treatment. In order to satisfy this requirement, the water system may be required to conduct a pilot study to verify the POE device can provide treatment equivalent to central treatment. In addition, the system would have to track the POE flow for a given time period, such as monthly, and maintain records of device inspection.

- ***Effective technology must be properly applied under the plan approved by the State and the microbiological safety of the water must be maintained. The State must require adequate certification of performance, field-testing, and if not included in the certification process, a rigorous engineering design review of the POE devices. The design and application of the POE devices must consider the tendency for increase in heterotrophic bacteria concentrations in water treated with activated carbon. It may be necessary to use frequent backwashing, post contactor disinfection, and heterotrophic plate count (HPC) monitoring to ensure that the microbiological safety of the water is not compromised.*** Again, the system must demonstrate that the technology is effective in removing the contaminant of concern and the system may be required to verify effectiveness through a pilot study or some other means. The system may also need to provide documentation that the POE device is adequately certified by an independent party for the applicable ANSI/NSF standards (see Section 5.7). If a rigorous engineering design review was not included in the certification process, the State must require the system to provide the engineering design review. The system also needs to maintain the microbiological safety of the water through such means as routine HPC testing at the POE devices (frequency of testing to be determined by the State), the installation of centralized disinfection, or the installation of disinfection, such as ultraviolet light (UV), at the POE device.

- ***All consumers shall be protected through proper installation, maintenance and monitoring. Every building connected to the system must have a POE device installed, maintained, and adequately monitored. The State must be assured that every building is subject to treatment and monitoring, and that the rights and responsibilities of the PWS customer convey with title upon sale of property.*** The system must install a POE device at every building connected to the system. Therefore, the system must obtain 100 percent participation of all property and/or building owners. Public education in order to obtain 100 percent participation is important to successfully implement a POE strategy (see Section 6.1). Also, the property owner's responsibilities for the POE device must be contained in the title to the property and "run with the land" so subsequent property owners understand their responsibilities.

2.2.2 40 CFR Section 142.62 - Variances and Exemptions from the MCLs for Organic Chemicals and IOCs

40 CFR Section 142 (July 2005 Edition) provisions relate to State programs for the implementation and enforcement of the NPDWRs. This section of 40 CFR also allows States to grant a variance or an exemption to a PWS at the State discretion.

2.2.2.1 40 CFR Section 142.62(f)

This section of the CFR reads as follows:

The State may require a PWS to use bottled water, POU devices, POE devices, or other means as a condition of granting a variance or an exemption from the requirements of §§141.61(a) and (c) and 141.62, to avoid an unreasonable risk to health. The State may require a PWS to use bottled water and POU devices, or other means, but not POE devices, as a condition for granting an exemption from corrosion control treatment requirements for lead and copper in §§141.81 and 141.82 to avoid an unreasonable risk to health. The State may require a PWS to use POE devices as a condition for granting an exemption from the source water and lead service line replacement requirements for lead and copper under §§141.83 and 141.84 to avoid an unreasonable risk to health.

This regulation allows the State to grant a variance or an exemption from the VOCs and synthetic organic chemicals (SOCs) listed in 40 CFR Sections 141.61(a) and (c) and the IOCs listed in 141.62 (that now includes arsenic) for a system using POU or POE devices. The POU and POE devices can be used by the system to avoid an unreasonable risk to health. This regulation also allows the use of POU devices, but not POE devices, as a condition of granting an exemption from corrosion control requirements for lead and copper (as required in 40 CFR Sections 141.81 and 141.82) which are briefly discussed in Section 2.2.4. The State may allow POE devices to be used as a condition of an exemption from the source water and lead service line replacement requirements for lead and copper (as required in 40 CFR Sections 141.83 and 141.84). See Section 2.2.4 for a brief discussion of these sections.

2.2.2.2 40 CFR Section 142.62(h)

This regulation reads as follows:

> ***PWSs that use POU or POE devices as a condition for obtaining a variance or an exemption from NPDWRs must meet the following requirements:***
>
> ***(1) It is the responsibility of the PWS to operate and maintain the POU and/or the POE treatment system.***
>
> ***(2) Before the POU or POE devices are installed, the PWS must obtain the approval of a monitoring plan which ensures that the devices provide health protection equivalent to that provided by central water treatment.***
>
> ***(3) The PWS must apply effective technology under a State-approved plan. The microbiological safety of the water must be maintained at all times.***
>
> ***(4) The State must require adequate certification of performance, field-testing, and if not included in the certification process, a rigorous engineering design review of the POU and/or POE devices.***
>
> ***(5) The design and application of the POU and/or POE devices must consider the potential for increasing concentration in heterotrophic bacteria concentrations in water treated with activated carbon. It may be necessary to use frequent backwashing, post contactor disinfection, and HPC monitoring to ensure that the microbiological safety of the water is not compromised.***
>
> ***(6) The State must be assured that buildings connected to the system have sufficient POU or POE devices that are properly installed, maintained, and monitored, such that all consumers will be protected.***
>
> ***(7) In requiring the use of a POE device as a condition for granting an exemption from the treatment requirements for lead and copper under §§141.83 and 141.84, the State must be assured that use of the device will not cause increased corrosion of lead and copper bearing materials located between the device and the tap that could increase contaminant levels at the tap.***

Regulations in 40 CFR Section 142.62(h) apply to both POU and POE devices; however, under this regulation, systems can only use these devices if they have been granted a variance or exemption from their State. The language in 40 CFR Section 141.62(h) is very similar to the language in 40 CFR Section 141.100, except that 40 CFR Section 141.62(h) allows the use of both POU and POE devices (in most instances) under a variance or an exemption. Also included in 40 CFR Section 142.62(h) is a condition for granting an exemption from the lead and copper source water and lead service line replacement requirements when a POE device is used. Under these circumstances, the State must be assured that the POE device will not cause increased corrosion of lead and copper between the POE device and the drinking water tap(s).

2.2.3 40 CFR Section 142.65 - Variances and Exemptions from the MCLs for Radionuclides

This regulation reads as follows:

(a)(2)A State shall require community water systems to install and/or use any treatment technology identified in Table A to this section* [see Exhibit A.2 of Appendix A]*, or in the case of small water systems (those serving 10,000 persons or fewer), Table B and Table C of this section* [see Exhibits A.3 and A.4]*, as a condition for granting a variance except as provided in paragraph (a)(3) of this section. If after the system's installation of the treatment technology, the system cannot meet the MCL, that system shall be eligible for a variance under the provisions of section 1415(a)(1)(A) of the Act.

…

(5) The State may require a community water system to use bottled water, point-of-use devices, point-of-entry devices, or other means as a condition of granting a variance or an exemption from the requirements of Section 141.66 of this chapter, to avoid an unreasonable risk to health.

This section of the CFR (July 2005 Edition) discusses the criteria the State must apply when issuing a variance or an exemption for regulated radionuclides. This section is similar to 40 CFR Section 142.62 (the provisions for granting a variance or an exemption to MCLs for organic chemicals and IOCs). It specifically lists both POU IX (for radium, beta particle activity and photon activity, and uranium) and POU RO (for all regulated radionuclides) as allowed SSCTs under a variance or exemption. Also included in 40 CFR Section 142.65 is the requirement for the system that uses POU or POE devices as a condition for obtaining a variance or an exemption from the regulated radionuclides to meet the conditions in 40 CFR Section 142.62(h)(1) through (6), as presented in Section 2.3.2 of this document.

2.2.4 Other Federal Regulations

- 40 CFR Section 141.62(d) lists both POU activated alumina (AA) and POU reverse osmosis (RO) as SSCTs (applies to systems serving 10,000 or fewer) for compliance with the revised arsenic standard of 0.010 milligrams per liter (mg/L), as promulgated in the Arsenic and Clarifications to Compliance and New Source Contaminants Monitoring Rule (Arsenic Rule) (January 22, 2001). This section of the CFR will not be discussed in this chapter, but more details on POU AA and RO are contained in Chapter 3 of this document. See also Appendix A for a list of SSCTs.

- 40 CFR Section 141.66(h) lists both POU ion exchange (IX) and POU RO as SSCTs (applies to systems serving 10,000 or fewer) for compliance with radionuclides, as promulgated in the Radionuclides Rule (December 7, 2000). POU IX is listed as an SSCT for compliance with the radium, beta particle activity and photon activity, and uranium MCLs. POU RO is listed as an SSCT for compliance for all regulated radionuclides. This section of the CFR will not be discussed in this chapter, but more details on POU IX and RO are contained in Chapter 3 of this document. See also Appendix A.

- 40 CFR Section 141.81 describes the criteria for compliance with the lead and copper corrosion control requirements. Basically, systems are considered to have optimized corrosion control if they meet the lead and copper action levels during two consecutive six-month periods, according to monitoring requirements in Section 141.86 (Section 141.86 requires that samples be taken from taps that do not have POU or POE devices).

Section 141.82 describes the options for corrosion control and the process for state approval, installation, and continued operation and monitoring.

- 40 CFR Section 141.83 describes the source water monitoring and treatment requirements for lead and copper. Systems that exceed the lead or copper action level, as measured under Section 141.86, must monitor source water. If lead or copper are found in the source water at levels of concern to the state, systems must install treatment and conduct follow-up monitoring at the tap. Systems that exceed the lead or copper action level after installing corrosion control treatment and/or source water treatment must replace lead service lines in their distribution systems, as required by Section 141.84.

- 40 CFR Section 141.23(a)(1) and (2) define a sampling point for monitoring purposes as occurring after the application of treatment. Therefore, monitoring of POU devices for the contaminant being treated should occur at the tap receiving the treatment. The treatment effectiveness of POE devices should be monitored after treatment has been applied.

- While not a regulation per se, EPA's 1998 *Federal Register* notice (63 FR 42032, August 6, 1998) published a list of small system compliance technologies appropriate for other contaminants. These technologies are described further in Section 3.1.1.

3. POU and POE Treatment Technologies

POU and POE treatment technologies are very similar to many centralized treatment technologies. As a State and system start evaluating POU or POE technologies, they should consider current rules and regulations that exist that govern POU and POE devices. Federal rules and regulations on POU and POE devices were presented in Chapter 2. Other rules (final and proposed) also exist that explicitly list POU or POE devices as SSCTs. They should also consider site-specific water quality issues and O&M issues that can impact the effectiveness of the technologies. These factors are summarized in Section 3.1.

3.1 Overview of POU and POE Treatment

3.1.1 Summary of Available POU and POE Treatment Technologies

The POU technologies discussed in this chapter include adsorptive media, ion exchange (IX), granular activated carbon (GAC), and reverse osmosis (RO). Adsorptive media such as activated alumina is listed as an SSCT for arsenic. Preliminary treatability data also suggest that it is effective for fluoride. AX is an SSCT for uranium and also can be used to remove arsenic. RO can remove contaminants as small as a molecule and is listed as an SSCT for arsenic, copper, lead, fluoride, radium and uranium. GAC is an SSCT for synthetic organic contaminants (SOCs, e.g., pesticides and herbicides). Both RO and IX are being studied for their ability to remove nitrate, which can also be removed through distillation.

Although some POU technologies are capable of removing microbial contaminants, VOCs, or radon, POU devices should not be used for achieving compliance with these contaminant rules. The SDWA strictly prohibits EPA from listing the use of POU devices as a compliance technology for any MCL or treatment technique requirement for a microbial contaminant or indicator of a microbial contaminant. VOCs and radon are both volatile and present an inhalation or contact exposure risk at untreated taps (e.g., showerheads). Therefore, POU devices at a single kitchen tap would not sufficiently protect the public from these risks.

The POE technologies discussed in this chapter include GAC and aeration. The proposed Radon Rule listed POE GAC as an SSCT. The proposed Radon Rule also explicitly stated that POU devices cannot be used for radon due to concerns of radon becoming airborne at untreated household taps. Aeration is a questionable POE technology for VOCs and Radon, due to off-gas emissions that make it unsuitable for residential use. As both of these technologies are prone to microbiological growth (particularly heterotrophic bacteria) in the filter media, it may be necessary to use UV disinfection and/or conduct heterotrophic plate count (HPC) monitoring after these treatment devices.

Currently, only two rules, the Arsenic Rule and the Radionuclides Rule, list POU devices as SSCTs. The Arsenic Rule lists POU AA and POU RO as SSCTs for those systems serving 10,000 or fewer people. The Radionuclides Rule lists POU IX (for radium, uranium, and beta particle activity and photon activity) and POU RO (for all regulated radionuclides) for those systems serving 10,000 or fewer people. (This chapter will focus on radium and uranium removal technologies as opposed to all regulated radionuclides.) These are the only two rules finalized since the 1996 SDWA Amendments that list POU technologies.

EPA has also developed an SSCT list for microbial and non-microbial contaminants, which was published in the *Federal Register* (Volume 63, No. 151, August 6, 1998). Three guidance documents were published by EPA to accompany the *Federal Register* notice for the SSCTs:

1. *Small System Compliance Technology List for the Surface Water Treatment Rule* (EPA 815-R-97-002, August 1997).

2. *Small System Compliance Technology List for the Non-Microbial Contaminants Regulated Before 1996* (EPA 815-R-98-002, September 1998).

3. *Variance Technology Findings for Contaminants Regulated Before 1996* (EPA 815-R-98-003, September 1998).

The aforementioned documents present background on the SSCT list published in the *Federal Register*.

Exhibits 3.1 and 3.2 present POU and POE technologies that could be used to remove the regulated contaminants listed. The exhibits list when POU or POE devices are:

- Listed or being considered as an SSCT by EPA; or,

- Considered technologically capable in the literature, but not listed as an SSCT by rule or in the *Federal Register*. Technologies denoted by an "x" as being able to remove a particular contaminant will not necessarily represent the most technically or economically feasible approach to the removal of that contaminant. A thorough evaluation of all the factors presented in Chapters 5 and 6 is required before selecting a treatment technology. Note that EPA's cost evaluation document will include only those devices certified under ANSI/NSF drinking water standards.

Even though Exhibits 3.1 and 3.2 show some treatment technologies as being able to remove a particular contaminant, only those technologies that have been through EPA's extensive regulatory review are listed as SSCTs.

Exhibit 3.1: Applicability of POU Treatment Technologies

Treatment Technology	Contaminant							
	Arsenic	Copper	Lead	Fluoride	Nitrate	SOCs	Radium	Uranium
Activated Alumina (AA)	SSCT			UI				X
Distillation [1]	X	X	X		SSCT		?	?
Granular Activated Carbon (GAC)						SSCT		
Anion Exchange (AX)	X				SFI			SSCT
Cation Exchange (CX)		SSCT	SSCT				SSCT	
Reverse Osmosis (RO)	SSCT	SSCT	SSCT	SSCT	SFI		SSCT	SSCT
Other Adsorption Media [2]	X							

[1] Large device size is not suitable for installation under the sink and has limited production capability, typically under 10 gallons/day
[2] Such as iron-, aluminum-, or titanium-dioxide-based media

SSCT = Treatment technology has been identified by EPA as an SSCT (*Federal Register*, Volume 63, No. 151, August 6, 1998).
SFI = Treatment technology has been suggested to receive further investigation for the listed contaminant (*Federal Register*, Volume 63, No. 151, August 6, 1998); anion exchange for nitrates is not currently recommended. See page 3-9.
UI= Under investigation; even though EPA continues to investigate the use of POU AA treatment, the preliminary view of treatability data indicates that it is effective.
X = Treatment technology can remove the noted contaminant, but is not listed as an SSCT in the *Federal Register* or in a rule.
? = Treatment technology is questionable for the listed contaminant.

Exhibit 3.1 (continued): Applicability of POU Treatment Technologies.

Treatment Technology	Contaminant						
	Antimony	Barium	Beryllium	Cadmium	Chromium	Selenium	Thallium
Anion Exchange (AX)	SSCT				SSCT	SSCT	
Cation Exchange (CX)		SSCT	SSCT	SSCT			SSCT
Reverse Osmosis (RO)	SSCT	SSCT	SSCT	SSCT	SSCT	SSCT	SSCT

SSCT = Treatment technology has been identified by EPA as an SSCT (*Federal Register*, Volume 63, No. 151, August 6, 1998).

Exhibit 3.2: Applicability of POE Treatment Technologies

Treatment Technology	Contaminant										
	Arsenic	Copper	Lead	Fluoride	Nitrate	SOCs	VOCs	Radon	Radium	Uranium	Microbial
Activated Alumina (AA)	X			X						X	
Aeration: Diffused Bubble or Packed Tower							Q	Q			
Granular Activated Carbon (GAC)						UI		PR			
Ion Exchange (IX)											
Anion Exchange (AX)	X				X					X	
Cation Exchange (CX)		X	X						X		
Ozonation											X
Reverse Osmosis (RO) [1]	X	X	X	X	X	X			X	X	X
Other Adsorption Media [2]	X										
Ultraviolet Light (UV)											X

[1] Currently, POE is excluded from NSF/ANSI 58 for RO devices; issues include the generation of large quantities of reject water and potential incompatibility of product water with copper pipes

[2] Such as iron-, aluminum-, or titanium-dioxide-based media

PR = Treatment technology is identified as an SSCT in the proposed Radon Rule for systems serving fewer than 500 people.
UI = Treatment technology is being investigated by EPA for the listed contaminant (*Federal Register*, Volume 63, No. 151, August 6, 1998).
Q = Questionable for residential use due to off-gas emissions; see discussion of limitations on page 3-13
X = Treatment technology can remove the noted contaminant, but is not listed as an SSCT or in a rule and may not be economically viable in certain situations.

3.1.2 Water Quality Issues That Affect POU and POE Devices

The use of specific types of POU and POE technologies may be restricted by site-specific water quality issues. The presence of high concentrations of competing contaminants or foulants can significantly reduce the removal efficiencies of these devices, making water quality testing and pilot testing important first steps in selecting a POU or POE technology. The table in Exhibit 3.3 shows the water quality parameters and competing ions that may reduce the efficiency of POU and POE devices.

Exhibit 3.3: Water Quality Parameters of Concern for POU and POE Technologies

Technology	Water Quality Parameter of Concern	Issue
Ion Exchange	Iron, Manganese, Copper	Fouling, Competing Ions
Adsorptive Media	Silica, Fluoride, Phosphate, Sulfate, Dissolved Iron and Manganese	Interfering/Competing Ions
Reverse Osmosis	Hardness, Iron, Manganese	Fouling
Granular Activated Carbon	Organics, multiple SOCs or VOCs present	Competing Ions
Aeration	Hardness, Iron, Manganese	Fouling, Scaling

3.1.3 O&M for POU and POE Technologies

All POU and POE devices require maintenance if they are to continue removing contaminants. Exhibit 3.4 presents O&M requirements for different POU and POE installations.

Exhibit 3.4: O&M for Various POU and POE Treatment Devices

Treatment Technology	Operation and Maintenance[1]
Adsorptive Media: Activated Alumina (AA)[2] and Specialty Media[3]	POU: Replacement of spent cartridges and particulate pre-filters (if used). POE: Periodic backwashing. Replacement of spent media and particulate pre-filters (if used). Maintenance and cleaning of storage tank (if used).
Aeration: Diffused Bubble or Shallow Tray	Only appropriate for POE Replacement of particulate pre-filters. Replacement of air filters for fan intake and for exhaust. Maintenance of fan, motors, and repressurization pumps. Replacement of post-treatment GAC polishing filters. Maintenance and cleaning of storage tank. If UV is used for post-treatment disinfection, replacement of UV bulb and cleaning bulb housing. If ozonation is used for post-treatment disinfection, maintenance of ozonation element.
Granular Activated Carbon (GAC)	POU: Replacement of spent cartridges and particulate pre-filters (if used). POE: Periodic backwashing. Replacement of spent media and particulate pre-filters (if used). Maintenance and cleaning of storage tank (if used). If UV is used for post-treatment disinfection, replacement of bulb and cleaning bulb housing. If ozonation is used for post-treatment disinfection, maintenance of ozonation element.

Treatment Technology	Operation and Maintenance[1]
Ion Exchange (IX): Anion Exchange (AX) and Cation Exchange (CX)	POU: Replacement of spent resin cartridges and particulate pre-filters (if used). POE: Regular regeneration and periodic backwashing. Replacement of salt used for resin regeneration. Replacement of lost or spent resin and replacement of particulate pre-filters. Maintenance and cleaning of storage tank (if used).
Reverse Osmosis (RO)	POU and POE: Replacement of exhausted membranes, particulate pre-filters, and pre- and post- treatment GAC filters. Maintenance and cleaning of storage tank. Maintenance of (re) pressurization pumps (if used).
Ultraviolet Light (UV)	POU and POE: Replacement of UV bulbs. Cleaning bulb housing.

1 Systems that elect to implement any POU or POE treatment strategy should conduct monitoring at each household according to a monitoring schedule approved by the appropriate regulatory agency (discussed in greater detail later in Section 5.10 of this document) to ensure proper unit operation.

2 The regeneration process for AA is complex and requires the use of strong caustics and acids. Therefore, to avoid potential health risks associated with the storage of these chemicals in residences, POE AA should only be considered for use on a throwaway basis unless systems can provide offsite regeneration and/or vessel exchange facilities.

3 Regeneration of specialty media is generally not effective due to the high affinity of the media for the contaminant(s) of concern and is typically a complex operation. Therefore, specialty media installed at the POU or POE should only be considered for use on a throwaway basis.

3.2 Examples of Treatment Approaches for Specific Contaminants

The following section focuses on the more likely applications of POU and POE devices. While many possible applications of either POU or POE are possible, it is beyond the scope of this guidance to address every one. The section is divided into subsections on contaminants that are most likely to be treated by POU devices, those that are apt to be treated equally well by either device, and those that are most likely to be treated only by POE devices. It should be noted that contaminants treated by POU devices could also be treated by POE devices under certain circumstances. Depending on the contaminant, economic factors and technical issues may influence whether a POE or POU approach is chosen. For example, just because arsenic treatment is discussed under POU technologies doesn't mean POE technologies might not be applicable in certain circumstances.

3.2.1 POU Technologies

3.2.1.1 Adsorptive Media for Arsenic and Selenium

Adsorptive media includes activated alumina (AA), granular ferric hydroxide (GFH), or other specialty iron-based media. AA is a hydrated aluminum oxide that has been heat-treated. Iron-based media is typically generated in a proprietary process and may consist of granules of ferric oxide or ferric hydroxide, activated alumina coated with iron, or natural minerals impregnated with a substantial quantity of ferric hydroxide.

Centralized AA treatment systems are often used for fluoride removal but are also applicable for arsenic (in an oxidized state) and selenium removal. Inorganic arsenic in groundwater supplies exists in two forms: as arsenate (As V) and arsenite (As III). The arsenite form of inorganic arsenic is uncharged at a pH below 9.2 and is, therefore, harder to remove from water. Arsenate, however, is an anion at a pH above 2.2 and is therefore easier to remove using an iron-based and/or other specialty media. Source water pH is typically adjusted in a centralized AA treatment setting to achieve optimum contaminant removal. Because POU AA units are not equipped to adjust the pH of the incoming water from typically neutral pH values of 7.0, the removal efficiency of POU AA may not be as optimal for these contaminants when compared to centralized treatment. However, EPA has determined POU AA to be a feasible treatment option for small systems treating for arsenic assuming the AA media is used on a throw-away basis (*i.e.*, no regeneration) and that arsenic exists in the oxidized state of arsenate (final Arsenic Rule). EPA is continuing to investigate the use of POU AA for fluoride and selenium; a preliminary review of treatability data indicates it is an effective treatment technology.

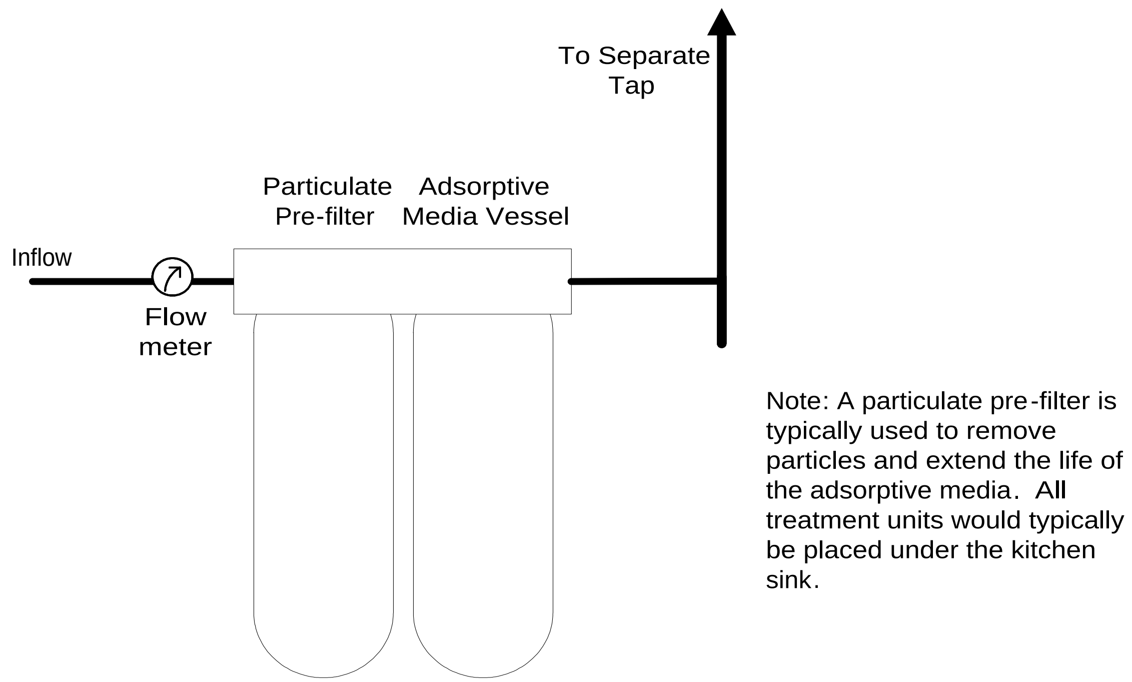
The use of specialty iron-based media is a relatively new treatment technology for arsenic removal and the media are currently being tested for POU feasibility by several companies using this media for centralized treatment. These iron-based media are not as sensitive to competing ions as AA and are typically used on a throwaway basis.

Raw water characteristics should be known, particularly pH and competing ions (fluoride and sulfate), when considering adsorptive media treatment options. When using AA, the greatest removal capacity for fluoride occurs at pH 5.5, and for arsenic, between pH 5.5 and 6.0. Hydroxide ions, which are the most highly preferred ions by AA, are more prevalent at higher pHs, and therefore compete with arsenic, fluoride, and selenium for available sites. Iron-based media have better arsenic removal over a broader range of pH, but manufacturers still do not recommend exceeding a pH of 8.5. Another factor inhibiting arsenic removal is the presence of interfering or competing ions such as silica, fluoride, phosphate, sulfate and dissolved iron and manganese. At certain concentrations, these competing or interfering ions can reduce the adsorptive capacity of the media for arsenic. However, iron-based media are typically not as sensitive to competing ions as AA.

In some cases, pilot testing may be very important to determine the adsorptive media's capability for each application. Water systems should consult with their State drinking water agencies concerning pilot testing requirements. Adsorptive media units should be installed with a particulate pre-filter to remove particles followed by the vessel containing the adsorptive media.

Exhibit 3.5 shows a typical POU adsorptive media installation. The units shown in Exhibit 3.5 are equipped with a pre-filter and one vessel filled with adsorptive media or a pre-manufactured cartridge that contains adsorptive media.

Exhibit 3.5: Typical POU Adsorptive Media Installation



<u>3.2.1.2 IX for Various IOCs, Radium, and Uranium</u>

IX can consist of anion exchange (AX) or cation exchange (CX). IX achieves the selective removal of charged inorganic species from water using an ion-specific resin (AWWA/ASCE 1998). As water containing undesired ions passes through a column of resin media, charged ions on the resin surface are exchanged with the undesired ions in the water. In a large centralized treatment system, the resin is regenerated and a regenerant waste stream is discharged. For POU units, the resin is replaced periodically as opposed to regenerating.

Resin fouling may occur if influent water has high concentrations of total suspended solids, iron, magnesium, or copper. Channels may develop in the resin bed if the pressure drop across the bed is too high due to fouling. These channels may permit water to pass through the unit without adequate contact with the treatment resin. Since POU IX units cannot be backwashed, the media life of these devices may be shortened when levels of these solids, iron, magnesium, or copper are high, and may preclude the use of these devices.

POE AX may be a preferred treatment alternative for nitrate, but POE AX is not listed as an SSCT at this time for any contaminant due to waste disposal and cost considerations. However, POU AX has been suggested by EPA to receive further investigation for nitrate removal. POU AX is listed by EPA as an SSCT for fluoride, antimony, chromium, selenium, and uranium.

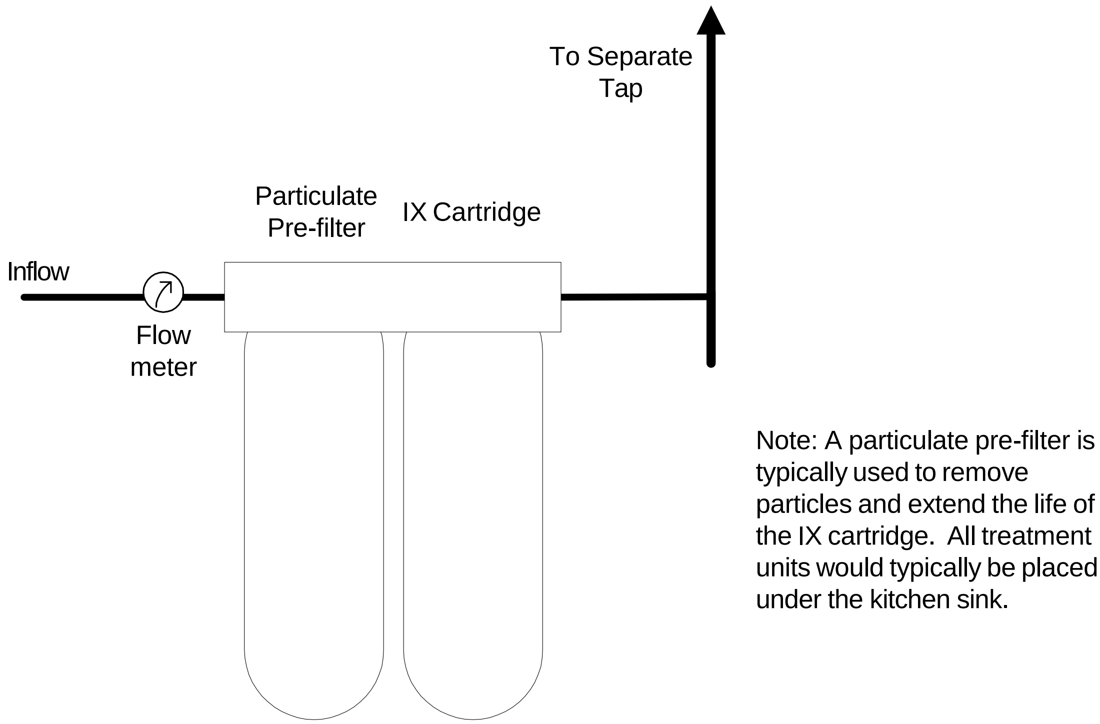
Special Considerations for Nitrate Treatment

Because POU devices do not treat all the water taps in a house, there is a potential health risk to household residents who consume untreated water. Households would need to be careful not to use untreated water to make infant formula. Nitrate is a potential hazard to infants; serious and occasionally fatal poisonings in infants have occurred following ingestion. Almost all established cases of water-related nitrate-induced methemoglobinemia in the United States have resulted from the ingestion of private well water used to make infant formula.

Water systems using POU treatment for nitrate removal should make special efforts to educate customers about the need for using only the tap that is treated, the health risks associated with consuming untreated water, and the need for a proper replacement frequency of the AX resins. Public education could include using the local newspaper, public notification by mail or posted in prominent places within the community, radio, television media and public forums. Including educational materials with the water bill is another option, as is the use of door hangers and fliers. Public outreach may result in significant costs and may offset any savings from using POU devices.

POU CX is listed by EPA as an SSCT for copper, lead, barium, beryllium, cadmium, and thallium. POU CX is listed as an SSCT in the final Radionuclides Rule for radium. Exhibit 3.6 shows a typical POU IX installation.

Exhibit 3.6: Typical POU IX Installation



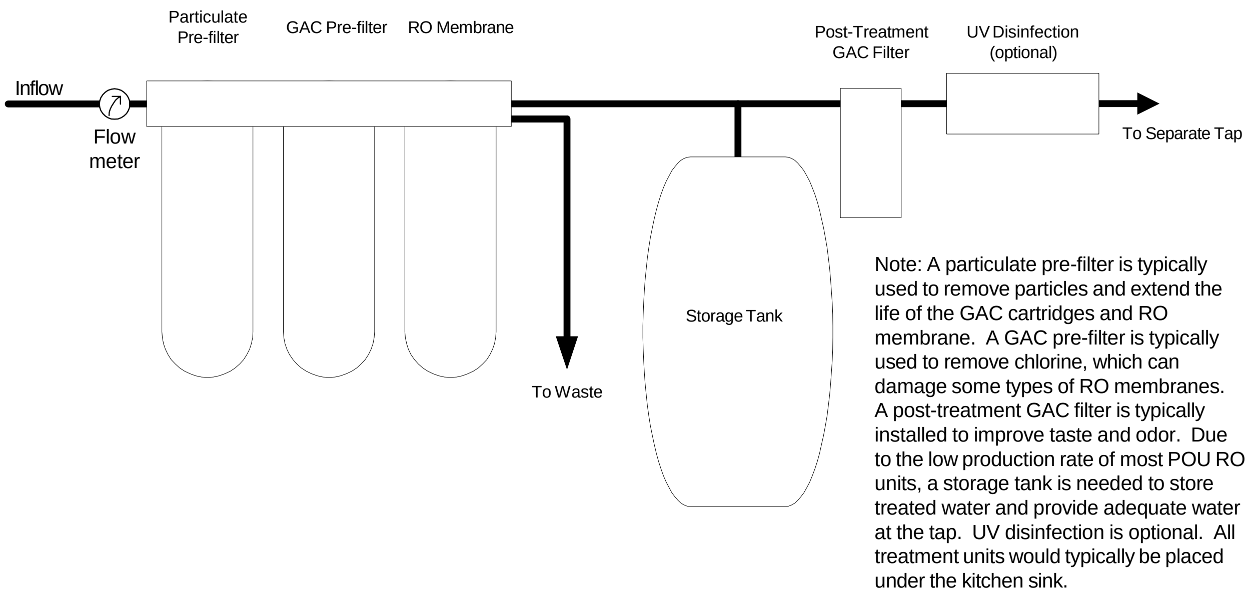
3.2.1.3 RO for Various IOCs, Radium, and Uranium

POU RO units essentially use the same technology as in centralized treatment. In RO, water dissolves into and through a membrane, while contaminant ions are rejected and discharged in a concentrated waste stream. Thus, POU RO units need to be provided with a means of discharging reject water to a drain. Some RO membranes are sensitive to chlorine, a consideration for those systems that have centralized chlorination installed. RO typically has a low production rate (around 40%), and storage is typically needed for a POU RO application.

High levels of water hardness tend to reduce membrane efficacy and result in more frequent replacement of the RO membrane. Also, high levels of iron, manganese, and aluminum can also cause membrane fouling. Additionally, RO units may not be the optimal treatment technology in arid or water-limited regions since RO units have low recovery rates.

POU RO has been identified in both the Arsenic and Radionuclides Rules as an SSCT for arsenic, uranium, and radium. POU RO is also listed as an SSCT by EPA for copper, lead, fluoride, antimony, barium, beryllium, cadmium, chromium, selenium, and thallium. POU RO is suggested to receive further investigation for its potential application for nitrate removal. The issues associated with using POU RO for nitrate are the same as presented in Section 3.2.2 for POU AX for nitrate. (See box on p. 3-10) Exhibit 3.7 shows a typical POU RO installation.

Exhibit 3.7: Typical POU RO Installation



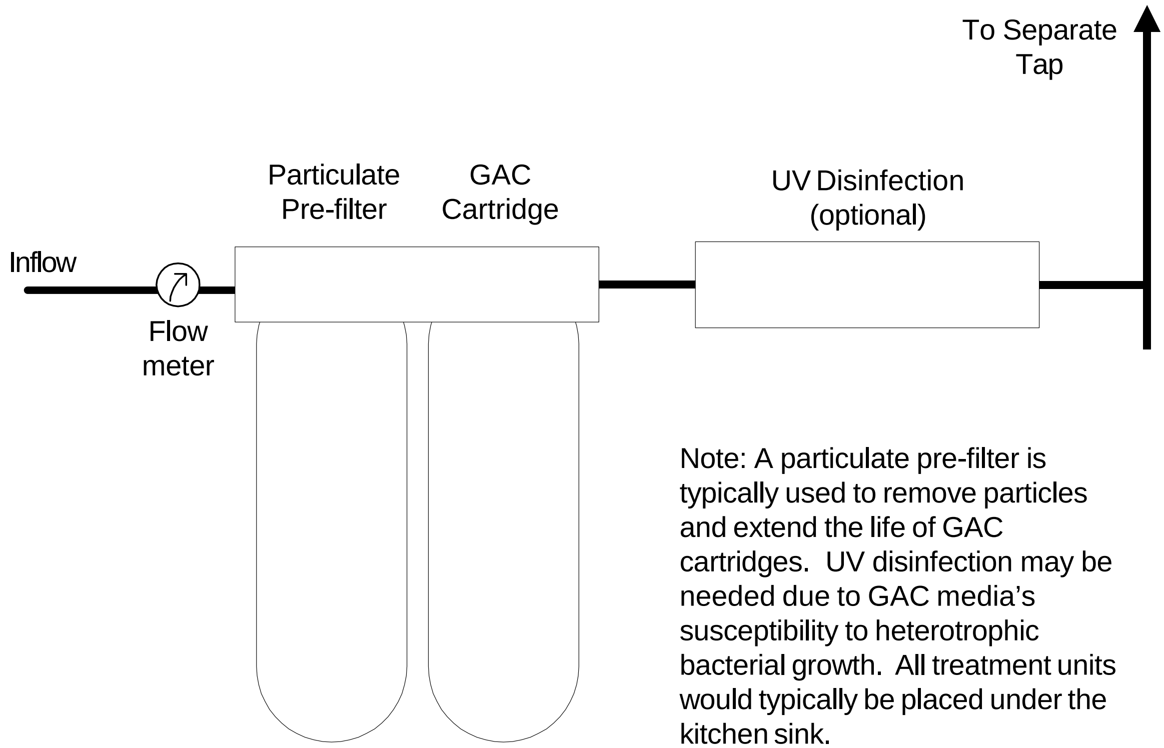
3.2.2 POU or POE Technologies—GAC for SOCs

POU and POE GAC are both potentially useful for small system applications for removal of SOCs. The capacity of GAC to adsorb SOCs varies, depending on the chemical properties of the SOCs. GAC has the added benefit of improving aesthetics (taste, odor, and color) of the water and is sometimes included in POU or POE applications for improved aesthetics. GAC unit performance and bed life depend on the amount of GAC used in the device, presence of co-occurring SOCs, other raw water parameters (e.g., pH) and the nature of the contaminants being removed.

In addition, GAC media are prone to microbial colonization (heterotrophic bacteria) on the GAC media. Some form of HPC monitoring and/or disinfection should be considered when using POU GAC and when using POE GAC, as mentioned in 40 CFR 141.100(d)(2).

POU GAC is listed as an SSCT for all regulated SOCs. POE GAC for SOC removal has been identified by EPA to receive further investigation. Exhibit 3.8 shows a typical POU GAC installation. A typical POE GAC installation is shown in Exhibit 3.10 in Section 3.4.

Exhibit 3.8: Typical POU GAC Installation



<u>3.2.3 POE Technologies—VOCs and Radon</u>

Due to the volatile nature of both VOCs and radon, many of the same concerns apply to both contaminants. Although not explicitly prohibited in SDWA or by rule, POU treatment devices *should not* be used to treat for radon or for most VOCs, including total trihalomethanes (TTHM) for compliance purposes, since these devices do not provide adequate protection against inhalation or contact exposure to these contaminants at untreated taps (*e.g.*, showerheads). Therefore, POU technologies are not considered for compliance technology listing even though many POU units have been certified for VOC reduction and a few for radon reduction. They have also been used by some consumers for further reducing the risk from at least the drinking water portion.

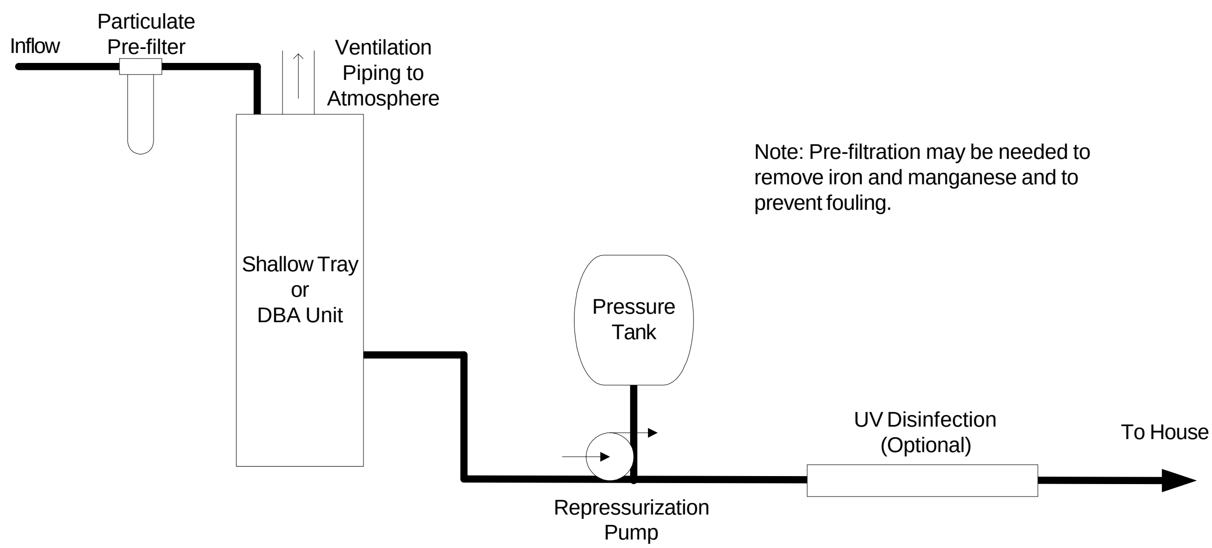
<u>Aeration</u>

Air stripping technologies such as shallow tray aeration and diffused bubble aeration (DBA) have been used in POE systems to remove VOCs from ground water (NRC, 1997). Similar to other aeration technologies, these systems rely on mass transfer to remove VOCs from water. While POE aeration is technically feasible, it is not commonly used for water systems and may not be as cost- effective as centralized aeration systems. Therefore, POE aeration has not yet been identified by EPA as an SSCT for VOCs. In addition, POE aeration was not identified in the proposed Radon Rule since it was not determined to be cost-effective.

The presence of high levels of iron or manganese can cause fouling of POE aeration units. The oxygen in the air bubbling through the water can oxidize the iron and manganese in the water and cause it to precipitate. Therefore, preoxidation and pre-filtration may be needed to remove iron and manganese and prevent fouling. In addition, UV disinfection may be necessary after as aeration devices are prone to bacterial and algal growth.

The potential for off-gas emissions from POE units is more likely to be a problem because these POE units would be located near homes. Off-gases may have to be treated using a scrubber, thereby increasing the complexity and the cost of the aeration units. Also, there is the potential for water quality deterioration from oxidized inorganics and instability resulting in corrosion and biological growth in the aeration device. Post-treatment disinfection may be needed with POE aeration units. For these reasons, this type of technology may be more appropriate for institutions that have adequate maintenance capabilities, rather than for homeowners. Exhibit 3.9 shows a typical POE aeration installation.

Exhibit 3.9: Typical POE Aeration Installation

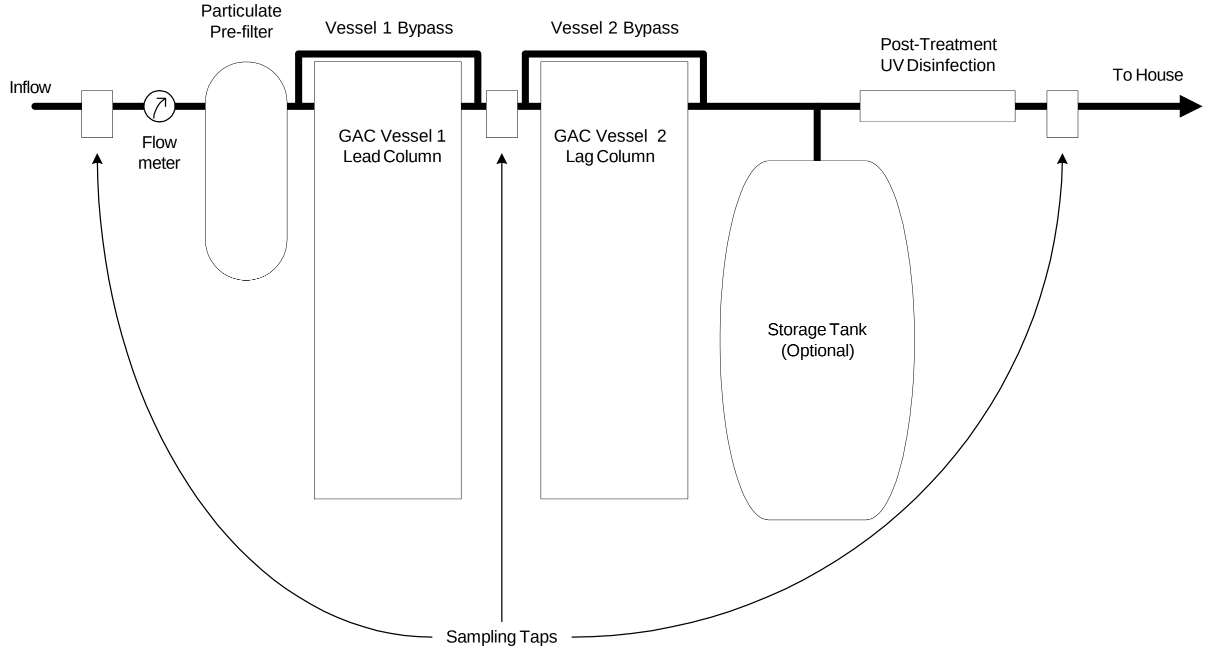


GAC

POE GAC has been identified in the proposed Radon Rule as an SSCT. This technology was determined to be a cost-effective and feasible treatment option for small systems. Proper disposal of GAC media should be evaluated since the spent media will contain radionuclides. Exhibit 3.10 shows a typical POE GAC installation. *Note that the Exhibit is only suggesting vessel bypass and not raw water bypass. This would only happen when media in either column is being replaced.*

As discussed in Section 3.3, natural organic matter and co-occurring VOCs or SOCs can reduce the efficiency of GAC. The pH of the water and the presence of iron, manganese, and calcium salts can affect the adsorption ability of the GAC media. In addition, GAC media are prone to microbial colonization (heterotrophic bacteria) on the GAC media. Some form of HPC monitoring and/or disinfection should be considered when using POU GAC and when using POE GAC, as mentioned in 40 CFR 141.100(d)(2).

Exhibit 3.10: Typical POE GAC Installation



Note: A particulate pre-filter is typically used to remove particles and extend the life of the GAC media. The GAC vessels are typically installed in series as a safety measure, with the first vessel functioning as a roughing unit and second vessel functioning as a finishing unit. A storage tank may be needed to store treated water and provide adequate water at the tap. UV disinfection is needed due to GAC media's susceptibility to heterotrophic bacterial growth.

3.3 Microbial Contaminants

SDWA (Section 1412(b)(4)(E)(ii)) states that POU devices cannot be listed as a compliance technology for any MCL or treatment technique requirement for a microbial contaminant or an indicator of a microbial contaminant.

SDWA does not exclude POE devices to be used to achieve compliance with microbial contaminant regulations or an indicator of a microbial contaminant. Several questions regarding disinfection require resolution before POE disinfection units, such as UV or ozonation, may be considered a viable option. As a result, EPA has not yet listed any POE device for microbial contaminant removal. If POE devices were used for a microbial contaminant or an indicator of a microbial contaminant, it would be necessary to determine a suitable degree and frequency of monitoring finished water quality to ensure health protection. Frequent monitoring needs could render POE devices impractical as a compliance technology for a microbial contaminant or an indicator of a microbial contaminant. Therefore systems should evaluate the cost effectiveness of centralized treatment in comparison with POE devices. In some systems, such as those serving large irrigated farms with worker housing, there may be cost savings associated with the POE disinfection option.

3.4 References

AWWA/ASCE. 1998. *Water Treatment Plant Design*. Third Edition. McGraw Hill. New York, NY.

NRC (National Research Council). 1997. *Safe Drinking Water from Every Tap: Improving Water Service To Small Communities*. National Academy Press. Washington, D.C.

4. Cost Considerations and Benefits of a POU or POE Treatment Strategy

Implementing a POU or POE treatment strategy may be substantially less expensive than building, expanding, or upgrading a central treatment plant since only a portion of water used in the household is treated to a higher level. Systems should understand both capital and O&M costs associated with a device and factors that impact costs.

For further information on costs, refer to Cost *Evaluation of Point-of-Use and Point-of-Entry Treatment Units for Small Systems* from EPA, which should be available during the 2nd half of 2006.

When a system determines that a POU/POE treatment device can adequately address site-specific factors and can comply with all State, local, and Federal regulations, (see Chapters 5 and 6) the system should then develop a cost estimate. The system should seek assistance from a professional when developing the estimate. The goal of the cost estimate is to determine if the POU or POE treatment strategy selected for consideration would be economically feasible in a full-scale application when compared to other alternatives.

When developing an estimate, systems should obtain capital costs and O&M costs. All the considerations listed in this chapter and Chapters 2, 5 and 6 should be evaluated. However, O&M costs associated with inspection, maintenance, and monitoring POU or POE devices may be difficult to determine. Systems should contact several vendors when seeking to purchase or lease POU or POE units to request references and replacement part costs from each vendor. Systems should also keep in mind that higher maintenance and monitoring costs may offset initial reduction in capital expenditures. In other words, the lowest bid may not necessarily be the cheapest option for a system if higher O&M costs are incurred.

Capital costs are affected by the following:

- Purchase costs. Purchase costs can be influenced by device configuration, ANSI/NSF certification, device production rate, volume discount rates, post-device disinfection, alarms, meters, and life of the unit.

- Installation costs. Installation costs can vary significantly depending on the type of POU/POE unit, complexity of the unit, and size of the unit. Some devices, such as POU RO or POE IX devices that regenerate automatically, require that a waste discharge line be installed that could affect costs. Also, POU devices installed under a sink may require additional carpentry work for the POU device to fit under the sink. Some systems may also elect to have a licensed plumber or other professional install the device, which would further affect installation costs.

- Number of taps being treated. If the system decides to install POU devices at multiple taps within each household (such as at the kitchen and bathroom sinks), then the capital costs will increase since more devices will need to be purchased.

- Engineering analysis or preliminary study. The system should acquire a professional to assist the system with evaluating all alternatives and determining if a POU/POE treatment strategy is the most cost-effective alternative.

- Permitting costs. The system may incur costs for permitting of the POU/POE treatment strategy. For instance, some States require an engineering review and approval of any treatment installed at a public water system and a fee is usually assessed by the State for this review.

- Pilot testing. In some instances, the system may elect or may be required to conduct a pilot study to verify the selected POU or POE device will adequately treat the water. A professional is usually needed to assist the system with establishing the pilot test protocol, overseeing the pilot test, taking samples to verify level of treatment (resulting in laboratory analysis costs), and developing a report that presents the pilot test results.

- Legal costs. The system may need to obtain legal assistance to develop access agreements that will grant system personnel, or an individual under contract with the system, legal access to all POU or POE devices for maintenance and monitoring.

- Public education. The system should invest in public education prior to installation of a POU or POE device. The system should educate its customers about POU/POE devices, how the devices work, required maintenance and monitoring, and the need for someone to have access to the device to perform required maintenance and monitoring.

O&M costs will be affected by the following:

- Maintenance frequency. The maintenance frequency will depend on site-specific conditions and should be established through a pilot test study. Maintenance will include replacement components (such as replacement cartridges) and labor. Labor costs typically consist of system personnel (a certified operator and clerical staff) or an individual under contract with the system to perform maintenance. Labor will include making the arrangements for the maintenance call and performing the maintenance call. A device that requires frequent maintenance visits may result in substantial O&M costs. For additional information on maintenance frequencies and associated costs, consult Chapter 6 of the EPA/AWWARF study, "POU/POE Implementation Feasibility Study for Arsenic Treatment."

- Emergency maintenance contingencies. The calculation of maintenance costs should also take into account unanticipated service calls to address leaks and other repairs. Service calls attended by the local vendor/representative are often charged by the hour (traveling time and repair time) and can represent an additional expense to the POU unit owner.

- Monitoring frequency. Monitoring costs consist of laboratory analyses costs and labor. Labor costs typically consist of system personnel (a certified operator and clerical staff) or an individual under contract with the system to perform monitoring. Labor will include making the arrangements for the monitoring visit and taking the water sample. A device that requires frequent monitoring may result in substantial O&M costs.

- Residual disposal. In some instances, the system may have to develop a new waste disposal system to accept the waste from devices, such as RO devices or IX devices that regenerate automatically. The system will probably experience ongoing costs for the O&M of the waste disposal system.

- Public education. The system should provide continued public education to customers and have someone available to answer questions. Also, the system should educate new customers on the POU/POE devices.

- Insurance costs. The system may need to obtain additional insurance to cover itself and employees since POU/POE devices are installed inside a private residence. The system should have adequate coverage in the event personal property is damaged (such as a POU/POE device that leaks and damages flooring).

Refer to Chapters 5 and 6 for more information on factors influencing POU/POE costs.

The system should consult a professional to assist the system with identifying alternatives, developing costs, and device selection. Leasing POU units could also significantly influence both capital and O&M costs. Under a purchase arrangement, the water system is responsible for capital and O&M, as well as for monitoring and repair costs to keep all the units operating properly. Under a lease arrangement, on the other hand, the system pays a fixed lease price to the vendor who then becomes responsible for all the above services. Thus, purchasing is likely to result in higher costs initially for capital expenditures. But under a leasing arrangement, the monthly payments would likely exceed operating, replacement and repair costs ordinarily associated with a treatment system that was purchased. The systems should therefore evaluate each option by estimating total costs over a considerable period of time, such as the expected lifetime of the units. Some sources of funding may be available to small systems attempting to achieve compliance with the NPDWRs by implementing a POU or POE strategy. Refer to Appendix B for more information on funding sources.

The cost findings for POU and POE devices compared to centralized treatment are discussed in *Cost Evaluation of Point-of-Use and Point-of-Entry Treatment Units for Small Systems*, which should be available from EPA during the second half of 2006. The POU and POE devices examined in the cost document are only those certified under ANSI/NSF Standards 44, 53, or 58 (see Section 5.7 for more information on ANSI/NSF Standards).

5. Implementation Considerations for POU and POE Devices

The considerations discussed in this chapter should be thoroughly addressed prior to any long-term investment in a POU or POE device, since each may impact the total cost of the entire undertaking. The requirements and considerations will vary depending on whether the POU or POE strategy is being implemented as a long-term compliance strategy or is being allowed under a variance or exemption.

Regardless of the reasons for choosing POU or POE treatment devices, the system will need to invest resources in public education of the service community prior to installing the device and have ongoing public education after installation (see Section 6.1). Relevant case studies (where available) are referenced at the end of each section in this chapter and can be found in their entirety in Chapter 7.

5.1 General State and Local Regulations and Requirements

In addition to the existing Federal requirements presented in Chapter 2, the system should fully understand that State and local regulations that may also affect the selection of a POU or a POE strategy. Many factors may deter or even prevent POU or POE as a treatment option. If POU or POE treatment is a strategy that systems decide to consider, it is important to immediately begin discussions with State and local regulatory agencies to identify their requirements for POU and POE devices.

The State may also want a feasibility study or similar study to justify the selection of POU or POE option for achieving compliance as opposed to other alternatives, such as blending, developing a new source, centralized treatment, or connection to a nearby water system. A pilot test may also be required to demonstrate the performance of the selected POU or POE device (see Section 5.2).

Exhibit 5.1 on the following pages shows the results of a survey of twenty-four State regulatory agencies dealing with the implementation of POU and POE policies. The table is taken from AWWA Research Foundation report 2730, *POU/POE Implementation Feasibility Study for Arsenic Treatment* (Narasimhan 2005). This table should not be considered a substitute for direct discussions with the State, particularly as State rules and policies are continuously evolving in this area.

Exhibit 5.1 Summary Of Survey Responses From State Regulatory Agencies

State	1. State agency with primacy authority for POU/POE rules, policy & guidance	2. POU/POE rules, policy, or guidance in place for implementation, reporting?	3. POU/POE rules, policy, or guidance in place for monitoring criteria?	4. State experience in regulating POU/POEs for SDWA compliance	
				Limitations	Potential solutions
Alaska	Dept. of Environ. Conservation	None in place	None in place	Not available	Not available
Arizona	Dept. of Environ. Quality	POU & POE rules in place, policies & guidance in process	POU & POE rules in place, policies & guidance in process	Not available	Not available
California	Dept. of Health Services	POE requirements for irrigation districts	POE requirements for irrigation districts	POE operating cost for small system	None
Delaware	Dept. of Health & Social Services	POU policy under development	POU policy being developed	Use of POUs limited to single service connection	Not available
Florida	Dept. of Environ. Protection	POU and POE rules	POU and POE rules	No experience	No experience
Idaho	Dept. of Environ. Protection	POU guidance, limited POE guidance	POU guidance in place, limited POE guidance	Achieving full participation by individual customers	National regs/guidance to require full participation
Illinois	Rules - IL Pollution Control Board	POU rules for emergency situations	POE rules in place	Just getting started, will adjust as needed during development	Hardness as indicator of radium content
	Policy - Illinois EPA	POE rules allow installation POE policy & guidelines being developed	POE policy & guidelines under development		
Indiana	Dept. of Environ. Management	None in place	None in place	Not available	Not available
Kansas	Dept. of Health & Environment	None in place	None in place	No answer provided	No answer provided
Maine	Maine Drinking Water Program	None in place	None in place	Not available	Not available
Massachusetts	Dept. of Environ. Protection	POU & POE rules (310 CMR 22.23) POU & POE policies under development	POU & POE rules in place, POU/POE policies being developed	No experience to date	No experience to date
Michigan	Dept. of Environ. Quality Water Div.	None in place	None in place	No answer provided	No answer provided
Missouri	Dept. of Natural Resources, Public Drinking Water Program	None in place	None in place	No answer provided	POUs for PB removal in school drinking fountains
Nevada	State Health Div, Bureau of Health Protection Services	None in place	None in place	No answer provided	No answer provided
New York	State Dept. of Health	POE rules in place, POE policy & guidance under development	POE policy & guidelines under development	Insuring continued O&M of the units	Require regular reporting as part of routine monitoring
North Dakota	Department of Health	None in place	None in place	No answer provided	No answer provided
Pennsylvania	Dept. of Environ. Protection, Bureau of Water Supply & Wastewater Mgt.	POU & POE rules in place	POE rules in place	POU only treats at single tap & not whole house	Restrict POUs to temp. use, restrict POEs to v. small systems
Rhode Island	Department of Health, Office of Drinking Water Quality	POU & POE rules in place	POE rules in place	POUs not allowed for compliance	No answer provided
S. Carolina	Dept. of Health & Environ. Control	POU & POE rules in place	Not available	No answer provided	No answer provided
Utah	Dept. of Env. Quality, Div. of DW	None in place	None in place	Not available	Not available
Vermont	State Water Supply Division	POU policy (case by case basis)	None in place	Only 1 potable tap	No answer provided
Virginia	Department of Health	POU & POE rules in place	No answer provided	No answer provided	No answer provided
Washington	State Dept. of Health	POU & POE policies in place POU & POE guidance under development	None in place (but under development)	Securing access to homes, 100% of connections must be treated	Restrict units to non-community settings; avoid monitoring at POU/POE taps
Wisconsin	Dept. of Natural Resources	POU rules in place	None in place	Not available	Not available

Exhibit 5.1 (continued)

State	5. Guidance/procedures in place if segment of community does not want to install POUs?	6. POUs or POEs allowed for which contaminants?	7. What system sizes can use POUs by regulation or policy?	8. What size systems are currently using POU devices?	9. Info. on systems currently using POUs for compliance purposes
Alaska	None	None	None	None	Not available
Arizona	In process of development	Radionuclides, As, Cr, VOCs	All	None	Not available
California	All must participate, water system responsible for resolving problem	Radionuclides, As, Cr, turbidity, microbials, VOCs	All	None	Pilot study in comm of 200, treating for As using activated alumina
Delaware	Not available	Nitrates	25-100	25-100	GW systems serving <100, nitrates, RO & Ion Exchange
Florida	None	Radionuclides, As	25-100, 101-1000	None	None used
Idaho	None at present	As, Cr, nitrate, F, Pb, Ba, Be, Cd, Cu, Se, thallium, cadmium	<25, 25-100	None	2 small systems - <100 - have explored POUs but not implemented
Illinois	Need to have 100% compliance	Only radium at this time	None	None	None used
Indiana	None in place	May only be used temporarily	None	None	None
Kansas	None	None	No answer provided	25-100	57 connections, GW, RO for Se & As
Maine	Not available	As under consideration	None	None	Not available
Massachusetts	No POU units approved for homes in a PWS	As, Cr, compliance with other MCLs if ANSI/NSF certified	No answer provided	No answer provided	No experience with POUs for compliance
Michigan	No answer provided	No answer provided	No answer provided	None	No answer provided
Missouri	None	Lead, POU/POE use considered on a case by case basis	None	501-3300 (515)	Elem school, GWw/Pb, cartridge POUs on drinking fountains
Nevada	None	No answer provided	No answer provided	None	No answer provided
New York	None	Radionuclides, As, Cr, turbidity, microbials, VOCs for POEs	None	None	No POU
North Dakota	No answer provided	No answer provided	No answer provided	None	No answer provided
Pennsylvania	POUs not acceptable for compliance short-term use only accepted	Radionuclides, As, Cr, turbidity, microbials, VOCs for POEs	None	None	POUs not accepted for compliance short-term use only accepted
Rhode Island	None, all must be protected	No list of approved applications, case by case basis	None	None	No answer provided
S. Carolina	No answer provided	No answer provided	No answer provided	No answer provided	No answer provided
Utah	Not available	No answer provided	None	None	Not available
Vermont	None, this would be a major problem	Radionuclides, As, microbials, VOCs - Yes; turbidity - maybe	None (case by case basis)	None	Not available
Virginia	No answer provided	No answer provided	No answer provided	No answer provided	No answer provided
Washington	100% of community must be covered, policy being developed to prohibit POU/POEs for community WSs	Radionuclides, Cr, As, VOCs noncommunity only	All	25-100, 101-500	small GW systems with POUs for nitrate treatment will not be allowed in future
Wisconsin	Not available	Radionuclides, POEs - some TCR and nitrate	All	None	None currently installed in community systems

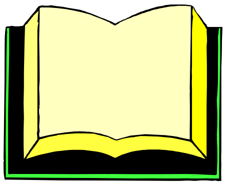
Exhibit 5.1 (continued)

State	10. Info. on system currently using POEs for compliance purposes	11. Experience/policies re. to WQ degradation due to membrane fouling, microbial degradation, loss of adsorptive capacity, other?	12. For communities using POU systems, estimate % that discharge wastewater to sewer, and % that discharge to septic systems	13. Concerns regarding wastewater from RO POUs and its disposal?	14. Attitude & perceptions of consumers in community where systems have been installed?
Alaska	Not available	Not available	Not available	Yes, will be a concern	Not available
Arizona	Not available	No answer provided	Not available	Not available	Good
California	Not available	Not available	Not available	None identified	Excellent, not clear if attitude will remain as positive once study is over & water system takes over
Delaware	Not available	Not available	Not available	No	No answer provided
Florida	None used	None identified	Not available	None identified	Not available
Idaho	Not available	None identified	100% septic systems	Yes	Average, unknown
Illinois	None so far, but have several GW supplies <500 that will use IEx for radium removal	Not available	Not available	No answer provided	No answer provided
Indiana	None	Not available	None	No answer provided	Unknown
Kansas	No answer provided	No answer provided	100% septic systems	No	Too early to tell
Maine	Not available	No answer provided	No answer provided	No answer provided	No answer provided
Massachusetts	Not available	Not available	Not available	Yes, brine disp regulated	No answer provided
Michigan	No answer provided	No answer provided	No answer provided	No answer provided	No answer provided
Missouri	Not available	No known problems	Not known	Not available	Excellent
Nevada	No answer provided	No answer provided	No answer provided	No answer provided	Unknown
New York	Limited use of POEs for SW & GW w/ VOCs & private wells	Yes - all, extensive experience w/ use of POEs for VOCs at wells	Not known	None in place at PWSs	Good, average
North Dakota	No answer provided	No answer provided	No answer provided	No answer provided	No answer provided
Pennsylvania	Small GW systems using UV POEs for disinfection	No answer provided	No answer provided	No answer provided	Unknown
Rhode Island	No answer provided	No answer provided	No answer provided	No answer provided	No answer provided
S. Carolina	No answer provided	No answer provided	No answer provided	No answer provided	No answer provided
Utah	Not available	No answer provided	Not available	Not available	Unknown
Vermont	Not available	No answer provided	No answer provided	Yes, would be regulated & be a problem for leachfields	No answer provided
Virginia	No answer provided	No answer provided	No answer provided	No answer provided	No answer provided
Washington	Not aware of any, some POEs may be used for single connection systems	Membrane fouling, policy requiring alarms under development	100% septic systems	None. Small amount of WW,all on septic systems	Unknown
Wisconsin	Small non-community GW systems for TCR compliance	No	Not available	Yes	Unknown

Exhibit 5.1 (continued)

State	15. Who is responsible for O&M of POU/POE devices?	16. What % of POU/POEs comply with SDWA MCLs?	17. What % of POU/POEs meet monitoring requirements?	18. Planned or proposed activities for SDWA compliance using POU/POE systems?	19. Related local or county regulations in state and contacts?
Alaska	Not available	Not available	Not available	Compliance & PH protection for As, radionuclides, nitrates	Not available
Arizona	Utility or 3rd party contractor	Not available	Not available	Currently monitoring 2 POU pilot projects	No
California	Equipment vendor (for pilot study)	Not available	Not available	Only to advise small WSs of this potential option for achieving compliance	No
Delaware	Utility	>90%	>90%	Waiting on EPA guidance	Not available
Florida	Not available	Not available	Not available	None	Not available
Idaho	Utility, 3rd party contractor, equipment vendor	Not available	Not available	None planned, awaiting further experience & interest	No answer provided
Illinois	Not available	Not available	Not available	Radionuclides using POE, may expand to other MCLs as experience is gained	No answer provided
Indiana	Not available	Not available	Not available	None, unless for emergencies	None
Kansas	City contract w/ vendor	No answer	No answer	None at present	Not aware of any
Maine	No answer provided	No answer	No answer	Under consideration for As	Not aware of any
Massachusetts	No answer provided	No answer	No answer	Developing guidance to det. DEP acceptance of POU/POEs	None
Michigan	No answer provided	No answer	No answer	May allow for contaminants reg. by Fed rule, but not microbials	No answer provided
Missouri	Utility	>90%	>90%	May allow POU/POEs in existing PWs on case by case basis	Not available
Nevada	No answer provided	No answer	No answer	Subject to reg. development	No
New York	Utility (resp.), 3rd party contr. (manage)	>90%	>90%	Will provide guidance on use of POEs by PWs	State regs - WQ treatment districts, private well guidance for activated carbon units
North Dakota	No answer provided	No answer	No answer	Will review apps to use POU & POEs on a case by case basis	None
Pennsylvania	Utility	>90%(POE)	>90%(POE)	None at this time	Not known
Rhode Island	POE-water supplier, no POUs allowed	No answer	No answer	No answer provided	None
S. Carolina	No answer provided	No answer	No answer	No answer provided	No answer provided
Utah	No answer provided	No answer	No answer	None for now	None
Vermont	No answer provided	No answer	No answer	None	None
Virginia	No answer provided	No answer	No answer	Considering policy that allows devices if utility owns & maintains	No answer provided
Washington	50% utility, 50% 3rd party contractor	>90%	No answer	Policy being developed - only allows devices in non-community, POU only for chronic contam, POE acute & chronic	Local plumbing codes?
Wisconsin	3rd party contractor; equipment vendor	>90%	75-90%	One system (>3300) investigating POE for radionuclide compliance	POE only allowed for non-community systems

5.2 Pilot Testing



40 CFR Section 141.100(d) states that effective technology must be properly applied under a plan approved by the State for POE. The State must require adequate certification of performance, field testing, and if not included in the certification process, a rigorous engineering design review of the POE devices.

40 CFR Sections 142.62(h)(3) and (4) have similar requirements as in 40 CFR Section 141.100(d) except that they apply to both POU and POE devices used under a variance or an exemption for inorganics, organics, and radionuclides.

The system should conduct extensive field or pilot testing of all potential treatment units *prior* to installation to ensure their effectiveness in reducing contaminant concentration(s) based on system-specific conditions. In fact, if the system uses a POE device, some form of field testing is required under 40 CFR Section 141.100. If POU or POE devices are used under a variance or exemption, 40 CFR Section 142.62(h) also requires field testing. The need for pilot testing is strongly supported by the experience of other systems that have installed POU and POE treatment devices as part of a compliance strategy. Several systems found that the treatment devices they had initially planned to install did not operate properly (*i.e.*, did not adequately reduce the concentration of the contaminant of concern in finished water) due to the presence of co-contaminants present in raw water supplies. As a result of prior testing, these systems installed appropriate units, avoiding unnecessary costs, and were able to achieve better levels of contaminant removal.

The first step in pilot testing is to develop a test protocol with assistance from the State. Equipment vendors may be a valuable additional resource in this process and should be consulted. It is also possible that the equipment vendor may loan the device to the system during the pilot test. The pilot test protocol should discuss the following:

1. **Length of the pilot test.** Pilot testing should be conducted for an adequate period of time to enable analysis of treatment efficacy in light of seasonal variations in water quality. However, if an extended testing period is not feasible, units should be tested for a period of at least two months to ensure consistent removal of the contaminant(s) of concern. For devices using adsorptive and ion exchange media, an important part of the pilot test is to determine the run-length of media between replacement, which may not be realized in a two-month pilot test. If seasonal variations are known to be minimal, an accelerated pilot test may be conducted to ensure consistent removal of the contaminant(s) of concern and establish the run-length of an adsorptive device. For POU RO devices, a steady state of removal of the contaminant of concern should be demonstrated for at least a month of operation. Regardless of seasonal variations, systems should always be guided by state requirements for pilot testing.

2. **Parameters to be monitored.** In addition to the contaminant(s) of concern, other parameters, such as heterotrophic bacteria, may need to be monitored during the pilot test. In the case of RO, total dissolved solids (TDS) are typically monitored since

elevated levels of TDS in the treated water indicate that the RO unit is losing treatment capability.

3. **Monitoring frequency.** Based on discussions with the State, vendor, and other individuals, the pilot test monitoring frequency should be established. The frequency should be based on the expected water demand and the objectives of the pilot test. The system should maintain accurate logs of all monitoring activities and results.

4. **Waste streams generated and disposal.** The system should document the waste streams generated throughout the treatment process, such as spent media or RO reject water. So that the State and other regulatory agencies can evaluate what waste disposal methods are most appropriate, the pilot test should document the characteristics and the amount of waste generated. Section 5.9 provides more information on disposal.

5. **Interpretation of results.** The system should seek assistance in interpreting the results of all collected information. All data collected should be considered and presented to justify to the State and the service community why a particular POU or POE device has or has not been selected. The system should consider cost of the unit, monitoring, replacement, maintenance, and waste disposal associated with each POU or POE device when developing costs based on pilot test results. The system should also be convinced that the POU or POE device will effectively treat the contaminant(s) of concern for all given source water characteristics.

6. **Preparation of report.** The system should prepare a report that includes all collected data to document the pilot test study.

Once a plan for pilot testing is in place, systems should begin conducting pilot testing on one or several POU/POE technologies they are considering. One of the important goals of pilot testing should be determining the need for pre- and post-treatments to ensure proper functioning of the POU/POE technology and effective removal of the target contaminant. It may be determined during pilot testing that several treatment technologies may need to be incorporated into a single POU or POE treatment system to address certain water quality problems. For example, a particulate pre-filter will greatly extend the life of RO membranes, while a post-filtration GAC filter will improve the aesthetics of treated water, resulting in improved customer satisfaction.

The pilot test can also be used to determine long-term monitoring and maintenance schedules based on effective unit capacities (*i.e.*, total gallons treated below the MCL) and average and minimum run lengths (see Section 5.10 for more information on monitoring and maintenance). Thorough pilot testing and the correct selection of one or more treatment technologies will help protect public health and prevent the need to install a new central treatment or make costly retrofits.

Relevant Case Studies: 7.1.4, 7.3.4, 7.4.3, and 7.6.3

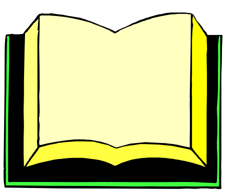
5.3 Number of Taps to Treat

While POE units treat all water used in a household, POU treatment devices only treat the water at a single tap. As a result, POU devices may not be appropriate for treating contaminants that represent an acute threat to human health (*e.g.*, nitrate - see box on p. 3-10) or for treating contaminants that may have a negative impact on health as a result of inhalation or dermal contact (*e.g.*, radon and VOCs). If POU is selected, the State and system should consider how many taps within the household or facility should be treated. For instance, in a school setting, it is important to treat all taps where children and faculty receive water or clearly mark those taps that are treated and suitable for human consumption. Additional considerations may be necessary for preschools or other establishments where individuals can not read. Similarly, in a household setting, the State and system may elect to treat additional taps beyond the separate drinking water tap near the regular kitchen tap. Additional taps that may be considered for treatment are refrigerator water dispensers, ice makers, and bathroom sinks. **If additional taps within the household or facility are required to be treated, this will significantly impact costs and will in most circumstances render the POU option uneconomical. At a minimum, the cost of water treatment at additional taps should be factored into the selection of treatment options.**

POU devices generally remove most contaminants which they are designed to treat to near zero or MCLG levels. Thus, if some untreated waters are occasionally consumed, the overall average may be below the allowable daily intake at the MCL level.

Relevant Case Studies: 7.1.3, 7.3.1, and 7.3.3

5.4 Participation



40 CFR Section 141.100(e) states that **all** consumers shall be protected when using POE devices. Every building connected to the system must have a POE device installed, maintained, and adequately monitored. The State must be assured that every building is subject to treatment and monitoring, and that the rights and responsibilities of the PWS customer convey with title upon sale of property.

40 CFR Section 142.62(h) states that the State must be assured that buildings connected to the system have sufficient POU or POE devices that are properly installed, maintained, and monitored such that all consumers will be protected under a variance or an exemption for inorganics, organics, and radionuclides.

In instances where POE devices are installed for compliance purposes, every building connected to the system must have a POE device installed, maintained, and adequately monitored (40 CFR Section

141.100). In addition, the State must be assured that every building is subject to treatment and monitoring. Therefore, a system using POE devices for compliance purposes must obtain 100 percent participation of all buildings connected to the system.

Under a variance or an exemption, the State must be assured that buildings connected to the system have sufficient POU or POE devices that are properly installed, maintained, and monitored such that all consumers will be protected (40 CFR Section 142.62).

POU Participation

The protection of all water system customers is essential. Yet some customers may object to the inspection and servicing of POU systems which are, necessarily, located within a building. If the participation of all customers cannot be ensured at start-up, state approval should be contingent on water system plans for complete participation of all customers within a specified time. Residents who continue to oppose POU devices could also be given the option of installing POE devices, though probably at a higher cost.

The system may need to pass an ordinance that requires customers to use POU and POE treatment units, and that provides systems with the authority to shut off a customer's water if the customer refuses to allow installation and maintenance of, tampers with, bypasses, or removes the treatment unit. Appendix C contains sample ordinance language a system may want to pass in order to secure participation. In San Ysidro, New Mexico, the village council passed an ordinance making water use contingent on POU installation. For more information on San Ysidro, refer to Section 7.1.2. However, this type of ordinance could be considered a drastic measure for some communities and positive communication between customers and water systems may allow these situations to be avoided. Therefore, it is important to establish and maintain good public relations and provide public education before, during and, if successful, after implementing a POU or POE treatment strategy to ensure continued participation from customers (see Section 6.1).

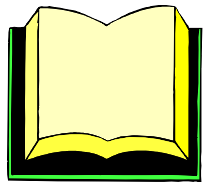
Relevant Case Studies: 7.1.2, 7.3.1 and 7.3.4

5.5 Disinfection and HPC Monitoring

The media or membranes used in POU and POE treatment devices may be susceptible to microbial colonization. Higher levels of bacteria have been found in the finished water produced by some POU and POE treatment devices, particularly those that incorporate an activated carbon element, than in the influent water.

In one study POU GAC filters were tested for the presence of bacteria. The study group consisted of households that had one of these POU filtration systems, while the control group received filters equipped with blank cartridges (Calderon, 1987). Another EPA study examined exposure to heterotrophic bacteria from POE GAC devices. In this study, one group of households was equipped with POE GAC devices at the beginning of the study, while the households in the control group did not filter their water (Bell, 1984). These studies demonstrated that POU and POE carbon filters were colonized by heterotrophic bacteria. In both studies, the researchers concluded that neither ingestion of, nor dermal contact with, water filtered by a POU or POE GAC unit constituted a risk factor for the study populations. However, these studies were not designed to examine the health effects heterotrophic bacteria may have on sensitive sub-populations such as immunocompromised individuals, the elderly, or infants.

At a meeting convened by the World Health Organization in 2002, an expert panel concluded that bacterial growth occurs in plumbed-in domestic water devices (including water softeners, carbon filters etc.) and plumbed in commercial devices such as beverage vending machines. HPC values in water samples typically increase in such devices. Increases in HPC (due to growth) in these devices therefore do not indicate the existence of a health risk, so long as the entry water meets acceptable water microbial quality norms (e.g. WHO Guidelines for Drinking Water Quality). Appropriate maintenance of these devices is required for aesthetic reasons per manufacturers' recommendations. This expert panel also indicated that there are increasing numbers of persons who are immunocompromised to various degrees and types living in communities, including some patients discharged to home care. Normal drinking water is not always suitable for all such individuals for all uses (e.g., wound irrigation). This relates to water safety in general and not to growth or HPC organisms in particular. Advice should be provided by public health authorities to at-risk groups in general and by practitioners responsible for individuals discharged to home care.



40 CFR Section 141.100(d) states that the microbiological safety of the water must be maintained when using POE devices. If POE activated carbon is used, the system must consider the increase in heterotrophic bacteria concentrations and it may be necessary to use frequent backwashing, post-contactor disinfection, and HPC monitoring.

40 CFR Sections 142.62(h)(3) and (5) have similar requirements as in 40 CFR Section 141.100(d) except that they apply to both POU and POE devices used under a variance or an exemption for inorganics, organics, and radionuclides.

In view of these conclusions, it is appropriate to recognize that although bacterial growth occurs in POU and POE water treatment devices, the increase of HPC in these devices does not indicate that a health risk exists, so long as the water entering the device meets acceptable water quality standards. Therefore, it is important to avoid using water of poor or unknown microbiological quality when instituting a POU or POE treatment strategy. If a system must rely on source water that is suspected of containing microbiological organisms, disinfection should be part of the water system central treatment strategy. Also, consumers should be instructed to run water at full flow for at least 30 seconds before use after a prolonged period of quiescence. Periodic backwashing of treatment devices, if possible, may also be beneficial. The system may want to consider post-treatment disinfection to ensure customer safety.

Relevant Case Studies: 7.1.2, 7.1.4, 7.3.1, 7.3.2, 7.3.4, 7.4.1, 7.5.2, and 7.6.3

5.6 Warning and Shut-off Devices

Each POU or POE treatment device installed as part of a compliance strategy must be equipped with a warning device (*e.g.* alarm, light, etc.) that will alert users when their unit is no longer adequately treating their water or has reached the end of its service life. Warning devices should be highly visible, *so locations such as under the sink or in a basement are not recommended for warning device locations*. Alternatively, units may be equipped with an automatic shut-off mechanism to allow systems to meet this requirement. Several communities have implemented POU or POE treatment strategies using units equipped with water meters and automatic shut-off devices to prevent contaminant breakthrough by disabling the units after a pre-specified amount of water has been treated. Water suppliers need to inform residents about whom to contact and how to do so when an alarm is triggered (see Chapter 6 for more information on this topic).

SDWA states that POU and POE units must have mechanical warnings to automatically notify customers of operational problems.

Relevant Case Studies: 7.1.2 and 7.3.4

5.7 Equipment Certification

SDWA states that if ANSI has issued product standards for a specific type of POU or POE treatment unit, then only those units that have been independently certified according to these standards may be used as part of a compliance strategy.

When selecting a POU or POE treatment device, water systems should ensure that the unit is appropriately certified. If ANSI has issued product standards (now referred to as ANSI/NSF standards) for a specific type of POU or POE treatment unit, then only those units that have been independently certified according to these standards may be used as part of a compliance strategy. ANSI/NSF standards cover six types of POU and POE devices:

- Standard 42: Drinking Water Treatment Units — Aesthetic Effects;
- Standard 44: Cation Exchange Water Softeners;
- Standard 53: Drinking Water Treatment Units — Health Effects;

- Standard 55: Ultraviolet Microbiological Water Treatment Systems;

- Standard 58: Reverse Osmosis Drinking Water Treatment Systems; and,

- Standard 62: Drinking Water Distillation Systems.

These standards currently do not address all regulated contaminants and are regularly updated to include additional contaminants. For instance, arsenic was recently added to Standards 53 and 58. To obtain current information on the standards, contact NSF International at www.nsf.org or call 877-867-3435. To obtain current lists of certified devices, contact any and all of the ANSI-accredited certification organizations that maintain a current list of only those devices certified by each of their organizations:

- NSF International at www.nsf.org/Certified/DWTU or 877-867-3435
- Water Quality Association at www.wqa.org or 630-505-0160
- Underwriters Laboratories at www.ul.com or 877-854-3577
- CSA International at www.csa-international.org or 866-797-4272

If a system plans to install a treatment device covered by one of the above six standards, the system must make sure that the product selected has been independently certified according to ANSI/NSF standards by one of the ANSI-accredited certifiers.

If the existing ANSI/NSF standards do not address a particular treatment device or contaminant, States should utilize manufacturers' substantiations of products' performances, results from pilot tests conducted by other systems or applications, and on-site testing by the system considering the POU or POE device. The State may also wish to (and in some cases, must) request that the system conduct a rigorous engineering analysis of the device and document its performance (see Section 5.2).

5.8 Access

SDWA states that POU and POE units must be owned, controlled, and maintained by the PWS or a contractor hired by the PWS to ensure proper operation and maintenance of the devices and compliance with MCLs. 40 CFR Section 141.100 and 142.62 both state that the system must adequately maintain and monitor the POU and POE devices such that all consumers are protected.

Federal requirements place the responsibility with the system, or a contractor hired by the system, to have access to the POU or POE devices for installation, maintenance and monitoring. Depending on the monitoring and maintenance schedule for the device, access could be required once a year, four times a year, during emergencies, or some other frequency. Local regulations may pose a challenge to the implementation of a POU or POE compliance strategy. For example, water system staff may not have the legal authority to enter private dwellings. As a result, the water system may need to convince its local government to pass an ordinance ensuring water system staff access to POU and POE treatment units to conduct maintenance and sampling activities. One system addressed this challenge in a different manner by requiring all homeowners in the service community to sign agreements explicitly providing water system staff with access to their homes for the purpose of conducting necessary maintenance and sampling activities. Appendix C contains sample ordinance language and Appendix D contains a sample access agreement that systems may find useful for obtaining access. Water systems should use these as a guide, but also seek legal counsel at the local level.

Establishing and maintaining good public relations with customers and providing continuing education may aide in a customer's willingness to work with systems to ensure proper access (see Section 6.1 for more information on public education).

Relevant Case Studies: 7.1.2, 7.3.1, and 7.6.3

5.9 Disposal

Systems should identify residuals that will be generated by the POU or POE device. The State and other appropriate entities, such as publicly owned treatment works (POTWs), should be consulted on how to properly dispose of the generated residuals and what permits, if any, are needed. *The handling and disposal of residuals may result in substantial costs and may make the selected POU or POE option not the most cost-effective option.*

If a water system plans on disposing of the residuals in a landfill or discharging the residuals to a surface water body, POTW, or underground injection well, it must adhere to Federal requirements, such as in the Clean Water Act or the Safe Drinking Water Act, and/or applicable state regulations. However, residuals generated by the POU or POE devices installed in residences are considered household waste and are exempt from being regulated as hazardous waste under the Resource Conservation and Recovery Act (RCRA).

The residuals that can be generated by the POU or POE devices are:

- Solid residuals, such as spent cartridges, media, resin, membranes, bulbs, and filters that require disposal at the end of their useful life. Disposal may occur several times a year or less frequently.

- Liquid waste streams will be generated by POU RO systems and POE IX, GAC, and adsorptive media systems if backwashed or regenerated. POU RO units produce a waste brine which is characterized by high contaminant concentrations. Backwashing and regeneration, required for proper operation of most POE IX, GAC, and adsorptive media treatment devices, will also result in the generation of intermittent liquid waste.

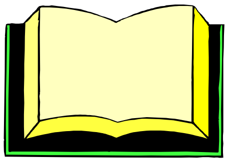
The quantity and characteristics of the residuals will vary based on the treatment technology used, contaminant(s) being removed, source water characteristics, and other site-specific operational conditions. In order to properly assess the quantity and quality of the residuals, pilot testing should be done.

Because the residuals generated by POU and POE units installed in residences are collected from individual households, these wastes are exempt from Federal regulations as hazardous wastes under RCRA. However, State regulations and each State's implementation of Federal regulations can vary. Solid residuals produced by these treatment systems often can be disposed of like normal household waste, delivered to a local landfill or regenerated. Liquid residuals may usually be discharged to POTWs (upon approval from the POTW), on-site septic systems (may require a permit from the State or local agency), or dry wells (may require a permit). In the case of liquid residuals, POTWs may issue their own limits for the discharge of certain contaminants, such as copper and TDS. However, waste that contains high concentrations of certain contaminants may require special handling and disposal.

POU and POE devices installed in commercial or business establishments may also be exempt from RCRA if the quantity of waste generated is considered small (defined in 40 CFR Section 261.5 as generating no more than 100 kilograms of hazardous waste in that month). For these types of installations, the system should contact the appropriate State or local regulatory personnel to assess proper classification and disposal of waste.

Relevant Case Studies: 7.1.2, 7.1.3, 7.3.1, 7.3.3, 7.3.4, and 7.6.3

5.10 Monitoring and Maintenance



SDWA states that POU and POE units must be owned, controlled, and maintained by the PWS or by a contractor hired by the PWS to ensure proper operation and maintenance of the devices and compliance with MCLs.

40 CFR Section 141.100 states that the PWS must develop and obtain State approval for a monitoring plan before POE devices are installed for compliance. Under the plan approved by the State, POE devices must provide health protection equivalent to central water treatment. "Equivalent" means that the water will meet all NPDWRs and will be of acceptable quality similar to water distributed by a well-operated central treatment plant. In addition to the VOCs, monitoring must include physical measurements and observations such as total flow treated and mechanical condition of the treatment equipment. All consumers shall be protected through proper installation, maintenance, and monitoring. Every building connected to the system must have a POE device installed, maintained, and adequately monitored.

40 CFR Section 142.62(h) states that before the POU or POE devices are installed under an exemption or a variance for inorganics, organics, or radionuclides, the PWS must obtain the approval of a monitoring plan which ensures that the devices provide health protection equivalent to that provided by central water treatment. The State must be assured that buildings connected to the system have sufficient POU or POE devices that are properly installed, maintained, and monitored such that all consumers will be protected.

In addition to required entry point and distribution system monitoring, the system will need to monitor the POU or POE devices. Monitoring of POU and POE devices should be conducted in a manner to substantiate the device performance and compliance with MCLs. The system must have a monitoring plan approved by the State for POU treatment strategies used under a variance or an exemption and for all POE treatment strategies. The goal of the monitoring plan should be to ensure coverage that will quickly identify units that are not providing an adequate level of protection to customers. Results of the pilot study should be used to develop the monitoring schedule.

Systems should contact the State or other appropriate regulatory agency to develop an approved compliance monitoring schedule. Also, States may have specific monitoring requirements depending on the particular situation. For instance, the Wisconsin Department of Natural Resources (DNR) has specific criteria for systems considering POE for radium. The system must monitor each device annually for radium and each device must be inspected monthly.

Many monitoring scenarios are possible. For instance, the system may consider monitoring every POU or POE device during the first year of operation and then modifying the monitoring frequency based on device performance during this first year. If sample results from each household indicate all units are properly functioning, a reduced monitoring frequency could be implemented. The monitoring frequency could be reduced to once every three years such that one-third of all units would be sampled each year for the contaminant(s) on a rotating basis. For acute contaminants (*e.g.*, nitrate), the regulatory agency should not allow reduced monitoring. Monitoring will affect costs, and the system should fully understand monitoring frequency requirements when considering POU or POE devices.

POU and POE monitoring may be augmented through the use of commercially available field testing kits, electrical conductivity meters (only appropriate for evaluation of RO operation), and water hardness testing (to evaluate the effectiveness of CX in removing radium and barium), which can be used to quickly and cheaply spot-check water quality on-site during routine maintenance visits. The use of field test kits or surrogates can reduce the cost of monitoring when compared to using certified laboratories for all analyzed contaminants. The system should verify with the State if the use of monitoring results obtained through methods other than certified laboratories is acceptable. For instance, Wisconsin DNR allows the use of surrogates for POE radium devices. Also, many field test kits exist that have different levels of detection and reporting accuracy. Note that test kits may not be available for all regulated contaminants, such as radionuclides. Appendix E contains a monitoring form that systems can use to track the monitoring of POU and POE devices.

POU and POE devices must be owned, controlled and maintained by the PWS. The PWS can contract maintenance activities if the PWS finds it advantageous. The system should maintain a detailed maintenance log for each individual POU or POE device. Maintenance can consist of:

- **Tracking flows.** When POE devices are used, total flow treated must be tracked (40 CFR Section 141.100). The media run lengths (or in case of POU RO, its membrane life) of POU or POE devices may be rated as total flow treated, and flow values may be the factor used to replace a media cartridge or membrane. Not all POU and POE devices are equipped with flow meters and may be an additional cost to the system.

- **Replacing parts.** As part of the monitoring schedule, the State may require that the system replace cartridges or media on a regular basis, such as semi-annually or other frequency. A replacement schedule should be developed that ensures continued production of safe drinking water.

- **Visual check of mechanical condition.** The PWS or contractor should inspect all components of the POU and POE device and replace or repair any parts as necessary in addition to routine replacement. Signs of leaking equipment should be remedied and noted on the maintenance log. Under a POE strategy, monitoring must include observations of the mechanical condition of the treatment device (40 CFR Section 141.100).

Appendix F contains a template systems may use to track maintenance on POU or POE devices.

To ensure the safety of the customers, systems should build a substantial safety factor into the maintenance schedule. ANSI/NSF drinking water treatment unit standards require a 20 percent margin of safety for systems with performance indication devices and 100 percent capacity margins for systems without performance indication devices. The ANSI/NSF POU/POE standards also require testing and substantiation of the accuracy and reliability of products' performance indication devices. An aggressive maintenance schedule will also help water system staff head off small problems (*e.g.*, leaks), before they become large ones (*e.g.*, damaged floors or burst pipes) and will build up customer confidence. Exhibit 3.4 of this document lists O&M activities associated with POU and POE devices.

A proactive maintenance schedule that includes replacement of key components prior to their scheduled replacement time may allow for a reduced monitoring schedule. Again, the replacement frequency should be substantiated by the pilot study. The system will need to fully consider the trade-off in costs associated with more frequent monitoring versus a higher replacement frequency. It may be more economical to monitor frequently and reduce replacement.

To minimize the burden associated with gaining access to monitor the devices in individual residences, POU and POE compliance sampling should be scheduled along with the routine maintenance of the devices. Systems can also coordinate this monitoring with previously required on-site sampling such as monthly coliform sampling and annual sampling for copper and lead. Reducing the number of house visits will reduce administrative costs and travel time, resulting in substantial cost savings as well as reducing the disruption to the residents. However, it may not be possible to combine monitoring activities with other activities.

Relevant Case Studies: 7.1.2, 7.1.3, 7.1.4, 7.2.2, 7.3.1, 7.3.3, 7.3.4, 7.4.2, 7.4.3, 7.5.1, 7.6.1, 7.6.3, and 7.7

5.11 Reporting, Record keeping, and Compliance Determination

As the system develops a monitoring schedule approved by the State, consideration should be given to reporting and record keeping requirements. The State should establish what information should be submitted to the State for review and when. The State may decide that all monitoring results, including which POU or POE devices were monitored, be submitted annually or some other frequency. Also, the State should develop some guidelines as to what constitutes a violation, such as whether an MCL exceedance at any POU or POE device would create a violation for the entire system. The system should retain all monitoring results and closely track when the POU or POE devices are monitored.

Relevant Case Studies: 7.3.4 and 7.7

5.12 Operator Certification Issues

The level of or need for a certified operator should be discussed with State and local regulatory agencies. State operator certification requirements vary State to State and systems should fully understand the level of operator needed. Operators responsible for treatment facilities typically require a higher level of certification. The system should understand the cost impacts associated with retaining a properly certified operator. Adequate training of system personnel is essential to the success of a POU or POE treatment strategy. As the use of POU and POE treatment devices becomes more prevalent, State and local technical assistance providers have begun to offer more training programs specifically targeted towards those individuals who install, maintain, and operate these devices. In addition, non-governmental groups such as NSF International and WQA offer training programs in the use and operation of POU and POE treatment units. WQA, for example, provides textbooks, training courses, and certification programs to certify those qualified individuals that pass WQA’s testing and continuing education requirements in water quality, water chemistry, and POU/POE treatment technology fields. Equipment manufacturers frequently offer training programs to vendors. It may be possible to negotiate with the manufacturer and vendor to attend this training. Furthermore, many vendors offer training in the proper operation and maintenance of their equipment as part of their sales packages.

Alternatively, some systems managing POU or POE treatment programs have arranged for the equipment vendor to install and maintain the devices, in which case they did not have to invest in additional training. Other systems relied on the vendor to maintain the units for a period following their initial installation while system personnel were being trained.

Some States may require water system operators and other system personnel to participate in structured training programs or obtain additional certification. Regardless of State requirements, systems will be better able to address potential problems as they arise if they regularly participate in training programs designed by States or other organizations specifically for the operation, maintenance, and administration of a POU and POE treatment strategy.

Relevant Case Studies: 7.1.2, 7.1.4, and 7.3.4

5.13 Local Plumbing and Electrical Codes

State or local laws may require treatment units to be installed by a certified installer, a licensed plumber, licensed electrician, or other licensed professional. For instance, an electrician may be required to supervise the installation of units that require large amounts of power (*e.g.*, aeration units). The use of licensed professionals may result in increased installation costs but result in long-term savings by minimizing problems associated with improper installation. WQA trains and certifies installers, and systems may want to contact WQA for information on certified installers in their area (www.wqa.org or call 630-505-0169). The system should contact State and local regulators to understand the requirements for using licensed professionals during the installation phase of the project. Again, the system should fully understand the costs associated with using these licensed professionals and understand the long-term implications associated with installation of the POU or POE devices.

Relevant Case Studies: 7.4.3 and 7.6.3

5.14 References

Bell, F., D. Perry, J. Smith, and S. Lynch. 1984. Studies on Home Treatment Systems. Journal AWWA, 76:2. pp. 126-130.

Calderon, R. 1987. An Epidemiological Study on the Bacteria Colonizing Granular Activated Carbon Point-of-Use Filters. 1987 Water Quality Association Annual Conference Proceedings. Dallas, TX.

Narasimhan. R. 2005. POU/POE Feasibility Study for Arsenic Treatment. AWWARF Project 2730. Chapter 3. Order Number 91083F

World Health Organization. 2002. Heterotrophic Plate Count Measurement in Drinking Water Safety Management. 2002 World Health Organization Conference Proceedings. Geneva, Switzerland.

6. Site-Specific Considerations for POU and POE Devices

In addition to the cost considerations covered in Chapter 4 and the implementation considerations discussed in Chapter 5, the system will have site-specific considerations that will impact the selection, cost, and implementation of a POU or POE treatment strategy. These considerations include:

- Public education;
- Treatment device selection;
- Installation;
- Liability;
- Logistics and administration;

These topics are discussed in more detail in the following sections, except for costs, which are discussed in Chapter 4.

6.1 Public Education

The system should plan on investing resources in public education to obtain and maintain customer participation and long-term customer satisfaction. Systems will want to hold one or several public meetings with all customers prior to installing any POU or POE devices. In addition, the system may want to regularly provide information and updates in bills, in separate mailers, and/or on flyers posted in public locations (similar to those locations used for public notification, such as a post office or a public library). Local radio, television and newspapers are also commonly used media, and web site announcements may be appropriate in certain circumstances. The system should have someone available to check the website and respond to questions and also have someone available to answer questions received by phone.

The system should arrange a series of meetings to allow public participation. The system will want to advertise the meetings well in advance and explain the purpose of the meetings. The first series of meetings should focus on the problem and why treatment is needed. In the case of an MCL, customers should already be informed through the public notification process. This first series of meetings (probably a minimum of two) should accomplish the following:

- **Inform the customers of the current situation.** The system should clearly explain the contaminant of concern, current contaminant levels in the system, how the current contaminant levels are near or exceed the MCL, and the health effects associated with the current contaminant levels.
- **Explain what options are available to the customers.** The system should have done some level of engineering evaluation on the alternatives to provide costs and other factors associated with the identified alternatives. Options that are probably available and should be investigated by the system are connection to a nearby system, blending of current sources, developing a new source, centralized treatment, and POU/POE devices. The system should justify the selection of POU/POE devices to the customers.
- **Explain what POU/POE devices are.** The system will want to clearly explain what POU and POE devices are and how they differ from centralized treatment. It is important

that customers understand that these devices will be inside their dwellings (in most instances) but will be owned and maintained by the system. The access issue should be discussed and the system can initiate access agreements or other approach for access. It is also important that customers understand that only a portion of the water will be treated. Other issues may arise, such as customers may want more than one tap treated. If and when customers want such additional units, they should be informed of the high impact of capital and operating costs. Systems should present all health issues associated with the contaminant, including ingestion, dermal, and inhalation health issues.

- **Establish ownership of the POU or POE devices.** In the instance where some households already have POU/POE devices installed, the system should clarify how ownership of these devices will be shifted from the homeowner to the system. The system should identify those dwellings that have POU/POE devices already installed, decide if the existing units provide the desired level of treatment, and then work with the affected customers on how these existing units will transfer to system ownership or will be replaced by the system.

- **Explain the purpose of the pilot study, if one is conducted.** If the system elects to (or is required to) conduct a pilot study, the customers should be informed of the pilot test procedure. The pilot test may be done at the wellhead or at the existing central treatment plant on an accelerated basis or in only a few households**,** and the system may pilot more than one device in order to select the best treatment unit.

Systems should be as prepared as possible for the first series of meetings. Customers will probably have many questions, and the system may experience resistance on the part of some customers. Systems should consider having their consultant and the POU/POE vendor representative present to assist with answering questions. The system may also want to have the actual POU/POE device at the meeting to better demonstrate the technology.

The next meeting or series of meetings should focus on:

- **Obtaining 100 percent customer participation.** In order to obtain 100 percent participation, the system should make every attempt to answer questions and address concerns of customers, either in public meetings or informal, one-on-one settings. The system should have someone available to answer questions on the telephone or establish a website where people can send questions. See also Section 5.4 on participation.

- **Developing a plan for access to units.** The system should have an approach for obtaining access to all units, such as through a local ordinance or a legal agreement between each homeowner and the system that grants access (see Section 5.8). The system should allow flexibility with scheduling access and accommodate all homeowner's schedules, such as being available on evenings and weekends. The homeowners should understand that someone might need to access the unit quarterly or more frequently in some instances. A sample ordinance and a sample access agreement are provided in Appendices C and D.

- **Informing customers of their responsibilities.** Customers should clearly understand how the unit operates, how to avoid damage to the unit, how the alarm mechanism works, and whom to call with questions or in the event the alarm is triggered. Customers should understand that they are not responsible for any maintenance on the devices and they should contact the system with any questions or concerns. Customers should also be informed that they are not to disconnect or damage the unit in any way.

- **Informing the customer about the POU/POE device.** Customers should clearly understand how the units will be installed and located and how the device will provide treatment. The system will want to explain the disposal of waste streams and other residuals, such as spent cartridges. The system, or someone contracted with the system, is responsible for all monitoring, maintenance, replacement, and disposal of units. The schedules for monitoring, maintenance, and replacement should be presented.

- **Explaining the cost of the units.** Customers will want to know how their water bill will be affected by the POU/POE device. The system should provide all information. If Federal, State, or local monies will be used, the system will want to present what funding will be provided and how the customer rates will be impacted.

- **If a pilot test was done, presenting pilot test results.** The system should present all information obtained during the pilot test, how the treatment unit was selected (if more than one device was pilot tested), and explain what level of treatment can be expected from each unit.

After the units have been installed for one month, the system should hold another public meeting to answer questions and concerns from customers. Again, the system may want to have a consultant or vendor representative present along with the actual treatment device to answer any questions or concerns.

Community water systems may use the Consumer Confidence Report (CCR) as a means to provide updates to customers on the POU or POE treatment strategy. Minutes from all public meetings should be made available on request and posted on the website or other public location so all customers can be informed.

If POU devices are used for nitrate removal, continued education should be considered to educate and remind customers about the health risks associated with nitrate, particularly for infants. Systems may want to consider including a public education flyer in mailings and posting information throughout the service area. A sample public education flyer that contains information about POU devices used for nitrate removal and health effects is contained in Appendix G. See also the box on p. 3-10.

6.2 Treatment Device Selection

Selecting a proper treatment device begins with identifying a potential POU or POE unit from the technologies listed in Exhibits 3.1 and 3.2 that will remove a system's contaminant(s) of concern. As discussed in Section 5.1, systems should contact the State if a contaminant or POU/POE device of interest is not listed and to get assistance in the preliminary selection of a unit.

Exhibits 3.1 and 3.2 can also be used as preliminary screens to help identify potential treatment technologies for contaminants. Note, however, that a system's decision should not be based on these tables alone. It is essential to weigh the advantages, disadvantages, and costs of different treatment strategies before selecting a treatment technology for consideration.

Site-specific factors that should be considered are:

- Raw water characteristics such as pH, hardness, and co-occurring contaminants, that may impact the removal efficiency of the device;

- Desired quality of treated water and whether the POU/POE device is capable of meeting the MCL or better;

- Operational requirements of the treatment technology (*e.g.*, backwashing, pre-treatment, potential for microbial colonization, disposal, and other operational issues) ;

- Technical skill required of operator (refer to Section 5.12 on operator certification); and,

Pilot testing should be done to assist the system with selecting the proper device (see Section 5.2).

6.3 Installation

Unit installation can be a complicated and time-consuming process, particularly for POE devices. Improper installation can lead to unit malfunction, a decrease in the unit's effective life, leaks, and difficulties with maintenance and sampling. It is important to install the unit in a manner that will permit servicing and monitoring quickly and easily. Sample taps installed before and after the treatment unit will allow system staff to obtain samples quickly and easily and isolate individual units as necessary. Remember, however, to consult with the manufacturer to ensure that the installation plan will not hamper unit operation. Refer to Chapter 3 for diagrams of typical POU and POE installations.

Before the actual installation of the units, all customers should be notified in advance (about one month) of what activities will occur. The system will need to arrange a time when each unit can be installed and explain to the customers that it can take anywhere from one to four hours. Customers need to understand where the unit will be located. For instance, for POU at the kitchen tap, the treatment unit will be installed under the sink. The system will need to convey to all customers that the system is responsible for all installation costs. In some instances, some extra carpentry or plumbing work may be required to place units under the kitchen sink. In other settings, the POU unit may need to be located in a crawl space due to physical limitations of the kitchen sink.

To alleviate space issues with POE units and to minimize the need for coordination with homeowners, it may be preferable to install POE units outdoors whenever possible. However, in colder regions, where temperatures drop below freezing even for part of the year, it will be necessary to install the POE unit inside to prevent damage. This could pose a problem for some customers who may not have adequate space in their homes or businesses for a POE device.

6.4 Liability

Under SDWA, the system is responsible for ensuring that the water provided by the system meets SDWA requirements. In addition, the system is directly responsible for the operation and maintenance of all POU and POE treatment devices installed as part of a compliance strategy. Therefore, the system may be liable in the event of device malfunction or failure. Liabilities the system should consider and may want to have covered are:

- Providing less than 100-percent public health protection if only treating a kitchen tap rather than the entire home;

- Entering a private residence;

- Failure of the device that results in water that exceeds an MCL; and,

- Property damage that occurs during installation or as a result of a malfunctioning unit.

Several options are available to the system to reduce its liability and risk. It is recommended that the system negotiate with the vendor or installer so that the vendor or installer retains responsibility for all units for a specified period after installation to allow for minor adjustments, leak repair, and a follow-up inspection. The system may also be able to negotiate certain contract provisions with the vendor who sells the treatment equipment or with a subcontractor that is hired to conduct sampling and/or maintenance to insulate the system (at least in part) from the consequences of device failure.

The system may purchase additional liability insurance. Several systems that have installed POU and POE treatment devices have acquired liability insurance to cover homeowner damages resulting from malfunctioning units. Contract and insurance laws are extremely complex. Therefore, it is highly recommended that legal assistance be obtained when deciding which option makes the most sense.

6.5 Logistics and Administration

The administrative tasks required to manage a successful POU or POE treatment strategy, including customer outreach, scheduling, and record keeping, can be time-consuming. The costs associated with these additional tasks should be considered in implementing a POU or POE treatment strategy. Good public relations are also important for systems that implement a POU or POE treatment strategy. Because these units are installed and maintained on customer property, this type of treatment requires frequent interaction with homeowners.

Below are some suggestions on how to ensure that the POU/POE treatment program runs as smoothly as other water system operations;

- **Schedule visits to homes near each other for the same day.** When coupled with the coordination of maintenance and sampling visits, this will minimize travel time and maximize productivity.

- **Communicate with the customers.** Sending a card like those used by dentist offices that reminds customers of the date, time, and purpose of the visit will help reduce the number of missed appointments. Confirmation calls are also very important. These procedures will save money by minimizing extra trips and will build consumer confidence.

- **Keep appointments and be flexible.** To maintain the trust and respect of customers, it is essential for systems to ensure that all appointments are kept, or to notify the homeowner in a timely manner if they must be rescheduled. To avoid scheduling and access problems, some systems have arranged for customers to provide system employees with keys to their houses or have installed treatment units (particularly POE units) in garages (if in a warm climate) or basements. Systems should also allow for maintenance and sampling to occur in evenings or weekends to accommodate customers' schedules.

- **Keep records.** To confirm that the sampling and maintenance schedules are followed and that the treatment units are performing as expected, it is helpful to keep track of all sampling and maintenance visits, work performed, and lab analyses in a log book or simple database. Appendix E and Appendix F contain forms that can be used to track monitoring and maintenance activities.

- **Management of vendor/third party contracts.** If contracts for installation, maintenance and/or replacement parts are established with vendors or another third party, systems should ensure that these tasks are performed in a satisfactory manner as stipulated by the contract.

- **Provide a customer complaint line.** Even with regular maintenance and replacement of certified, reliable units, there are likely to be unanticipated problems, particularly when the devices are first installed. Since water availability is so important, repair staff should be on call at all times. Quick response will ensure the customer's safety and comfort while helping to prevent more costly repairs in the future.

To be prepared for equipment failure, water systems should stock replacement units and parts. Ongoing parts availability should be considered when selecting an equipment supplier. To minimize storage costs, some systems have negotiated deals with equipment vendors who promise to provide all replacement parts on demand at or below retail cost.

As with all equipment purchases and service contracts, water systems should confirm that their potential supplier is reliable and trustworthy. A good vendor should be easy to contact and should provide technical assistance in the event a problem occurs.

7. Case Studies

Information on 22 POU and POE projects was gathered from published studies and contacting State, EPA, and system personnel. The case studies presented in this chapter are intended to provide other systems with information on how to implement a POU or POE treatment strategy. Each case study summary contained in this chapter includes information on the following topics, if available:

- The contaminant(s) of concern (and its concentration in the raw water);
- The applied treatment technology;
- Pilot test protocol;
- The number of households equipped with POE or POU treatment units and the number of households served by the water system;
- The administrative strategy used by the water system;
- The monitoring plan used to ensure adequate protection of public health;
- The maintenance schedule selected by the water system;
- Details on the capacity and performance of the treatment units; and,
- The capital and O&M costs for each unit.

The case studies that follow are organized by the primary contaminant of concern. Again, these case studies are presented to provide information to other systems and States that may be helpful when developing a POU or POE treatment strategy. A water system should not select a device described in the following case studies simply because the device was successfully used to treat the same contaminant present in another water system. Systems should contact their State and local regulatory agencies to determine what requirements or restrictions apply to the use of POU and POE devices (see Chapter 5 for more information on State and local requirements).

7.1 Arsenic Treatment

7.1.1 Fairbanks, Alaska and Eugene, Oregon (POU AA, AX, RO for Arsenic Removal)

This study investigated the efficacy of AA, AX, and RO devices for arsenic removal. Two homes in Eugene, Oregon and two homes in Fairbanks, Alaska were equipped with POU systems designed to treat household drinking water. Each of these systems was composed of an AA tank, an AX tank, and an RO system. A water meter was used to measure the true throughput of each unit. The households chosen for the study were selected with the cooperation of State organizations and individual homeowners. All relied on private well water that frequently exceeded the MCL for arsenic (0.05 mg/L). This case study was summarized by Fox (1989).

Arsenic concentrations in the source water for the study households ranged from less than 0.005 mg/L to more than 1.1 mg/L during this study. Arsenate was believed to predominate at all four test locations. It is important to note that iron and sulfate concentrations were low in the source water (see

Exhibit 7.1) because these contaminants may interfere with the removal of arsenic. Iron compounds will clog and foul AX resins and AA media, thereby reducing the removal capabilities of each unit or reducing water throughput. Sulfate is preferentially selected over arsenic by AX resins and also interferes with arsenic removal by AA. In a 1982 study, Clifford and Rosenblum showed that arsenic adsorption was reduced by 50 percent in the presence of 15 milliequivalents (meq) of sulfate per liter in deionized water. During this study, treated water was not consumed by homeowners.

Exhibit 7.1: Source Water Quality of Surveyed Households in Fairbanks, AK and Eugene, OR

Contaminant	**Influent Concentration for Households in Fairbanks**		**Influent Concentration for Households in Eugene**	
	Household One (mg/L)	Household Two (mg/L)	Household One (mg/L)	Household Two (mg/L)
Arsenic (range)	0.25-1.08	0.22-1.16	< 0.005-0.28	0.005-0.32
Calcium	22	8.9	18	19
Magnesium	10.6	9.3	5.3	5.5
Sodium	6.0	4.4	40	62
Chloride	< 10	< 10	< 10	< 10
Iron	< 0.1	0.20	0.24	0.18
Sulfate	< 15	< 15	< 15	< 15
Turbidity (NTU)	0.48	0.32	0.43	0.24
Alkalinity	108	56	151	206
pH	8.0	7.4	8.3	8.3

The POU units were operated automatically by a system of solenoid valves and timers. The timers were initially set to open the valves daily at the times when an average family might use water. The system was designed so that each treatment unit would operate separately and no two valves would be open at the same time. The timers actuated the valves nine times a day, permitting the treatment of one gallon of water by both the AX and the AA tank, and 0.5 gallons of water by the RO unit each time the valves were opened. After six months, the valves were opened 18 times a day to increase flow through the units to speed up arsenic breakthrough.

Local and State employees performed all sampling of the units. Samples were collected biweekly from the influent and effluent lines of each of the three treatment elements and were sent to EPA in Cincinnati, Ohio, for analysis.

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7.1.1.1 AA

The AA tanks used in this study were 46 inches tall and 9 inches in diameter. Each AA tank was filled with 1 cubic foot of activated alumina media. The AA media was designed to be pre-treated in the tank. The pre-treatment process consisted of passing a sodium hydroxide solution through the tank, rinsing the medium with clean water, and then treating the medium with dilute sulfuric acid to lower its pH. At a flow rate of 1 gallon per minute (gpm), the surface loading rate of the tank was 2.7 gpm per square foot, and the minimum empty bed contact time (EBCT) was 7.5 minutes. The actual contact time was probably greater because the effluent valves were opened for only 1 minute by the timers, and the water sat undisturbed in the tank (in contact with the AA) until the next valve-opening period.

The three AA units that failed to work as well as expected suffered from inadequate pretreatment. The units that failed had not been pre-treated with dilute sulfuric acid. Therefore, the pH of the water in the AA units was well above the ideal level for arsenic adsorption (pH 6). Thus, the tanks' capacity to adsorb arsenic was much lower than anticipated. However, the six properly prepared AA units performed extremely well, consistently maintaining arsenic levels well below the MCL until they were taken off line. Three units successfully treated more than 10,000 gallons of water (10,784, 15,427, and 18,557 gallons) while the remaining three AA units each successfully treated more than 6,000 gallons. Based on the results of this study, a capacity of about 1.0 mg of arsenic per gram of AA could probably be expected in future applications of AA if source water concentrations of iron and sulfate are limited and the AA undergoes all appropriate pretreatment. (Note: POU AA identified in the Arsenic Rule assumes no pretreatment.)

7.1.1.2 AX

The AX tanks used in this study were the same size as the AA tanks. Each AX tank was filled with 1 cubic foot of a strong base AX resin. The resin was regenerated in the tank into the chloride form. At a flow of 1 gpm, the surface loading rate of the tank was 2.7 gpm per square foot, providing a minimum EBCT of 7.5 minutes. The actual contact time was probably greater because the effluent valves were only opened for 1 minute by the timers, and the water sat undisturbed in the tank (in contact with the resin) until the next valve-opening period.

Two AX units exhibited erratic removal of arsenic. A third unit performed poorly due to inadequate regeneration practices at the start of the project. However, the remaining four AX units worked extremely well, successfully treating water containing as much as 1.16 mg/L of arsenic to concentrations of less than 0.05 mg/L. Three of the units treated more than 10,000 gallons successfully (11,858, 16,254, and 20,935 gallons) and were disconnected at the end of the project even though the capability of the resin to adsorb arsenic had not been exhausted. Depositions of up to 0.86 mg of arsenic per gram of resin were found in the AX tanks when they were opened at the end of the study.

7.1.1.3 RO

The RO units studied for this project were designed to produce between 3 and 5 gallons of drinking water per day and to operate with source water pressures ranging from 20 to 100 pounds per square inch (psi) with a reject-to-product water ratio of about 10:1. Each RO unit was equipped with a 5-μm cartridge pre-filter, a carbon post-filter, a cellulose-acetate RO membrane, and a small storage tank. Two years into the study, a second type of RO system was installed at one location. This unit was identical to the old unit, except that a booster pump was added to increase operating pressure to 195 psi. The use of the high-pressure RO system improved the reject-to-product water ratio to 3:1 but also increased electrical costs.

The low-pressure RO systems initially removed 60 to 80 percent of influent arsenic. However, due to the high arsenic concentrations of the source water at the study sites, the RO units rapidly deteriorated and were not always successful in lowering the arsenic concentration below the MCL. On average, the low-pressure RO units provided only a 50 percent removal rate for arsenic over the life of their membranes. For the low-pressure RO system to serve as an effective treatment option given the raw water characteristics observed during this study, the cellulose acetate membranes would need to be replaced at least twice a year. The high-pressure RO unit successfully reduced arsenic levels below the MCL for 330 days before it was taken off line at the conclusion of the study. All of the RO systems significantly lowered the level of TDS in the source water.

One potential cause of concern for system administrators who select this treatment technology is the limited production capability of some RO units (less than 3 gallons of treated water each day). The large amount of water wasted by low-pressure RO units may be a source of concern in water-scarce regions. On the other hand, since arsenic is not accumulated on the RO membrane, membrane disposal is not a concern as it may be with media from POU AX and POU AA systems.

7.1.1.4 Cost Data and Study Conclusions

Costs for the various elements of the pilot systems installed in Alaska and Oregon were provided by Fox and Sorg (1987). The capital costs reported in the case study were $350, $250, and $292 for the AX unit, AA unit, and RO unit, respectively (1983 dollars).

The author of the study drew several conclusions about the ability of POE and POU devices to treat contaminated water adequately:

- Any medium used in a POE or POU device should undergo adequate pre-treatment to permit efficient and effective contaminant removal. (Note: POU AA identified in the Arsenic Rule assumes no pretreatment.)

- Sampling should be done immediately after installation and periodically thereafter to confirm adequate contaminant removal.

- A complete source water analysis is necessary to determine the proper type of POU or POE devices to be used.

- POE devices should be used when skin adsorption or inhalation of a specific contaminant is of concern.

7.1.2 San Ysidro, New Mexico (POU RO for the Removal of Arsenic, Fluoride, and Other IOCs)

Rogers (1988 and 1990) authored the original report detailing the San Ysidro experience from which much of this summary was drawn. Details regarding this case study were also reported by Lykins, Jr., et al. (1992) and Thomson and O'Grady (1998). A follow-up report was presented by Thomson, Fox, and O'Grady (2000). Additional information was provided by Pasteros (2001).

The Village of San Ysidro is a rural community located approximately 45 miles north of Albuquerque, New Mexico. The population over the last 20 years has remained around 200 people. Village water is disinfected by a hypochlorination system at the source, a nearby infiltration gallery. The village has a long history of water supply problems, including low water pressure, unpleasant aesthetics (poor taste, color, clarity, and odor), sporadic coliform violations, and arsenic and fluoride contamination. The local ground water has a high mineral content because geothermal activity causes leaching from the area's abundant mineral deposits. At the beginning of the study, the ground water exceeded the MCL for arsenic (0.05 mg/L) and the secondary standards for fluoride, iron, manganese, chloride, and TDS (2.0 mg/L, 0.3 mg/L, 0.05 mg/L, 250 mg/L, and 500 mg/L, respectively). The contaminants of primary concern to the village were arsenic and fluoride. Arsenic and fluoride concentrations averaged 0.17 mg/L and 5.2 mg/L, respectively, in the village well. Of the arsenic found in village water, 35 percent was found to be arsenite.

Four deep test wells were drilled by a local engineering firm to determine if a better water source was available. However, the best of these wells had water merely equal in quality to that of the infiltration gallery. A University of Houston study determined that central treatment of the entire water supply was not feasible for several reasons. First, central treatment would leave the village with the expensive problem of disposing of either arsenic-contaminated sludge from AA column regeneration or the concentrated reject brine produced by a central RO system. Second, building a central treatment plant would be prohibitively expensive. Third, a central treatment facility was deemed too complicated to be operated efficiently by a community the size of San Ysidro (the village had never been able to attract and retain well-trained operators).

A public meeting was held in December of 1985 to discuss the water quality problems and the procedures that would be necessary before POU devices could be installed. By July of 1986, all of the eligible water system customers had agreed to participate.

Since arsenic and fluoride are harmful only if ingested in excessive quantities for an extended period of time, only water destined for human consumption (i.e., water used for drinking and cooking) needed to be treated in San Ysidro. An analysis of unit removal cost, efficiency, and management requirements led to the identification of POU RO treatment as the best solution to the village's water supply problems. The village was given permission to use POU RO as a solution to the arsenic and fluoride problems under a variance. Therefore, EPA, in conjunction with the village, began a study designed to determine whether POU RO units could function satisfactorily in lieu of central treatment to remove arsenic and fluoride from the community's drinking water supply.

A competitive bidding process was used to select a POU RO unit for the village. The selected vendor provided installation and maintained all of the treatment units in the community for a monthly service fee. Over the course of the service contract, the village maintenance specialist received field training from the service contractor. The maintenance contract between the village and the vendor remained in effect for 20 months, after which the village maintenance specialist took over all maintenance and monitoring duties.

In order to ensure the effectiveness of the selected RO membrane and the acceptability of the POU RO unit to the community, a POU RO unit was installed in the community center. In addition, each customer was sent a notification letter and a public meeting was held. The public meeting forum was used to explain the water quality problems and the agreement between the village and EPA to utilize POU RO units to remedy the water quality problems.

To meet its responsibilities under Section 1412(b)(4)(E)(ii) of SDWA, San Ysidro passed an ordinance making the use of village water contingent upon the installation of a POU device in the home. The ordinance was deemed necessary because POU treatment should not be considered a viable alternative to central treatment if the water system does not supply safe (i.e., treated) drinking water to all of its customers.

The number of units used by the community of San Ysidro ranged from 67 units at the beginning of the project to 78 units at the end. The units were each equipped with a particulate pre-filter, a GAC pre-filter, a GAC post-filter, a spiral-wound polyamide RO membrane, a 3-gallon storage tank, and an in-line TDS monitor. Each unit was designed to produce between 5 and 8 gallons of product water per day. Three units were equipped with totalizing (water) meters to measure household water use. All of the units were equipped with alarms that were triggered when the TDS in the treated water exceeded 200 mg/L. No units were equipped with automatic shut-off devices. One unit was installed per household at the kitchen sink. All liquid wastes from the RO units were discharged to the household septic system through a connection with the sink drain. After several samples tested positive for coliforms, an air gap was added at the connection to each RO unit to prevent cross-contamination from the household wastewater. Samples were collected for the next few months and tested for coliforms. None of these samples tested positive for coliforms.

Within the first six months, six units that were not working properly were replaced. Another 35 units required service due to leaks, TDS monitor malfunction, or water flow problems. Customers were expected to pay for any damage to their RO units that resulted from their own negligence.

The successful operation of a community-wide POU treatment strategy requires that the responsibilities of water users and the water utility be clearly identified. The village council of San Ysidro outlined six responsibilities for water users and three for the water utility (the village). All water users were required to:

1. Allow access to their units (each water customer was required to sign a permission form allowing a village designee to enter his or her home for installation and for periodic testing and maintenance);

2. Protect their units from damage;

3. Assume liability for damage to their units;

4. Refrain from tampering with or disconnecting their units;

5. Allow periodic inspection of their units; and,

6. Report any problems with their units to the water utility in a timely fashion.

The village was required to provide unit maintenance, periodic monitoring, and liability insurance to cover any damage caused to a resident's home by a treatment device. The Village of San Ysidro secured a liability policy designed to cover water damage resulting from improper installation or device malfunction.

The village clerk played a vital role in managing the installation, maintenance, and monitoring of the units. As the contact person for water customers, the clerk made arrangements with customers for unit installation and all necessary maintenance work. The clerk coordinated this effort with the contractor's service manager during the 20-month service contract and with the village maintenance specialist after the contract expired.

The village made special provisions for commercial establishments. Although the primary responsibility for providing safe drinking water lies with the water utility operator, the village decided to transfer this responsibility to the commercial water user through a new ordinance. This served two purposes. First, the village was relieved of the burden of trying to coordinate the leasing, purchasing, and maintenance of RO units of various sizes. Second, the ordinance allowed commercial establishments some flexibility in selecting the most economical way to provide safe drinking water to their customers. Note that this transfer of responsibility and liability may not be legal in all localities; it also may not have any effect on liability under federal law.

Data were collected during the San Ysidro study to evaluate the effectiveness of POU RO units in removing arsenic, fluoride, and TDS from the water. Samples were collected from each unit on a bimonthly basis and were analyzed for arsenic and fluoride. Every 4 to 6 months, samples were also analyzed for chloride, iron, and manganese. In addition, samples were periodically collected from a smaller group of 40 units and were analyzed for total coliform organisms. All samples were tested by a certified laboratory. A schedule for sample collection was typically placed in the customer's water bill.

The RO units were very effective in removing arsenic and fluoride from the community's water, reducing average influent concentrations of arsenic from 0.17 mg/L and fluoride from 5.2 mg/L to less than 0.05 mg/L and 2.0 mg/L, respectively. The units also reduced chloride, iron, manganese, and TDS to desired levels despite low system pressure (sometimes less than 20 psi). However, the removal percentages were approximately 10 percent below those stated in the manufacturer's literature. This was most likely due to the quantity and combination of contaminants in San Ysidro's water.

According to the maintenance plan, units were to be serviced once every three months. The service procedure included inspection of the pre-filter assembly, replacement of the pre-filter, inspection of the carbon post-filter with replacement as needed, inspection of the RO module housing assembly for cracks or leaks, inspection of all hose connections for leaks, inspection of the reservoir tank for cracks or leaks, and restarting the unit and again inspecting for leaks. However, some time after the village took over the maintenance of the units, most units were still being serviced, though seldom on a three-month frequency. Several reasons were given for the infrequent servicing of these units:

- The residents were not home when the operator arrived to perform regular service (many residents commute to Albuquerque and are gone for most of the day);

- Some residents were reluctant to allow outsiders into their homes; and,

- Some residents did not want the POU units and avoided having them serviced. Many of the residents, especially older residents, had been drinking the system water for a long time and were not very concerned about treatment.

Few maintenance records were kept by the village maintenance specialist so it is not known how often cartridges and membranes were replaced.

The following recommendations were drawn from early experiences in San Ysidro:

- Since combinations of contaminants may alter the removal efficiencies of POU devices, a pilot test of potential treatment devices should be undertaken using the system's source water before the device is selected for system-wide use.

- Public acceptance is more vital to the success of a POU treatment strategy than for a central treatment strategy. For example, new water customers should be educated in the procedures and requirements of the POU system. Existing customers should also be periodically reminded of these responsibilities.

- Routine maintenance and sampling operations are best carried out by local water utility employees or members of the immediate community once they have received sufficient training. In this way, travel expenses will be minimized, coordination with customers will be streamlined, and better quality control procedures may be implemented.

- Monitoring costs may be minimized by using conductance (for RO units) as a means to test for breakthrough of inorganic contaminants such as fluoride or arsenic.

- Pre-assembly of POU units may drastically reduce on-site installation time and associated labor costs.

- It is important to ensure that the price residents are charged by the water system covers the actual costs of providing necessary maintenance and monitoring.

In recent years, the San Ysidro water system has experienced compliance problems. Many of the residents are elderly and have been drinking the same water for years. These residents were less concerned about water treatment than by how much the water system is interfering with their lives and were therefore not very motivated to keep the POU units working. The village had been trying to use volunteers to perform maintenance, but had to return to using a full-time staff member to keep up with the demand. EPA assigned staff to the water system to return the system to compliance. The RO units were cleaned and repaired and EPA staff went to San Ysidro once per week to pick up samples until all units were tested and returned to compliance. At least for the time being, San Ysidro will continue to use POU devices to remove arsenic (Thomas 2005).

7.1.3 Hancock, New Hampshire (POE AA for Arsenic Removal)

Monadnock Area Cooperative School, a small non-profit school in Hancock, New Hampshire, is comprised of two separate schools, a preschool and a primary school, located in the same building. A licensed water operator was contracted to develop a plan to address the high levels of arsenic found in the school's water (Messina, 2001). The operator submitted a compliance plan to the State of New Hampshire for approval. Once approval was obtained, the operator worked with school maintenance personnel to install a POE AA system in late 2000. The unit, consisting of a single AA tank and equipped with GAC pre- and post-filters, has effectively reduced arsenic levels below detection since its installation.

The bids initially provided by local retailers for this system were quite high (in excess of $5,000). Given the financial constraints faced by the school, the school opted to purchase the unit directly from a local manufacturer (based in Londonberry, New Hampshire) instead of a retailer and to hire the operator to install the unit. Purchasing the unit in this manner enabled the school to obtain and install the unit (and all the necessary valves and piping) for less than $1,000. Despite no previous experience in installing this treatment device, the installation process went smoothly and took only three hours. Since the unit was designed to treat only water dispensed at the kitchen tap of each school and a single drinking fountain, the children in the school were told from which taps they may drink. It is unknown whether significant alterations to the plumbing were necessary to supply treated water only to the drinking fountain and kitchen taps.

The treatment device does not include an automatic shut-off valve or warning light; however, high concentrations of contaminants can be detected through monitoring. Monitoring is conducted according to State regulations which mandate quarterly sampling for bacteria and arsenic. Samples are collected by the operator and then submitted to the State laboratory in Concord, New Hampshire, for analysis. Costs for the school for these tests average between $10 and $20 every three months.

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The treatment system installed in the school has minimal maintenance requirements. A member of the school's maintenance staff regularly monitors the system's pressure gauge to verify that the media has not become clogged. If pressure decreases beyond levels recommended by the manufacturer, the pre-filters for the treatment unit are replaced. The pre-filters are expected to last at least one year. The pre-filters used in the unit are very inexpensive, costing only $5 to $10 each. Spent filters are disposed of in the school's trash.

To date, Monadnock's AA unit has presented no problems and continues to successfully reduce the arsenic levels in the school's drinking water. The operator who recommended and installed this system emphasized that the system is not only very simple, economical, and effective, but also easily maintained.

7.1.4 Lummi Island, Washington (POE AX for Arsenic and Cyanide Removal)

This case study is summarized from system documentation provided by Thielemann (2001) and Kunesh (2003). Marine View Estates is a subdivision with a homeowners association on Lummi Island, in Whatcom County, Washington. Ten homes within the subdivision are served by one centralized well and classified as a community water system by EPA and the State of Washington. Another 10 homes within the subdivision are served by individual wells.

A homeowner attempting to develop a lot on the island was unable to obtain financing due to high arsenic levels in the water. The homeowner investigated centralized AX treatment, but the Washington Department of Ecology would not approve a discharge permit from the treatment process to a new drainfield due to concerns that the AX regeneration process might produce a hazardous waste stream. Instead, the homeowner proposed and received approval for the installation of POE units at each home, including the proposed home. The spent regenerant and backwash from each unit would be discharged to the existing individual drainfields, which did not require a permit. The approval of the use of the POE units was contingent on the following:

- The system must have a certified operator;
- Units must be checked monthly;
- Subsequent homeowners must be notified of the POE units; and,
- It must be demonstrated that the units could be checked in the field by a simple method.

The arsenic concentration in the source water is around 0.27 mg/L and is well above the current MCL of 0.05 mg/L. Cyanide is also present at a concentration of 0.25 mg/L, just above the MCL of 0.20 mg/L. During the pilot testing, it was shown that arsenic levels could be reduced to less than 0.01 mg/L and cyanide levels could be reduced to less than 0.02 mg/L with the POE AX treatment. Throughout the treatment cycle the arsenic concentration remained below 0.02 mg/L.

The POE AX unit that was pilot tested and selected for this system consisted of a twin tank system with Purolite A-300E strong base resin. The tanks are operated in parallel to provide a larger flow rate and the backwash cycles are staggered so that water is available continuously. The tanks are preceded by a sediment pre-filter. The system also contains a flow restriction to ensure that the flow rate through the system does not exceed the design flow rate. The POE AX units are non-electric and contain non-electric flowmeters to initiate backwash and regeneration.

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Pilot tests were conducted between 1995 and 2000. The initial pilot test was conducted to determine the effectiveness of the POE AX technology to remove arsenic and cyanide from the source water. Water was run through the unit at a rate of 1 to 2 gpm until 1,000 gallons had passed through the unit. The pilot test was operated without preoxidation for the first 500 gallons and with preoxidation for the last 500 gallons. The pilot test showed that preoxidation was not required for efficient removal of arsenic and cyanide from the source water.

The second pilot study was conducted at one household for six months. The purpose of this pilot test was to achieve the following:

- Evaluate system operating parameters, such as flow rate and run length;

- Verify that a simple field test, such as pH or alkalinity, can be used for routine evaluation of the treatment system;

- Confirm that the treated water remains free from coliform bacteria;

- Verify that the drop in pH after resin regeneration is not a concern in successive cycles;

- Verify that preoxidation is not required for effective arsenic and cyanide removal; and

- Verify the effectiveness of backwash and regeneration.

During the second pilot study, samples were taken daily when possible and before each regeneration cycle. Samples were analyzed for arsenic, cyanide, bacteria, pH, and alkalinity.

Approval of the use of POE AX for the Marine View Estates water system took about four years from inception. This was largely due to the time required for pilot testing and a great deal of paperwork. The homeowners were not resistant to the implementation of the plan. All residents were notified by a memo that failure to install the proposed treatment could present an obstacle to the sale or transfer of their property.

To obtain approval for the use of the POE AX devices, the homeowners association was required to develop an O&M manual to be distributed to all homeowners. The homeowners are responsible for installation, maintenance, and daily operation of the POE AX units. However, the homeowners association was also required to retain the services of a certified operator to provide ongoing technical assistance, routinely verify proper operation of the POE treatment units, and collect samples for compliance.

Compliance with the arsenic MCL for the CWS is determined on a house-to-house basis. Compliance with all other contaminants regulated at the entry point to the distribution system is based on entry point monitoring.

Maintenance is performed on an as needed basis for both the sediment pre-filter and the resin. The sediment pre-filter is checked every 6 months and is replaced if a change in system pressure occurs. The media has not yet needed to be changed (longest media in use has been six years), but the media is expected to last for about five years. The media will be replaced more frequently if it is no longer effectively removing arsenic and cyanide throughout the complete treatment cycle. Since there are no toxic pollutants held within the media, it is expected that the AX resin may be disposed of with the household trash.

The cost of the units is dependent on the contaminant(s) being removed. The average cost of the units treating for arsenic only was about $3,400, but ranged from about $2,500-$8,000 (the more expensive units also remove such contaminants as excessive sodium). This cost includes an initial and follow-up annual sampling done by the vendor in the first year, as well as necessary additional sampling. After the first year, it costs $4.50 per sample for the vendor to test the water for arsenic. All sampling results are sent to the State. The CWS is monitored by a certified operator on the island, who is responsible for sampling and routine maintenance. This certified operator is required to check the AX units every three months to ensure that they are operating properly.

The POE AX units are still in use at Marine View Estates. The units are considered a permanent compliance solution to the arsenic and cyanide problem in the water system. However, modifications to the systems may be necessary to comply with the new MCL for arsenic of 0.010 mg/L. As noted previously, the units are capable of achieving arsenic removal to below 0.010 mg/L, but by the end of the treatment cycle may rise to about 0.02 mg/L.

The homeowners are considering changing to an iron oxide media system. The problem with this system is that the media is expensive to replace (though it too can be thrown out with household trash) and needs to be changed every three to four years. Currently, there is only one distributor of these types of systems, so the cost is prohibitively high. If the cost of these units drops, the water system will likely change over to these units.

7.1.5 Fallon Naval Air Station (POU RO for Arsenic Removal)

This case study is summarized from information provided by Mazanek (2003), Jones (2001), and Manley (2001). The Naval Air Station in Fallon, Nevada (NAS Fallon), is made up of offices, living quarters, and various other base facilities. NAS Fallon water comes from three, 500-foot deep wells tapping an underground source of water called the Basalt Aquifer. The Basalt Aquifer also provides water for the City of Fallon and the Fallon Paiute-Shoshone Tribe through their respective distribution systems. The Basalt Aquifer has high, naturally occurring levels of arsenic, which are greater than the MCL. After water comes out of the NAS Fallon wells, it is treated with a chlorine disinfectant to protect consumers against microbial contaminants and pumped to the NAS Fallon water distribution system. At this site, a temporary POU treatment measure was decided upon to lower the arsenic levels. The affected population was provided information regarding the reason for treatment units and the danger of arsenic by means of the annual CCR. Individuals new to the base are informed through the military indoctrination process that familiarizes new employees and residents with the base and its operation.

POU RO devices, equipped with GAC pre- and post- filters and a sediment pre-filter, were installed all over the base. There was no pilot test because this was intended to be a temporary treatment solution. The units do not have water meters, automatic shutoff, or warning lights, but do have storage tanks and re-pressurization chambers. The units were tested and certified by NSF International. The units typically filter around 25 gallons per day (gpd).

The units were installed and are maintained under contract with the vendor. Installation required about one hour per unit, including PVC piping between the unit and a separate stainless steel tap, which was included in the purchase price of the unit. Maintenance and disinfection are performed every nine months, sediment and GAC filters are replaced every nine months, and RO membranes are replaced every 27 months. The vendor disposes of all the residuals. Access to units is assured through Navy mechanisms set up to enable house inspections. There is no contract set up for the vendor to insulate the system should a unit fail. Base maintenance or the vendor handles complaints or questions within 24 hours.

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About 360 POU RO under-the-sink units were installed in base quarters in May 2001. Additionally, approximately 75 water cooler style RO machines were installed in common areas such as offices, gyms, and daycares, and there are 11 strategically located RO vending machines for on and off-base residents to fill one- to five-gallon bottles. The RO units effectively remove 90 percent of arsenic from the water, reducing the average influent concentration of 0.10 mg/L down to below detection limits. The RO units are serviced quarterly and tested twice a year to make sure the water meets drinking water standards. No major operational problems have been identified thus far, and the base residents seem satisfied with the units' performance.

The costs associated with the under-the-sink RO devices are about $300 per unit for purchase and installation and about $129 per unit per year for maintenance and replacement. The costs of maintenance run high, partially due to the distance (65 miles) between the system location and the vendor, and partially due to the costs for replacement parts ($9 per sediment filter, $12 per GAC filter, and $55 per RO membrane).

NAS Fallon is collaborating with the City of Fallon to design and build a central water treatment facility for treating arsenic. Once the central treatment is on-line, the POU devices will be abandoned.

7.1.6 EPA Demonstration Project in Grimes, CA (POU AA and Iron Media for Arsenic Removal)

The information in this case study is summarized from information provided by Bellen (2003 and 2004), EPA (2004), and Narasimhan (2005). An EPA demonstration project was completed to identify, measure, and record the conditions necessary for successful implementation of a centrally managed POU treatment strategy for compliance with the new arsenic standard of 0.010 mg/L. The focus of this study was on POU AA and POU iron media for arsenic removal. However, because POU iron oxide media was not commercially available at this time, only POU AA devices were installed in the community. Iron oxide media was pilot-tested along side AA. Based on that pilot, it could have lasted twice as long as the AA device.

The criteria for site selection included community size (25-100 service connections), an arsenic level between 20 and 50 ppb, compliance with MCLs for all other contaminants, water quality, and local and/or State support. Grimes, California, with a population of about 300, was selected as the site for the study. POU devices were installed in 122 locations, of which 105 were residences and 17 were community buildings or businesses. One of the residences in the study includes a daycare. Eleven residences or businesses declined to participate.

The pH of the water is 8.0–8.4, and the arsenic is present in the system as arsenic V due to chlorination. There are slightly elevated levels of silica in the water as well.

Each unit had an automatic shutoff device. The POU AA units were equipped with two AA media cartridges and a GAC post-filter. The AA media cartridges were expected to last for 500 gallons before needing to be replaced. After one year, 90 percent of the POU AA cartridges did not need replacement. The POU iron media units used in the pilot were equipped with one iron media cartridge, one pre-sediment filter and a carbon post-filter. Installation of each AA device took about one hour due to the age and diversity of the plumbing in the community. In a community of more modern homes, installation would probably have required only 15 minutes per device. Cartridge replacement for both devices took about 15 minutes. The POU devices, installation, and maintenance were donated to the community by Kinetico for the study. Access to the homes for installation and maintenance of the POU devices was not difficult to achieve, but coordination of schedules to ensure that someone was home was sometimes difficult. One other problem is that some residents may not have actually been using the POU systems after they were installed.

Every POU device was sampled for arsenic after installation, with composites of samples from five units analyzed to save on analytical costs. Then, a portion of the POU devices was sampled quarterly with each device sampled at least once during the study period. Two samples exceeded the new arsenic MCL of 10 ppb during the study. Each device was re-sampled and the cartridge was replaced if the result was confirmed. Microbiological samples were also collected during the study. The geometric mean for HPC was 320 cfu/mL. None of the samples tested positive for fecal coliforms. If any of the samples had tested positive for fecal coliforms, the media cartridges would have been replaced and the system would have been sanitized. The units were rated at 500 gallons capacity. The iron media cartridges actually treated 800 to 1,100 gallons before breakthrough; the AA media cartridges lasted longer, treating as much as 1,600 gallons before needing replacement.

At the end of the study, the overall attitude of the community toward the use of the POU devices was positive.

The POU devices cost about $300 each retail; however, Kinetico stated that it would consider providing POU units at cost. Management and reporting could cost $125 to $200 per year per unit, resulting in a household cost of $17 to $25 per month (using a 3 percent interest rate over 10 years). Depending on the frequency of sampling and filter cartridge change-out, this approach could cost less than half the estimated cost of central treatment. For additional information, contact the National Sanitation Foundation, which has conducted research on this system.

7.1.7 American Water Works Association Research Foundation (AwwaRF) Project 2730 (Multiple POU/POE Technologies for Arsenic Removal)

An AwwaRF project evaluated the feasibility of using POU and POE treatment systems for small system compliance with the new arsenic MCL of 0.010 mg/L (Narasimhan 2005). Technologies examined in this study include POU RO, POU AA, POU manganese AA, POE GFH, and POE iron AA. These technologies were evaluated at various sites in Arizona, Nevada and Texas. These devices were operated in both continuous and intermittent conditions. Contaminants being monitored include arsenic, TDS, silica, hardness, and HPCs.

POU and POE devices were field tested at the water systems’ facilities, rather than at residents’ homes, in tests designed to simulate one year of residential use. The field testing program had two phases. During phase A, which lasted two weeks, POU devices were conditioned by operating 40 minutes on followed by 40 minutes off, 16 hours per day. POE devices were run 16 hours on and 8 hours off. During the 10 weeks of Phase B, POE devices were operated continuously. POU devices were operated according to the schedule shown below in Exhibit 7.2.

During both phases, samples were taken weekly from raw water for arsenic and other water quality parameters. Treated effluent was sampled for arsenic and certain parameters three days per week.

Exhibit 7.2: Operational Schedule for POU Devices During Phase B

Period	Operating Times	Duration (minutes)
1 (Weeks 1-2)	6:00 am	2
	8:30 am	5
	11:30 am	5
	5:30 pm	2
	6:30 pm	5
	9:30 pm	3
2 (Week 3)	no flow (simulated vacation)	
3 (Weeks 4-10)	6:00 am	2
	8:30 am	5
	11:30 am	5
	5:30 pm	2
	6:30 pm	5

All the devices tested were shown to be capable of removing arsenic to levels below the new MCL, except that the POU RO device in Unity, Maine, was not effective at removing arsenic III. Arsenic levels in raw water at Unity were high (0.098 mg/L). The authors suggested that the device might be effective if pre-oxidation was used to convert arsenic III to arsenic V before treatment. The results of all field testing are summarized in Exhibit 7.3 below.

Exhibit 7.3: POU and POE Performance Summary

Location	Technology	Effluent Si, as SiO_2 (mg/L)	Effluent pH	Effluent Arsenic (mg/L)	Gallons Treated before 10 ppb Breakthrough	Sufficient for 1 Year Operation in 5-Person Home? (1,000 gal)
Metro Water, Tucson, AZ	POU RO	4.8– 7.7	6.7–8.8	<0.002	>780	Yes
	POU AA	0.2–15.0	7.4–8.6	<0.002	2,660	Yes
	POE Fe-AA	24–39	7.0–7.7	<0.001–0.010	356,400	Yes
	POE GFH	34–39	7.2–7.7	<0.001–0.006	343,400	Yes
Sun City West, AZ	POU RO	0.9–2.3	7.1–8.7	<0.002	>1,300	Yes
	POU AA	<0.1– 14.9	7.7–8.4	<0.001–0.025	1,780	Yes

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Location	Technology	Effluent Si, as SiO_2 (mg/L)	Effluent pH	Effluent Arsenic (mg/L)	Gallons Treated before 10 ppb Breakthrough	Sufficient for 1 Year Operation in 5-Person Home? (1,000 gal)
	POU Mn-AA	<0.1– 14.2	7.9–8.5	<0.001–0.026	1,780	Yes
	POE Fe-AA	1.3–13.6	7.2–8.5	<0.001–0.022	63,400	Yes
	POE GFH	0.1–15.4	7.2–8.5	<0.001–0.014	368,600	Yes
Stagecoach, NV	POE Fe-AA	1.2–26.0	8.0–8.3	<0.001–0.014	34,600	Yes[1]
	POE GFH	4.1–29.0	8.0–8.3	<0.001–0.009	110,000	Yes
Unity, ME	POU RO	<1.0	8.2	0.053–0.100	0	Yes[2]
	POU Mn-AA	7.0–8.5	8.0–8.1	<0.001–0.110	640	Yes
Carson City, NV	POU GFH	1.3–23	7.7–8.3	<0.002–0.012	15,200	Yes
	POU Mn-AA	1–21	8.0–9.0	<0.002–0.016	7,700	Yes
Houston, TX	POE GFH	not available	6.2–7.8	<0.001–0.008	>328,900	Yes
	POE Fe-AA	not available	5.2–7.0	<0.001–0.014	201,450	Yes

7.2 Copper Treatment

7.2.1 Florence, Montana (POU CX for Copper Removal)

POU CX units were installed at a school and a trailer park in Florence, Montana, to study the efficiency of these units in reducing copper levels at these sites as part of a study (Abdo, et al., 2000). One POU CX unit was installed at a drinking fountain at the school and another unit was installed under a sink in a residence in the trailer park.

Florence-Carlton School is a nontransient, noncommunity water system that serves approximately 950 students and 100 staff members during the school year. Water for the school is obtained from two wells sunk in alluvial fan deposits and is stored in a 500-gallon tank prior to distribution. The source

[1] May be applicable with periodic backwashing of the Fe-AA media.

[2] May be applicable with pre-oxidation, prior to treatment.

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water is characterized by low levels of copper. However, the source water also has low TDS (<150 mg/L) and is corrosive to the school's water distribution system, causing relatively high levels of copper in school drinking fountains.

The Bitterroot-Pines Trailer Court is a CWS that serves 16 trailers and two homes. This system relies on water pumped from the same aquifer as the school. Copper levels in the source water are below detection limits, and TDS levels are even lower than those found at the school (<100 mg/L). The source water is also corrosive to the plumbing materials used in the trailer park residences.

Weekly samples were collected at locations directly before and after the POU CX units. These samples were analyzed for pH, sodium, alkalinity, bicarbonate, specific conductance, copper, lead and heterotrophic bacteria. The total flow through each of the devices was also recorded weekly. Breakthrough of copper was observed after about five months (approximately 125 gallons of water treated) at the school and after about two months (approximately 170 gallons of water treated) at the trailer park. Prior to breakthrough, the unit reduced influent copper levels by 8 to 84 percent at the school and 58 to 98 percent at the trailer park. It is believed that the broad range of removal rates (especially those observed at the school) is related more to the variability of influent copper concentrations than to the effectiveness of the treatment unit. However, it is important to note that when breakthrough did occur, chromatographic peaking was observed (i.e., the treated water had higher levels of copper than the influent). This observation indicates that copper was being displaced from the resin by another contaminant (not identified in this study) in the water for which the CX resin had a higher affinity. The use of a special-purpose copper-specific resin may increase run length.

7.2.2 Location 2, Montana[3] (POU RO for Copper and Lead Removal)

Four-stage POU RO units were installed in a 16-unit trailer park in Montana in the spring of 2000 to reduce high levels of lead and copper (0.005 mg/L and 3.25 mg/L, respectively). The units consist of a particulate pre-filter, a GAC pre-filter, an RO membrane, a 3-gallon storage tank, and a GAC post-filter. A separate tap was also included with each RO unit. The cost of each system was $970 installed ($15,520 for the entire trailer park). The trailer park has entered into an ongoing maintenance agreement with the vendor for $150 per year. Under this agreement, the vendor will check each RO unit twice per year and handles disposal of the spent cartridges and membranes. However, the cost of replacement parts is not included in the $150 fee and is borne by the trailer park.

To date, the units have worked well, reducing the copper levels to 0.22 mg/L (93 percent reduction) and reducing lead levels to 0.003 mg/L (40 percent reduction).

7.3 Fluoride Treatment

7.3.1 Suffolk, Virginia (POU RO for Fluoride Removal)

The King's Point subdivision in Suffolk, Virginia was chosen by EPA and the State of Virginia as a demonstration site to evaluate the feasibility of POU RO treatment for fluoride. The study later became a part of the compliance plan for King's Point. This study was summarized from Lykins Jr., et al. (1995) and Werner (2001, 2002, and 2003).

King's Point subdivision has its own water system served by two well sources. At the beginning of the study, the water from the two well sources was not disinfected or otherwise treated. The water

[3] Name of trailer park and location withheld at request of system for confidentiality.

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available to King's Point contained fluoride in the range of 5.0 to 6.1 mg/L, which exceeds the primary MCL of 4.0 mg/L. When the site was chosen for inclusion in the study, the King's Point water system served 40 connections (39 residential, one commercial); by the end of the project period it served about 57 connections (56 residential, one commercial).

Due to the high concentration of fluoride in the drinking water system, Suffolk received two notices of violation, one from the Virginia Department of Health in 1989 and one from EPA in 1991. After examining its options, the city chose POU treatment as the most attractive option based on cost, timeliness, and O&M requirements. In 1992, the city and State agreed to the POU demonstration project as part of the city's compliance plan.

The project team included EPA, the Virginia Department of Health, the City of Suffolk, and three manufacturers of consumer drinking water products. During the study period, the unit suppliers were responsible for all costs. The POU units used in the study consisted of a sediment pre-filter, a high-flow thin-film (HFTF) membrane, a storage tank, and GAC post-filter. Initially, flowmeters were not installed on the POU RO units. The units were also not equipped with alarms or shut-off devices. The units were installed under the kitchen sink at all homes and were also connected to refrigerators that were equipped with ice-makers. The units were installed in all homes in April 1992. Three manufacturers supplied units and services for the study, with each manufacturer supplying one-third of the RO units used in the study. No pilot testing was done before installing the RO units since the project was intended as a demonstration study.

All homeowners in the King's Point subdivision were required by the City of Suffolk and the Virginia Department of Health to participate in the study before the State and EPA would accept the POU alternative. The EPA regional office required 100 percent participation in this study, lest they continue with the enforcement proceedings regarding the fluoride violation, since POU treatment was not acceptable as the best available technology (BAT). The homeowners were also required to sign a home access agreement that relieved the city of liability for damages caused by the treatment units. There were no significant problems in achieving 100 percent homeowner participation in the study.

The subdivision was divided into three regions, each served by a different manufacturer of POU RO units. The initial monitoring plan called for one resident from each region to volunteer their home as a distribution sampling site, where chemical and microbiological samples would be collected monthly by a city official. The analyses were performed and recorded by the Suffolk Department of Public Utilities. The analyses included conductivity, fluoride, HPC, pH, sodium, TDS, and turbidity. Coliform analysis and a semiannual complete inorganic scan were later included. A representative of the manufacturer was called if a unit required routine service.

Shortly after initiation of the project, high HPC levels were detected in the water treated by the RO units. To remediate this problem, central chlorination of the well water was implemented. In addition, the chlorine sensitive HFTF membranes were replaced with cellulose triacetate (CTA) membranes, the sediment pre-filter and GAC post-filters were replaced with non-carbon turbidity filters or no filter at all, and all of the RO units were disinfected. The GAC post-filters were believed to be a significant factor causing the high HPC levels. In response, an additional monitoring and sampling site in each manufacturer's service region was added. In the event of high HPC or fluoride levels, a manufacturer's service representative scheduled necessary maintenance with the homeowner. Data were collected from the sampling sites for nearly two years.

After implementing the disinfection strategy, the HPC levels appeared to be rising again. To reduce these levels, a weekly flushing program was implemented at all dead end mains to ensure that a 1.5 mg/L free chlorine residual was maintained at the ends of the distribution system. In addition, educational flyers were mailed to each household instructing the customers that frequent use of the RO devices improves the water quality delivered. The flyers also included information on the high quality of the water produced by the RO units.

A new plan was developed in 1994 to monitor all of the RO units and to demonstrate typical maintenance. The manufacturers were responsible for scheduling and collecting samples from residences in their respective regions quarterly on a monthly rotating basis among manufacturers. The sampling within each month was staggered throughout the month rather than conducting all sampling on the same day. Sampling was usually conducted by paying a visit to target homes after 5 p.m. or on the weekends. Approximately 10 percent of all appointments were not kept. During each visit the homeowner was asked if the treatment unit was operating and if they used the water from the treatment unit for all of their cooking and drinking needs. In addition, the homeowner was informed of good operating practices, such as frequent use and flushing, that would improve the quality of the water from the treatment unit. In a routine service call, pre- and post-device free chlorine, total chlorine, and conductivity measurements were recorded. Observations indicated that the conductivity reduction from the influent to the treated water was generally lower than the fluoride rejection rate. Therefore, conductivity could be used as a surrogate for monitoring the efficacy of the unit in removing fluoride. Membranes were replaced when the conductivity reduction fell below 70 percent of the influent.

In the event that mechanical problems occurred with the RO units, the customers could call a manufacturer's representative. It was mandated that such problems were to be addressed within 24 hours of the service call. Any other problems or complaints were addressed to representatives of the city.

Liquid residuals from the RO treatment process were sent to the kitchen sink drain and ultimately were disposed of with the household wastewater into septic systems. The RO unit manufacturers were responsible for membrane and cartridge replacement, and ultimately for the disposal of spent membranes and cartridges.

Fluoride levels in tap water were maintained below 2.0 mg/L in all households in the subdivision. Monitoring results for a one-month period showed fluoride concentrations at the tap ranging from roughly 0.1 mg/L to 0.6 mg/L. Variations in fluoride concentrations from month-to-month or residence-to-residence were explained by membrane degradation. Exhibit 7.4 shows the data for treated water collected from one residence and the raw feed during a quarterly sample collection.

Exhibit 7.4: Performance Data for a Typical POU RO Unit in Suffolk, VA

Contaminant	Influent (1/12/95)	Effluent (1/9/95)
Total Coliform (coliform organisms/100 mL)	< 1	< 1
Heterotrophic Plate Count (cfu/mL)	12	5
Fluoride (mg/L)	5.62	0.352
Sodium (mg/L)	207	18.0
Total Dissolved Solids (mg/L)	474	36
Turbidity (NTU)	0.18	0.08
Conductivity (μmho/cm)	768	62.5

If units were not meeting the MCL or found to be otherwise in non-compliance, they were targeted and resolved on an individual basis.

A customer survey was conducted at the beginning of the study, after disinfection was implemented, and again at the end of the study. Customers were asked questions about how they would rate the water before and after the POU RO units were installed, water usage, maintenance visits, and their preferred option for dealing with the high fluoride levels in the system. In the final survey, 75 percent of the respondents indicated that they used the RO water for all of their drinking and cooking. Overall, the customers were satisfied with the service and quality of the RO water. Some homeowners initially resisted the installation of the RO units because it required that a hole be drilled in the sink to insert a tap for the RO unit. However, this problem was circumvented when the city agreed to replace the sinks when the RO units were removed. Five of the homeowners indicated that they resented the intrusion into their homes that was necessary for installation and service of the RO units.

In March 1995, the demonstration project was completed, and the City of Suffolk chose to lease the POU RO units so that the distributors would maintain responsibility for routine service and O&M activities. The approximate costs for water treatment ran $400/year/unit to rent the units and $400/year/unit for labor, maintenance, sampling, and analyses. Despite the overall success of the project, the King's Point subdivision was ultimately connected to the Suffolk, Virginia, city water system in February of 1998. The decision to connect to the city water system was largely due to rapid growth in the King's Point subdivision, which made POU treatment increasingly less economical.

7.3.2 Emington, Illinois (POU RO for Fluoride and TDS Removal)

This case study is summarized from Bellen, et al. (1985) and Lykins Jr., et al. (1992). In Emington, Illinois, 47 low-pressure RO units were installed by equipment dealers and monitored for eight months. The primary target contaminants for removal were fluoride and TDS. The RO systems consisted of a 5-μm particulate pre-filter, a GAC pre-filter, a pressurized 2-gallon tank, a GAC post-filter, and a thin-film RO membrane. Treated water was stored in the tank and passed through the GAC post-filter before being dispensed.

The POU units removed an average of 86 percent of the fluoride from source water containing 4.5 mg/L. TDS rejection averaged 79 percent from source water concentrations of 2,620 mg/L. A wide

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variation in rejection rates was observed. Most of the variation was attributed to a pressure drop across the pre-filter assembly. RO membranes (especially cellulose acetate membranes) are more effective for contaminant removal in high water pressure environments. Exhibit 7.5 tabulates the performance data for the Emington POU project.

While the POU RO units operated satisfactorily, a significant drawback was their low water output—approximately 3 gpd. To supplement their needs, many homeowners purchased up to 30 gallons of bottled water per month at a cost of $1 per gallon.

The HPC of treated water was found to be an order of magnitude higher than that of untreated water. Controlled sampling from various stages of the RO unit established that most bacterial growth occurred in the GAC polishing unit (i.e., post-filter). Coliforms were found in four pre-device and 11 post-device samples (16 percent of all samples).

Exhibit 7.5: Performance Data for POU RO Devices in Emington, IL (1985$)

Number of Participating Sites	47
Service Area Type	Central system with single family homes
Mean Treated Water Use (gpd)	0.8
Mean Flow Rates (gpd) Product Water Reject Water	 2.9 22.5
Fluoride (mean mg/L) Influent Effluent	 4.5 0.6
Total Dissolved Solids (mean mg/L) Influent Effluent	 2,530 520

7.3.3 New Ipswich, New Hampshire (POE RO, AA, UV for Fluoride Removal)

Boynton Middle School, located in New Ipswich, New Hampshire, serves approximately 600 students and staff. In early 1997, the school hired a consulting firm to implement a drinking water treatment system to reduce high fluoride levels in the school's water (Guercia, 2001). Prior to the installation of a new treatment system, the maximum fluoride concentration in the school's water was greater than 5.5 mg/L. To achieve a goal of 90 percent reduction in influent fluoride, the consultant recommended that the school install a single treatment system with a parallel plumbing system that would treat water traveling to six water fountains and two sinks in the kitchen. This option was predicted to be less costly and easier to maintain than installing multiple individual units at each fountain and sink.

Multiple and redundant treatment components were incorporated into the treatment system to ensure the efficient removal of the contaminant of concern. Water first travels through a 5 x 20 inch 5-μm sediment pre-filter cartridge, followed by a 5 x 20 inch 1-μm sediment cartridge. The water is then forced through a 900 gpd RO unit. Next, the water passes through a contact vessel containing one cubic foot of AA and two cubic feet of crushed limestone in order to restore the pH to its original level. The water then enters a 500-gallon atmospheric storage tank before it is repressurized and sent through a UV

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element. Finally, the water travels through a GAC post-filter containing two cubic feet of media prior to distribution.

After receiving State approval, the system was installed in the summer of 1997. In addition to the system itself, the consultant also recommended that the school incorporate a drinking water quality section into its science program to educate the students on the importance of safe drinking water and to inform them of the particular water fountains and sinks in the school from which they should drink. The system cost $17,230 installed. The development and submission of all documentation required for State approval of the system was included in this price.

The consultant continues to serve as the operator of the Boynton system and is responsible for the unit's maintenance and monitoring. Every six months, the consultant visits Boynton to perform preventative maintenance on the system. This maintenance includes: ensuring that the machinery is operating efficiently, replacing cartridges, testing for TDS before and after the treatment unit, adding crushed limestone as needed, changing the AA and carbon media as needed, testing for fluoride before and after the RO unit once per year, and changing the UV lamp once per year. The preventative maintenance takes approximately three to four hours to complete and is covered under the school's contract with the consultant. Rather than charging the school for each individual service call, the consultant bills the school at the beginning of each year for all services expected to be provided over the course of the year. The school has the choice of pre-paying (and receiving a 10 percent discount) or making monthly payments on the annual fee. Based on the average number of service calls made each year, the school is charged approximately $500 for each maintenance visit.

The consultant is also required by the State to sample for fluoride on a quarterly basis. Since it is often not possible for school maintenance personnel to monitor the system even on a weekly basis, the treatment system was designed with enough redundancy to reduce the potential for a problem to arise between scheduled maintenance and monitoring visits. It should be noted, however, that the system lacks an alarm or automatic shut-off. The school has contacted the consultant on several occasions in response to visual signs of problems, such as an overflowing or empty storage tank.

The consultant recommends that the RO membrane for this system be replaced every 3 to 5 years; both of the sediment filter cartridges be replaced every 4 to 6 months; the AA media be replaced after 2 to 3 years; limestone be added every 6 to 12 months; and the GAC media be replaced after 4 to 5years.

For every one gallon of water that the RO generates, one gallon of water is wasted (50 percent recovery). The wastewater, which contains approximately twice the mineral content of the untreated well water, goes directly to the school's septic system. The spent cartridges are disposed of in the garbage at no cost, and the AA is incinerated at a nearby facility at a cost of $65 per cubic foot. Note, however, that the spent AA could be disposed of in a standard landfill since it is not classified as a hazardous material.

Thus far, the Boynton system has been extremely effective at treating the school's drinking water and reducing the fluoride levels. The school has encountered very few problems with the system. However, an unidentified black material has recently begun to accumulate on the cartridge filters. Because this material obstructs the flow of water, the consultant has had to make one or two additional visits to Boynton in order to replace the clogged filters. In general, additional maintenance visits are uncommon (about one unscheduled service call every other year).

7.3.4 Opal, Wyoming (POU RO for Fluoride and Sulfate Removal)

This case study was based on information from Jack Theis of EPA Region 8 (2002, 2003). The town of Opal, Wyoming, is a small, rural community of about 40 homes and roughly 98 people. The community is served by a centralized well that is chlorinated and has individual septic tanks and drainfields serving each home. The system is regulated by EPA Region 8.

The town's well water was in violation of EPA drinking water standards, containing an average fluoride concentration just over the MCL of 4 mg/L and elevated levels of sulfate which adversely affected the taste and odor of the water. EPA Region 8 determined that POU RO treatment was the most economically feasible approach for this community. After several sparsely attended town meetings, the town passed an ordinance to guarantee 100 percent participation in the POU project. EPA Region 8 decided to first conduct a six-month pilot study prior to full-scale installation, during which they paid the installation and monitoring costs for six NSF-certified POU RO units. Two different out-of-state home water treatment unit vendors were contracted to handle installation, on-site maintenance and monitoring of the POU RO units. From inception to installation, the process took about 16 months.

Each household that participated in the pilot study had an under-the-sink unit installed at the kitchen sink tap. Each unit contained GAC cartridges before and after the RO membrane. The first GAC cartridge was to remove chlorine that could damage the RO unit, while the second, after the RO membrane, was for taste and odor. The units themselves were equipped with both storage tanks and re-pressurization mechanisms, but not flowmeters. The units had warning lights to indicate unit (membrane) failure, based on a conductivity test. In addition, a bad taste or odor, caused by sulfur passing through the device, would indicate failure. The units were not equipped with an automatic shut-off device.

During the pilot test, fluoride, sulfate, and HPC bacteria were monitored monthly at each unit. High HPC counts were observed during the pilot study, but were not determined to be harmful. HPC levels were around 20,000 to 30,000 cfu/ml and were reduced to around 5,000 cfu/ml after flushing the unit. The residents were highly satisfied with the removal of the water's unpleasant tastes and odors. During the pilot testing, only a few leaks and other problems occurred in the units that required a visit by the vendor.

The town obtained special consent from the State to use the lowest level of state-certified water system operator in the servicing, operation, and maintenance of these units, since they are extremely simple to operate. Complaints about the units went through the system operator or the mayor of the town. Access to the units was fairly simple to arrange; scheduling maintenance appointments was also fairly simple, since the residents were generally cooperative and interested in the project. However, the residents in the pilot study were hand-picked, and other residents may not be as cooperative. The biggest problem was getting the vendor to arrive and make the repairs in a timely manner. By the end of the six-month pilot test, all of the units were working satisfactorily and treating fluoride to less than 0.1 mg/L.

An administrative order outlining the units' maintenance requirements when the whole town goes on-line has been sent out to relevant and interested parties, but thus far the sampling protocol/schedule is still under development, and the final protocol must be approved by legal staff. The recommendations are as follows:

- One unit per month will be sampled for heterotrophic bacteria. A different unit must be sampled each month. Heterotrophic bacteria will be sampled at the regular kitchen tap and the tap served by the POU device for comparison.

- One unit will be sampled for fluoride each quarter. This can be the same unit that is sampled for heterotrophic bacteria.

- SOCs and inorganic chemicals (IOCs) will still be sampled at the entry point to the distribution system to determine how the water quality is changing.

- Lead and copper will be sampled, but a new protocol/approach must be developed.

- This sampling schedule will be dictated by treated water quality and a conservative maintenance/replacement schedule.

In disposing of the residuals, the town is considering either contracting this service out, or maintaining responsibility itself. Since the principal contaminants are fluoride and sulfate, the present plan is to dispose of solid residuals (such as used cartridges and membranes) in the household trash. Liquid residuals from the RO treatment process were sent to the kitchen sink drain during the pilot study and ultimately were disposed of with the household wastewater into septic systems. Both GAC cartridges and RO membranes are scheduled to be changed annually upon inspection.

Compliance will be determined based on all units treating to below the fluoride MCL. The whole system is to be considered in violation upon the failure of any one of the units to treat to below this MCL. The system is also required to maintain records of each unit and make these records available during sanitary surveys.

There was some reluctance on both the State's and the citizens' part at first, mostly focused around the cost of operating the system. The purchase price was around $700-800 per RO unit, and the maintenance fees are anticipated to run about $16 per month per household. However, due to the improved taste of the water treated by the RO units, a POU system has become the favored and accepted option for water treatment in this area. This POU treatment strategy requires considerable involvement from the regulatory agency and the success of this project will lie in the maintenance and sampling program, but overall, the POU RO water treatment seems to have high potential as a solution to Opal's water problems.

7.4 Nitrate Treatment

7.4.1 Suffolk County, New York (POE/POU GAC, IX, RO, and Distillation for Nitrate Removal)

A 1983 study evaluated various water supply options for the towns of Riverhead and Southhold, both located in the predominantly rural North Fork of Suffolk County. This case study was summarized from Lykins Jr., et al. (1992). Due to the size and demographics of the communities, it was determined that the development of public water supplies throughout the high nitrate areas would be prohibitively expensive. Individual POU/POE units were recommended for these contaminated areas.

POE devices and countertop and line bypass POU units were examined in this study. Several treatment technologies were tested, including GAC, IX, RO, and distillation. All units demonstrated the ability to remove the contaminants of concern to the necessary levels, and consumers were satisfied with the performance of the units. Exhibit 7.6 summarizes the water quality problems, the types of POU/POE devices used to treat the nitrate, chloride, and/or VOCs, and the performance of each unit.

Exhibit 7.6: Performance Data for POU and POE Devices in Suffolk County, NY

Unit Number	Water Quality Problem	Type of Device	Average Nitrate		Average Organics	
			Influent (mg/L)	Effluent (mg/L)	Influent (μg/L)	Effluent (μg/L)
1	Nitrate	Countertop (GAC+IX)	9.2	3.3	NA	NA
2	Nitrate	Countertop (GAC+IX)	7.7	2.4	NA	NA
3	Nitrate, chloride	Line bypass (RO+GAC)	10.8	4.6	NA	NA
4	Nitrate	Line bypass (RO+GAC)	9.9	4.3	NA	NA
6	Nitrate, VOC	Countertop (Distiller)	12.2	< 0.2	12	< 2
7	Nitrate	Line bypass (RO+GAC)	11.1	0.3	NA	NA
8	Nitrate	Line bypass (RO+GAC)	7.7	0.2	NA	NA
10	Nitrate	Line bypass (RO+GAC)	11.2	0.3	NA	NA
12	Nitrate	Batch (distiller)	9.3	0.2	NA	NA
15	Nitrate	Line bypass (RO+GAC)	8.6	0.8	NA	NA
17	Nitrate	Line bypass (RO+GAC)	11.5	0.3	NA	NA
18	Nitrate	POE (IX)	12.1	0.6	NA	NA

Despite the success of the units, the sampling results during the study revealed several problems that could be traced to improper installation or inadequate maintenance. Several units developed plumbing leaks that required repair. Organic contaminants leached into treated water from three units due to solvents used during the manufacturing or assembly of the units. High levels of copper were found in the effluents from two units that used copper discharge lines. Once these units were replaced, all units functioned satisfactorily for the duration of the study.

Bacteria were present in samples from all of the treatment units that included a GAC filter. However, no evidence of pathogenic bacterial growth was found, even in samples that exhibited elevated HPCs.

The effluents from three units tested positive for coliform bacteria after installation, though follow-up samples were satisfactory. Two of the contaminated units were countertop models, which are more susceptible to cross-contamination by homeowner activity. Additional disinfection procedures should be followed before and after installation of these models if they are selected by the water system for use in a compliance strategy.

The RO units exhibited varying removal efficiencies. This was probably due to the lower efficiencies of the cellulose acetate membranes used in some units relative to the thin film composite membranes used in others.

A detailed description of the monitoring plan, the capacity of the POU units, a full discussion of the division of responsibilities, and the cost per gallon of water treated were not provided in the literature

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reviewed. However, the study did emphasize the need for conservative design of POU/POE treatment devices to preclude premature contaminant breakthrough due to interactions between multiple contaminants (and from contaminants as yet undiscovered in the area).

7.4.2 Hamburg, Wisconsin (POE AX for Nitrate Removal)

Prior to the installation of a POE AX treatment system, Maple Grove Elementary School, a small rural school located in Hamburg, Wisconsin, experienced several problems with its drinking water (Maher, 2001). First, the corrosive nature of the system's source water led to high levels of lead and copper scavenging from the school's pipes. Second, because the school is located in an area with sandy, gravel-like soil that was once heavily farmed, high nitrate levels were also present in the water. To address these water quality issues, Maple Grove installed a treatment system in 1996. The system is comprised of an AX element for nitrate reduction, and a polyphosphate feed as a corrosion inhibitor. Although the school still encounters some difficulties with corrosion control, the AX element has been extremely successful at reducing the nitrate levels present in the water, maintaining levels well below the MCL since the system's installation.

Maple Grove purchased its treatment system from a local vendor. The vendor was also responsible for installing the system. The installation process took approximately seven hours to complete. The treatment system includes two resin beds with automatic regeneration, two feed pumps, and two solution tanks (one feeding chlorine and one feeding orthophosphate). Currently, the system serves approximately 200 students and staff members.

The unit lacks both an alarm and an automatic shut-off system; however, the vendor has supplied the school staff with test kits for sampling purposes. Under the regulations established by the Wisconsin DNR, the vendor must establish a service contract with its customers to ensure proper system operation to retain its license. As a result, all of the vendor's service contracts include a provision that provides for monthly visits to perform testing and to confirm ongoing effective system operation. Although these monthly visits are included under the service contract between Maple Grove and the vendor at no extra charge, Maple Grove is charged for any additional maintenance visits that may be required. Since the system has been installed, the school has required about three additional visits per year at a cost of $42 for the first half-hour and $42 for each additional hour.

A timer triggers regeneration of the AX units once per week during the night. To ensure ongoing water availability, the two resin beds are operated in parallel. A saturated brine solution (60 percent) is used for regeneration.

The AX resin is expected to last for 10 to 16 years. Since the system was only recently installed, the school has not yet had to deal with media disposal issues. At other installations, the vendor re-bedded the system on site and the property owner disposed of any remaining spent media in a standard landfill.

7.4.3 Fort Lupton, Colorado (POU RO for Nitrate and Total Suspended Solids (TSS) Removal)

To comply with an enforcement order for nitrate issued by the Colorado Water Quality Control Division (WQCD), the Wattenburg Improvement Association (WIA) elected to install POU RO units in each residence in Wattenburg, a town of approximately 100 households (Alberts and Peterson, 2000). Prior to selecting the specific device to install, the WIA hired a contractor to evaluate the capabilities of RO units manufactured by three different firms. Each device was equipped with a booster pump to increase line pressure from 30 to 60 psi.

Pilot testing was conducted in the homes of three volunteers from the Board of Directors of the WIA. One device was installed underneath the kitchen sink in the house of each volunteer in June of 2000 and was operated for approximately three months. Over the course of the evaluation period, the volunteers were asked to answer questions regarding the convenience and performance of the units. Homeowners were pleased with the taste of finished water and the quantity of water available from the treated tap. They were also satisfied with the convenience of the units. However, the volunteers reported being less satisfied with the installation and maintenance of the filters. Specifically, they were concerned that maintenance would be difficult if POU RO units were installed in each household in the community. The homeowners did, however, recommend hiring knowledgeable professional maintenance personnel to perform all necessary maintenance activities.

Following the pilot test, a vendor was selected to provide treatment units to the community. The unit selected by the WIA consistently removed 91 percent of nitrate and more than 90 percent of TSS. Despite the concerns of the Board of Directors regarding the difficulties associated with installing and maintaining the units and their liability should the units stop working correctly, the WIA began to install POU RO units in each of the houses in Wattenburg. The community planned to hold a town meeting during the installation of the units to explain the reason for installing the treatment units (including the health effects associated with the consumption of excess nitrate), the operation of the units, the effectiveness of the units, and the manner in which the purchase of the units would be completed. In addition, all residents would be provided with an owner’s manual for the treatment unit as well as informational materials printed in both English and Spanish that explained:

- Nitrate contamination of drinking water;
- The role of the Colorado WQCD and the WIA; and,
- The funding process.

Due to the Board of Directors’ concerns about liability for damages in the event of unit leakage, they supported the use of a licensed plumber and licensed electrician to oversee each installation. In addition, they requested the development of a specifications manual to detail the requirements for each installation. Further, the Board of Directors recommended the use of an independent inspector to verify the quality of each installation. At the time of installation, the installer was to reiterate to each resident the points covered in the public meeting (e.g., unit operation, need for treatment, etc.).

The responsibility for conducting routine maintenance was to be borne by the WIA since the Board of Directors did not feel that residents, particularly renters, should be required to know how and when to perform this maintenance. The WIA is also responsible for keeping records of all maintenance on the units.

7.5 Radon Treatment

7.5.1 Various States (POE GAC for Radon Removal)

This case study is summarized from a report by Lowry, et al. (1989). To determine the effectiveness of POE GAC units in removing radon from drinking water, 121 POE GAC units in 12 states were monitored to varying degrees over seven years. Each house was equipped with a separate POE GAC system consisting of fiberglass vessels filled with either 1.0, 1.7, or 3.0 cubic feet of GAC, supported on a bed of gravel. The units were installed downstream of the existing pressure tank and operated in the downflow mode. Sixty percent of the installations were done by the homeowner without outside assistance.

Most units underwent initial sampling and analysis three weeks after installation to confirm the success of the installation. Sampling and analyses were conducted every six months thereafter for a period of two years. Samples were collected by homeowners and mailed to the Radon Research Laboratory at the University of Maine for liquid scintillation analysis. Some units were selected for long-term or monthly monitoring. The monitoring protocol used either direct syringe scintillation vials or glass septum capped vials (VOC type).

The GAC units in this study treated water supplies with a wide variety of radon levels, ranging from 2,576 picoCurie per liter (pCi/L) to more than 1,000,000 pCi/L. Average household water use was estimated at 157 gpd for purposes of determining performance. Performance data for the POE GAC devices observed in this study are presented in Exhibit 7.7.

Exhibit 7.7: Performance Data for POE GAC Devices

GAC Device	Flow (gpd)	Average EBCT (hrs)	Expected Removal Rate	Observed Removal Rate
GAC 10	157	1.14	96.7%	90.7%
GAC 17	157	1.94	99.7%	92.5%
GAC 30	157	3.43	> 99.99%	98.6%

In most cases, O&M costs were negligible. In a very few instances, GAC beds had to be replaced at a cost of $130 per cubic foot of GAC. Gamma emissions from POE GAC units used to treat for radon may lead to negative health effects for both members of the household and maintenance personnel. Exposure to gamma radiation depends upon the level of radon in the raw water and the location and shielding of the GAC unit. Therefore, the need for shielding or other protective measures should be evaluated for each specific site. If necessary, shielding may be provided either by a metal cover surrounding the treatment unit or by placing the GAC treatment vessel inside a larger vessel filled with water. Cost data for the POE GAC devices observed in this study are presented in Exhibit 7.8.

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Exhibit 7.8: Cost Data for POE GAC Devices

GAC Device	Cost of GAC Unit	Cost of Sediment Filter	Cost of Water Shield	Installation Cost	Total Cost
GAC 10	$600	$50	$25	$100	$775
GAC 17	$750	$50	$90	$100	$990
GAC 30	$950	$50	$125	$100	$1,225

Note: Shipping costs (averaging $30 per unit) were paid by the installer.

7.5.2 Derry, New Hampshire (POE GAC and Aeration for Radon Removal)

POE GAC and POE aeration for radon removal were evaluated by Kinner, et al. (1993). The effectiveness of two GAC units and two aeration units (one diffused bubble aeration (DBA), one bubble-plate aeration) were studied over the course of one year of continuous operation.

Each of the two GAC units consisted of a fiberglass contact vessel preceded by a sediment filter. The contact vessels were filled to 70 percent of their capacity with GAC (1.6 cubic feet of GAC per unit), providing an EBCT of 6 minutes at a flow rate of 2.0 gpm. One of the POE GAC units incorporated a separate CX element to remove iron and manganese in addition to the sediment filter and GAC element. The CX bed contained 1.4 cubic feet of strong-acid CX resin. The CX resin was regenerated every two weeks over the course of the study using a standard sodium chloride solution.

The DBA unit was comprised of a single vessel with three compartments in series, each containing an internal diffuser. The bubble-plate aeration system was also housed in a single vessel, however, this system contained a single spiral diffuser. For both units, finished water was stored in a 20-gallon hydropneumatic tank. A 38 cubic foot per minute (cfm) blower powered the DBA system while the bubble-plate aeration system was powered by a 315-cfm blower. Off-gases from both systems were vented via separate PVC vent pipes.

Radon levels of 22,837 to 54,765 pCi/L (average 35,620 ± 6,727 pCi/L) were reduced by more than 97.5 percent to less than 900 pCi/L for the first four months of the study by both of the POE GAC systems. For the remaining eight months of the study, radon levels in finished water rose to 3,000 to 6,000 pCi/L. This POE GAC configuration would not comply with the radon MCL (300 pCi/L) or alternative radon MCL (4,000 pCi/L) per the proposed Radon Rule. While the authors of this study were not able to determine the reason for the reduction they observed in system performance, they postulated that the presence of a contaminant that was also removed by the GAC reduced its capacity for radon. It should also be noted that the GAC system that incorporated the CX element remained somewhat more effective than the GAC unit that did not include this element (removal rates of 85 percent verses 79 percent), and also removed 99 percent of influent radium. Iron residues found in the top layers of GAC in the latter unit may have fouled the media or contributed to channelization which reduces effective contact time.

Both GAC units were colonized by bacteria. As a result, the use of such devices for compliance with the SDWA may require the use of some form of post-treatment disinfection to ensure the microbiological safety of the finished water, particularly for immuno-compromised individuals.

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The POE DBA system reduced influent radon levels to less than 200 pCi/L (> 99 percent) throughout the course of the study. The small size of the bubbles forced through the water in this unit contributed to the high radon removal rates, as did the high air-to-water ratio (119:1 assuming a water flow rate of 2.3 gpm). The POE bubble-plate system also typically reduced radon by more than 99 percent. However, when the air intake for the blower for this system was clogged, restricting airflow through the system, radon removal rates dropped significantly. This potential problem could have been avoided if the system had been equipped with an automatic alarm or shut-off valve or through more frequent inspection of the unit. Based on monitoring conducted outside of the building in which these units were installed, it is expected that the exhaust from aeration units will be rapidly diluted to background levels. If influent radon levels are exceptionally high, it may be necessary to further dilute the exhaust (through the use of a more powerful blower) or to treat the exhaust prior to release.

The costs in Exhibit 7.9 are based on actual expenditures incurred during this project. However, engineering/subcontractor and contingency fees were built into the capital costs for these estimates based on records from actual POE installations at well sites in New Hampshire. These cost estimates are reflective of the market in the New England region. These estimates do not include the costs associated with radon monitoring ($15 to $50 per sample - in 1990 dollars). Both estimates for the GAC units do, however, assume the worst-case scenario for waste disposal (handling and disposal of spent media as low-level radioactive waste at a cost of $28.09 per cubic foot - in 1990 dollars). The cost evaluation of the aeration systems was based on the assumption that additional treatment for the off-gases produced by the units would not be required.

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Exhibit 7.9: Cost Estimates for POE GAC and Aeration Systems (1990$)

Item	GAC (w/o pretreatment)	GAC (w/pretreatment)	Diffused Bubble Aeration	Bubble-Plate Aeration
Capital Costs				
Equipment	$785	$1,500	$2,215	$3,295
Installation	$275	$345	$880	$880
Total Capital Costs	$1,060	$1,845	$3,095	$4,175
Amortized Capital Costs (9% for 5 yrs)	*$273*	*$475*	*$796*	*$1,074*
Annual O&M Costs				
Power ($0.10157/kW-hr)	- NA -	- NA -	$80	$54
Maintenance	$160	$185	$345	$368
Labor	$45	$50	$545	$583
Administration	$49	$56	$195	$209
Disposal Costs	$56	$113	- NA -	- NA -
Total O&M Costs	*$310*	*$404*	*$1,165*	*$1,214*
Total Annual Costs	**$583**	**$879**	**$1,961**	**$2,288**
Production Cost (270 gpd design flow)	**$5.34/Kgal ($5.91/Kgal)**	**$7.77/Kgal ($8.92/Kgal)**	**$19.90/Kgal**	**$23.22/Kgal**

7.6 Trichloroethylene (TCE) Treatment

7.6.1 Byron, Illinois (POU/POE GAC for TCE Removal)

This case study is summarized from a paper presented by Bianchin at the 1987 Conference on Point-of-Use Treatment of Drinking Water (Bianchin, 1987). The Byron Johnson Salvage Yard is a 20-acre facility located in a rural area of northern Illinois. In the 1960s, the salvage yard was operated as a junk yard. From 1970 to 1972, the Illinois EPA conducted periodic inspections to identify operating deficiencies. In 1972, the Illinois EPA ordered the yard closed, and in 1974 the salvage yard ceased operation. In December 1982, the site was placed on the Superfund National Priority List. Illinois EPA began a remedial investigation/feasibility study, focusing on contamination directly on or below the site. The study revealed that both major aquifers in the area were contaminated by VOCs. In addition, cyanide and some inorganic compounds were found in the ground water beneath the salvage yard.

From 1983 through 1985, contamination levels in nearby (down-gradient) wells were monitored by EPA, Illinois EPA, and the Illinois Department of Public Health. Private wells were found with TCE levels of up to 710 μg/L. In July 1984, EPA temporarily placed residents in areas adjacent to the salvage yard, whose water was characterized by TCE concentrations greater than 200 μg/L, on bottled water. In May 1986, EPA installed POU GAC treatment devices as an interim measure for residents using bottled

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water. In July 1986, EPA initiated a monthly sampling program of these units to monitor the effectiveness of the POU devices.

In October 1985, EPA undertook a phased feasibility study to investigate the health threat posed to another nearby development from exposure to the contaminated water supply. Rock River Terrace Subdivision is located 1.5 miles down gradient of the salvage yard along the Rock River. Wells in the subdivision were contaminated with TCE levels up to 48 μg/L. Three treatment alternatives were analyzed for their potential to solve the subdivision's contamination problem. First, all residences could be connected to the Byron Municipal Treatment Facility. This alternative would cost approximately $900,000 (in 1986 dollars) and would take one to two years to implement. Second, all affected homes could be supplied with bottled water. This alternative was estimated to cost $91,150 per year and could be implemented almost immediately. However, since the water entering local households is not treated, and since bottled water would only be used for drinking or cooking, this alternative would provide no protection from inhalation of or direct contact with contaminated water. Third, each household could be equipped with a POU treatment unit. This alternative would cost $26,000 and installation would take about three months. However, as with the bottled water option, since all taps would not be treated, residents would not be completely protected from health problems resulting from inhalation or direct contact with contaminated water. Fourth, each household could be equipped with a POE treatment unit. This alternative would cost $115,000 and, like the third option, would require about 3 months to install. The fourth alternative would provide treated water at all taps within the household.

The fourth alternative was selected as the strategy most protective of public health and most economically feasible. Beginning in September 1986, EPA installed POE GAC systems in the basements of residences or in insulated, outdoor sheds throughout the subdivision. Each system consisted of a 5-μm pre-filter and two GAC tanks in series. Each GAC tank was 54 inches tall and contained 110 pounds of GAC. The system was designed for a flow of 7.5 gpm. Since carbon replacement rates depend on many factors including the level of contamination, water temperature, pH, water usage, and the presence of other constituents, periodic monitoring was conducted to ensure that contaminants were being effectively removed. Samples were collected on a monthly basis, before and after the carbon tanks, and sent to a local lab for analysis. The carbon was scheduled for replacement upon breakthrough. However, a year after installation, breakthrough still had not occurred.

<u>7.6.2 Elkhart, Indiana (POE GAC, Aeration for TCE and Carbon Tetrachloride (CCl4) Removal)</u>

This case study is summarized from Lykins Jr., et al. (1992) and Bianchin (1987). In June 1986, severe contamination by TCE (800 μg/L) and CCl_4 (488 μg/L) was detected in a well in Elkhart, Indiana. EPA instituted a sampling program covering 88 wells. Significant levels of TCE (5,000 μg/L) and CCl_4 (7,500 μg/L) contamination were detected in this effort (Bianchin 1987). EPA immediately provided bottled water to all affected residents and advised those with the most contaminated wells not to use their water for any reason. Due to the time required to extend the city's water mains, EPA decided to install 54 POE GAC and 22 POU GAC units at private residences. The Indiana Department of Environmental Management agreed to sample the affected homes periodically to ensure the continued efficiency of the treatment units.

The POE GAC units were 13 inches in diameter and permitted the use of up to 3.8 cubic feet of carbon (50 inches of carbon depth). Each POE unit contained 110 pounds of 20 x 50 mesh size GAC. Carbon replacement costs were approximately $510 per tank, while the sediment pre-filters cost $40 each to replace (in 1989 dollars).

Two residences were equipped with treatment systems consisting of a PTA element connected to two GAC tanks in series. These units were located in the basement and were vented outside. The air strippers had a 40:1 air-to-water ratio and operated at a rate of 5 gpm. The air strippers were packed with 1-inch diameter polypropylene cylinders. Although no microbiological problems have been encountered, a UV light may be installed in the POE system for post-GAC disinfection. The installed cost of the entire unit (one air stripper and two GAC tanks) was about $4,000 (in 1989 dollars). The installer recommended flushing the system any time that water stood unused for more than a day. Special monitoring was undertaken to test the effectiveness of these POE systems. The results of this monitoring showed that the units effectively reduced the levels of CCl_4 and TCE in the water.

GAC isotherm calculations, sometimes used to estimate breakthrough for GAC media, proved unreliable in accurately predicting breakthrough in the POE GAC units in Elkhart. The time to breakthrough was significantly over- or under-estimated. The number of gallons successfully treated before breakthrough ranged from 25,000 to over 300,000 gallons. Competitive effects, possibly from CCl_4 or TCE, were evident in one dual GAC unit in Elkhart that was monitored for a special EPA study. In this case, isotherm data predicted breakthrough for chloroform at approximately 225,000 gallons, but chloroform ($CHCl_3$) was estimated to have actually broken through after about 130,000 gallons were treated by the unit. Over the course of the study, methylene chloride concentrations of 115 μg/L were consistently lowered below detection levels. Exhibit 7.10 summarizes data from homes in Elkhart that experienced breakthrough and provides an illustration of GAC capabilities.

Exhibit 7.10: Performance Data for POE GAC Devices in Elkhart, IN

Site	Average influent concentrations (μg/L)			Gallons treated	Months	Possible Cause for CCL_4 Breakthrough
	TCE	CCl_4	$CHCl_3$			
1	170	291	15	30,500	25	Competitive effects; bacterial colonization
2	60	2,864	ND	120,000	22	High influent levels
3	418	2,188	ND	150,000	24	High influent levels
4	331	135	10	135,000	16	Competitive effects; TCE concentration
5	1,686	348	50	140,000	18	TCE concentration

7.6.3 Hudson, Wisconsin (POE GAC for TCE and 1,1,1-Trichloroethane (TCA) Removal)

This case study is summarized from system information provided by Anklam (2001). In the 1960s and 1970s, TCE, TCA, as well as low levels of tetrachloroethylene (PCE) and 1,1-dichloroethylene seeped into well water in the town of Hudson, Wisconsin. In the 1980s, it was discovered that the ground water source for a populated subdivision in the western part of the town was also contaminated. The State of Wisconsin conducted an investigation and identified an industrial facility as the source of the contamination. As a result, the State required the industrial facility to either provide treatment or provide an alternate water source for the subdivision. The industrial facility chose to provide POE GAC units to the affected homes. Prior to the installation of the POE GAC units, the water for this subdivision was not subject to any kind of treatment.

The industrial facility is the responsible party for oversight and maintenance of the water systems. A private consulting firm is under contract with the industrial facility to provide administrative oversight and sampling for the system. A home water treatment unit vendor is contracted to handle on-site maintenance of the POE units and carbon replacement.

Two pilot tests were conducted prior to full-scale installation of the POE GAC units in Hudson. The POE GAC unit was installed at six residences with State approval. The POE unit consists of two, 1.25 cubic foot tanks in series, filled with FCS-AC11 coconut-shell granular activated carbon. The effluent was sampled monthly for TCE, TCA, and other organics over a two-year period. A larger unit, comprised of two, 3.61 cubic foot tanks, was pilot-tested separately at a local business. This unit was operated continuously and sampled regularly until breakthrough was detected. In 1995, at the beginning of the study, the average concentration of TCA and TCE in the source water was 51.2 μg/L and 33.3 μg/L, respectively. The POE GAC units consistently maintained TCA and TCE concentrations well below the MCLs of 0.2 mg/L and 5 μg/L, respectively.

The pilot tests demonstrated that the POE GAC units effectively remove TCE, TCA, and other trace organics present in the raw water to below detectable levels. After obtaining state approval for a full-scale POE compliance strategy in 1995, the industrial facility conducted a residential sampling program to verify water quality. After determining which residences qualified for POE treatment, the industrial facility began offering GAC units to the residents of Hudson to treat their contaminated ground water at no charge. Currently, about 155 households and ten businesses have POE GAC units installed.

In order to obtain a POE unit, residents are required to sign an access agreement with the industrial facility that, among other provisions, requires the residents to schedule appointments with the contractor and subcontractor for periodic maintenance, water sampling, and carbon replacement. If the resident refuses access, the industrial facility will then provide bottled water as an alternative, although the Wisconsin DNR does not recognize bottled water as a "permanent water supply." Residents that refuse to have a POE GAC unit installed must also sign a consent form indicating that they understand that the water is contaminated and choose not to treat the water. Only one household chose bottled water over POE GAC filtration. If residents have questions concerning the contaminated water supply, they are referred to the Wisconsin Department of Health for additional information about potential health effects.

Both the influent water characteristics and water usage at a specific site are considered when deciding what size POE GAC unit to install. For low concentrations of TCE and TCA (11-12 µg/L and 15-16 µg/L, respectively) at normal-sized households (six or fewer people), the smaller unit is installed. In cases where the contaminant levels are higher (>12 µg/L for TCE and >16 µg/L for TCA) or water usage is greater (*e.g.*, nearby businesses), the larger unit is installed. In order to complete the installations, the vendor was required to have Wisconsin Restricted Appliances Journeyman Plumber certification or greater. A cartridge-type pre-filter for iron and/or sediment removal is installed on some units, depending on the characteristics of the influent water quality. Sediment filters are required more frequently than iron filters, due to the town's raw water characteristics. The subcontractor will change the filter cartridges during the annual carbon change-out, or on an as-needed basis.

As a permanent solution to the water supply contamination problem, ground water remediation was initiated. Since that time, the TCE and TCA concentrations in Hudson's wells have steadily decreased to about 3-4 μg/L. As a result, a less rigorous residential sampling schedule was implemented. Initially the POE effluent was tested for TCE and TCA on a quarterly schedule, but with State approval the sampling frequency was reduced to semi-annual testing and eventually, to annual testing as the concentrations decreased. Concentrations of TCA and TCE in the treated water are currently below the detection limits of 0.2 μg/L and 0.4 μg/L, respectively. Tests are also performed for total coliform

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bacteria at points before and after the filter unit, to determine if bacterial growth is occurring in the GAC media. All samples are processed by a certified laboratory.

One unconfirmed instance of TCE breakthrough was detected at a household POE unit in the initial years of operation, but no additional breakthroughs have been detected since then. Rather than re-sampling and confirming the single instance of breakthrough, the media was changed out.

The carbon is replaced in all of the POE GAC units on an annual or biennial cycle, depending on water usage. During change-outs the carbon in both tanks is replaced simultaneously to avoid potential bacterial growth in the filter media. The spent carbon from the households is taken to a holding facility and then trucked to a regeneration facility, where it is re-activated for other purposes. Regenerated carbon is not used in Hudson's POE GAC units.

The vendor bills maintenance and carbon replacement appointments at two different rates. A lower rate is charged if the call can be completed during the day, and a higher rate (by at least 10 percent) is charged if the call must be completed in the evening or on a Saturday. Scheduling appointments to gain access to the POE units can be difficult at times, but generally runs smoothly.

Some minor technical issues have been encountered with the operation of the POE GAC units. Some customers complain about pressure drops in their taps, and during the summer condensation may cause water to collect beneath the GAC tanks. In addition, residents with swimming pools are reluctant to fill them with the POE treated water, and some have tried installing bypasses before the treatment unit to fill the pool with untreated water. However, these bypasses are highly discouraged because of liability issues.

7.7 Radium Treatment: Illinois EPA Study (POE CX)

This case study is summarized from a presentation given by Selburg at the NSF International and the Center for Public Health Education Conference on Public Water System Compliance Using Point-of-Use and Point-of-Entry Treatment Technologies (Selburg, 2003). In this project, which is currently in the planning stages, POE CX will be evaluated as a compliance option for radium removal for small systems. The objectives of this project are:

- To determine how many samples and homes with softeners are needed to demonstrate hardness as a surrogate indicator for radium concentration;

- To determine how many homes are needed to demonstrate the effectiveness of softeners for radium removal; and

- To determine how many radiological samples are needed to verify that the public health protection provided by POE CX treatment for radium is equivalent to that provided by central treatment.

Several criteria have been set in order for this study to proceed. First, 100 percent participation by homeowners in the community is required. Second, in accordance with SDWA, the water system must be totally responsible for all aspects of the operation. In addition, only POE units will be allowed in the study.

One CWS will be selected for the pilot study, though other interested systems will be allowed to participate in the project after the first quarter of the pilot study has been completed. Before the pilot study begins, the selected water system must work with regulatory authorities and a consultant to develop

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technical provisions for the pilot study and timeliness and dates for a compliance agreement. The selected water system must also submit plan documents, the compliance agreement, an operating plan, a contractor agreement, and any other related documents to the Illinois EPA for review. The Illinois EPA will then draft a permit and review all documentation with EPA Region 5. After the permit has been issued, the pilot study may begin.

In the first phase of the pilot test, one POE CX unit will be installed in a residence and samples will be collected once per month for two months. Each sample will be analyzed for hardness, gross alpha, and combined radium. If the results from both months are satisfactory, the second phase of the pilot study will begin with the installation of additional POE CX units in 11 other homes served by the water system. Hardness will be monitored at least quarterly in all 12 homes during the second phase of the pilot test to verify hardness as a surrogate indicator for radium. Four homes will also be selected for collection of four quarterly radium samples for compositing. The four-quarter composite and the samples that are collected at the end of the second quarter will be analyzed for gross alpha and combined radium. If the results of this sampling are satisfactory, the operational practices will also be considered satisfactory.

During the second and third years of operation, quarterly hardness monitoring will be continued in all 12 of the pilot homes. Two of these homes will also be selected for collection of four quarterly samples for compositing. These composite samples will be analyzed for gross alpha and combined radium. At the end of the three-year study, a follow-up report will be prepared by the Illinois EPA to discuss the findings and evaluate the use of hardness as an indicator for radium.

Based on the hardness and radium data from pilot testing, a hardness indicator level correlating to combined radium exceeding 5 pCi/L will be selected for each participating CWS. This hardness indicator level will be incorporated as a permit condition for the system. When full-scale operations have begun, POE units must be serviced if the hardness exceeds the trigger level. After a unit is serviced, a sample will be collected and analyzed for hardness, gross alpha, and combined radium. No further radionuclide monitoring will be required if the gross alpha and combined radium are less than the MCLs. However, if the gross alpha or combined radium exceeds the MCL, quarterly monitoring will be required for the unit with continued servicing. If the unit continues to exceed the MCL after one year of quarterly monitoring, the CWS will be considered out of compliance. In addition, if the gross alpha or combined radium samples from any unit exceed a level four times greater than the MCL at any time, the CWS will be considered out of compliance. In either situation, the system must issue public notification and take whatever actions the State deems necessary. If the hardness trigger level is exceeded more than once at the same CWS, the problem will be evaluated by the Illinois EPA and EPA Region 5 to determine the appropriate testing and remedy. If the hardness trigger level is exceeded repeatedly by a single POE CX device or within a single CWS, resin change-out or radium testing will be required unless other actions are determined by the regulatory authorities to be more appropriate.

7.8 References

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Appendix A
Small System Compliance Technologies

Exhibit A.1: Small System Compliance Technologies (SSCTs)[1] for Arsenic[2] (40 CFR 141.62(d)

SSCT	Affordable for listed small system categories[3]
Activated alumina (centralized)	All size categories
Activated alumina (POU)[4]	All size categories
Coagulation/filtration[5]	501-3,300; 3,301-10,000
Coagulation-assisted microfiltration	501-3,300; 3,301-10,000
Electrodialysis reversal[6]	501-3,300; 3,301-10,000
Enhanced coagulation/filtration	All size categories
Enhanced lime softening (pH>10.5)	All size categories
Ion exchange	All size categories
Lime softening[5]	501-3,300; 3,301-10,000
Oxidation/filtration[7]	All size categories
Reverse osmosis (centralized)[6]	501-3,300; 3,301-10,000
Reverse osmosis (POU)[4]	All size categories

[1]Section 1412(b)(4)(E)(ii) of SDWA specifies that SSCTs must be affordable and technically feasible for small systems.

[2]SSCTs for arsenic V. Pre-oxidation may be required to convert arsenic III to arsenic V.

[3]The Act specifies three categories of small systems: (i) those serving 25 or more, but fewer than 501, (ii) those serving more than 500, but fewer than 3,301, and (iii) those serving more than 3,300, but fewer than 10,001.

[4]When POU or POE devices are used for compliance, programs to ensure proper long-term operation, maintenance, and monitoring must be provided by the water system to ensure adequate performance.

[5]Unlikely to be installed solely for arsenic removal. May require pH adjustment to optimal range if high removals are needed.

[6]Technologies reject a large volume of water—may not be appropriate for areas where water quantity may be an issue.

[7]To obtain high removals, the iron-to-arsenic ratio must be at least 20:1.

Exhibit A.2: Best Available Technologies for Radionuclides (40 CFR 141.66(g), 142.65(a)(2))

Contaminant	Best Available Technology
Combined radium-226 and radium 228	Ion exchange, reverse osmosis, lime softening
Uranium	Ion exchange, reverse osmosis, lime softening, coagulation/filtration
Gross alpha particle activity (excluding radon and uranium)	Reverse osmosis
Beta particle and photon radioactivity	Ion exchange, reverse osmosis

Exhibit A.3: List of SSCTs for Radionuclides and Limitations to Use (40 CFR 141.66(h), 142.65(a)

Unit Technologies	Limitations (See Notes)	Operator Skill Level Required	Raw Water Quality Range and Considerations
1. Ion exchange	a	Intermediate	All ground waters
2. POU Ion exchange	b	Basic	All ground waters
3. Reverse osmosis	c	Advanced	Surface waters usually require prefiltration
4. POU reverse osmosis	b	Basic	Surface waters usually require prefiltration
5. Lime softening	d	Advanced	All waters
6. Green sand filtration	e	Basic	Ground waters with suitable water quality
7. Co-precipitation with barium sulfate	f	Intermediate to Advanced	All ground waters
8. Electrodialysis/ electrodialysis reversal	--	Basic to Intermediate	All ground waters
9. Preformed hydrous manganese oxide filtration	g	Intermediate	All ground waters
10. Activated alumina	a, h	Advanced	All ground waters; competing anion concentrations may affect regeneration frequency
11. Enhanced coagulation	i	Advanced	Can treat a wide range of water qualities

a. The regeneration solution contains high concentrations of the contaminant ions. Disposal options should be carefully considered before choosing this technology.
b. When POU devices are used for compliance, programs for long-term operation, maintenance, and monitoring must be provided by the water utility to ensure proper performance.
c. Reject water disposal options should be carefully considered before choosing this technology.
d. The combination of variable source water quality and the complexity of the water chemistry involved may make this technology too complex for small surface water systems.
e. Removal efficiencies can vary depending on water quality.
f. This technology may be very limited in application to small systems. Since the process requires static mixing, detention basins, and filtration, it is most applicable to systems with sufficiently high sulfate levels that already have a suitable filtration treatment train in place.
g. This technology is most applicable to small systems that already have filtration in place.
h. Handling of chemicals required during regeneration and pH adjustment may be too difficult for small systems without an adequately trained operator.
i. Assumes modification to a coagulation/filtration process already in place.

Exhibit A.4: Compliance Technologies by System Size Category for Radionuclides (40 CFR 141.66(h), 142.65(a))

Contaminant	Compliance Technologies for System Size Categories[1]		
	25-500	**501-3,300**	**3,301-10,000**
Combined radium-226 and radium-228	1-9	1-9	1-9
Gross alpha particle activity	3, 4	3, 4	3, 4
Beta particle activity and photon activity	1-4	1-4	1-4
Uranium	1, 2, 4, 10, 11	1- 5, 10, 11	1-5, 10, 11

[1]Numbers correspond to those technologies listed in Exhibit A.2.

Appendix B. Potential Funding Sources for the Implementation of a POU or POE Compliance Strategy

Funding for PWS improvements, such as the installation of POU and POE treatment devices for compliance with an MCL, can be obtained by applying for loans or grants. Also, some manufacturers and dealers may provide financing options. A table summarizing available funding sources and contact information can be found in Exhibit B.1. More detailed information on funding and funding sources can be found on EPA's website http://www.epa.gov/efinpage/.

Exhibit B.1: Funding Sources.

Name of Program	Limitations	Contact Information
Drinking Water State Revolving Fund (DWSRF)	• System must demonstrate adequate technical, financial, and managerial capacity • System can not be in significant noncompliance, unless funding will ensure compliance • Loans will not be provided for O&M expenses • Lab fees for monitoring may not be financed with a DWSRF loan • Standard loan term: 20 years (term may be extended to 30 years in some States for economically disadvantaged communities) • Additional State-specific requirements	State website, State DWSRF Program Manager, or http://www.epa.gov/safewater/dwsrf/contacts.html
Rural Utilities Service Water and Waste Disposal Loan and Grant Program	• Project may not service ≥ 10,000 people • Private, for-profit systems not eligible • Grants provided only to reduce user charges to reasonable level in communities where the service area median household income falls below poverty level or 80% of the State non-metropolitan median household income (whichever is higher) • Grants limited to 70% of eligible costs	State Rural Development Office or http://www.usda.gov/rus/water/prog.htm
Community Development Block Grants	• Average income of community may not exceed Department of Housing and Urban Development's Section 8 low-income limit for metropolitan areas, or 80% of the State or county MHI for non-metropolitan areas	State Community Development Block Grants Program Office
Public Works and Infrastructure Development Grants	• Grants normally limited to 50% of eligible costs • Under conditions of severe distress, grant funding may cover 80% of project costs	Regional Economic Development Administration Office
Rural Community Assistance Corporation	• Eligibility limited to communities in 11 "western" States • Project may not service ≥ 20,000 people • Assistance limited to rural utilities • Maximum loan term: 25 years	Rural Community Assistance Corporation online at http://www.rcac.org/programs/serv-financial.html

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Appendix C. Model Ordinance Language for a System Implementing a POU or POE Compliance Strategy

Following is an example ordinance systems may want to use in order to grant the PWS the ability to implement a POU or POE treatment strategy. The ordinance also grants the PWS the ability to access private dwellings for installation, monitoring, maintenance, and other activities related to POU and POE devices. This example ordinance was drafted to be overly inclusive in order to cover situations that could arise due to the implementation of a POU or POE treatment strategy. Some sections may not apply to specific systems because of current service agreements; specific administrative or legal process requirements; or other geographic, political, or financial constraints. Water systems should amend and adapt this model to meet their particular needs. Water systems should seek legal assistance prior to preparing an ordinance based on this model.

Model Ordinance

Section 1. Introduction

1. In accordance with the federal Safe Drinking Water Act and State drinking water regulations, *INSERT NAME OF PUBLIC WATER SYSTEM* must minimize contamination in drinking water. It is the intent of the *INSERT NAME OF PUBLIC WATER SYSTEM* to accomplish this through the installation and operation of *INSERT TYPE OF TREATMENT UNIT THAT WILL BE INSTALLED* which *INSERT NAME OF BODY PASSING THE ORDINANCE* has decided is the most protective and cost efficient way to meet drinking water standards.

Section 2. Purpose and Intent

2.1 The *INSERT NAME OF BODY PASSING THE ORDINANCE* is passing this ordinance in order to comply with the Safe Drinking Water Act, State drinking water regulations, and to protect the health of the consumers of water supplied by the *INSERT NAME OF PUBLIC WATER SYSTEM*.

2.2 The specific purposes of this Ordinance are:

2.2.1 To require the installation of *INSERT TYPE OF TREATMENT UNIT THAT WILL BE INSTALLED* to improve the quality of drinking water.

2.2.2 To minimize *INSERT TYPE OF CONTAMINATION THAT TREATMENT UNITS WILL REMOVE* in drinking water supplied by *INSERT NAME OF PUBLIC WATER SYSTEM*.

2.2.3 To provide for an operation, maintenance, and monitoring program for *INSERT TYPE OF TREATMENT UNIT* that will be installed as part of this Ordinance.

Section 3. Applicability

This ordinance applies to all customers connected to the *INSERT NAME PUBLIC WATER SYSTEM* and all customers who connect to the *INSERT NAME PUBLIC WATER SYSTEM* in the future.

Section 4. Authority and Effective Date

INSERT NAME OF BODY PASSING THE ORDINANCE is authorized under *INSERT BODY OF LAW PROVIDING JURISDICTION* to adopt this ordinance.

This ordinance becomes effective immediately upon adoption.

Section 5. Definitions

5.1 **Building** means a combination of any materials, whether portable or fixed, having a roof to form a structure for the shelter of persons, animals, or property.

5.2 **Consumer** means any person, corporation, or other entity using or receiving water from the *INSERT NAME PUBLIC WATER SYSTEM*.

5.3 **Customer** means any purchaser or buyer of water from the *INSERT NAME PUBLIC WATER SYSTEM*.

5.4 **Dwelling Unit** means a house or other structure in which a person or persons live.

5.5 **Non-Residential User** is defined as a user of water provided by the *INSERT NAME PUBLIC WATER SYSTEM* for purposes other than personal consumption. Such purposes may include, but are not limited to, resale, as a component or ingredient in other products designed for resale or service to the public, or otherwise providing water directly or indirectly to a person for the purposes of consumption.

5.6 **Owner of the Premises** includes the legal owners, their agents, or authorized representatives.

5.7 **Person** means a human being, partnerships, associations, corporations, legal representatives, or trustees.

5.8 **Potable Water** means any water supply intended or used for human consumption or other domestic use.

5.9 **Premises** means any real property to which water is provided, including all improvements, buildings, dwelling units, mobile homes, and other structures located on it.

5.10 **Residential User** is defined as any person occupying a dwelling unit receiving water from the *INSERT NAME PUBLIC WATER SYSTEM* for the purpose of personal consumption.

5.11 **Service Connection** is the point of delivery at which the *INSERT NAME PUBLIC WATER SYSTEM* connects to the private supply line.

5.12 **Structure** means anything constructed or erected, the use of which requires a fixed location on the ground or attached to something located on the ground.

5.13 **Tap** means any faucet, spigot, or fountain that supplies water for consumption by drinking or cooking (including ice).

5.14 **Treatment Unit** includes any device installed by the *INSERT NAME PUBLIC WATER SYSTEM* to treat water as well as any associated equipment or devices, including separate taps, storage tanks, and bypass valves.

5.15 **Water Supplier** means *INSERT NAME OF PUBLIC WATER SYSTEM* , its employees, agents, and authorized representatives.

Section 6. Residential Users

6.1 Installation

6.1.1 The owner of the premises or residential users will allow the Water Supplier to install *INSERT TYPE OF TREATMENT UNIT* and all ancillary equipment needed for the proper operation of the treatment units.

6.1.2 A treatment unit will be installed on a separate tap next to the kitchen tap to be used for drinking and cooking water (*or INSERT TAPS THAT WILL BE TREATED*).

6.1.3 Treatment units will be installed by a properly trained and certified person. All units will be installed in accordance with State and local codes, if any, and in accordance with the manufacturer's specifications.

6.1.4 Title to the treatment units remains with the Water Supplier. While in effect, this Ordinance shall run with the land and shall be enforceable on all parties having or acquiring any right, title, or interest in any dwelling unit.

6.2 Maintenance

6.2.1 The Water Supplier will maintain the treatment units. Maintenance may include, but is not limited to: any required repair to, or replacement of a treatment unit; any sampling of a treatment unit or the water a treatment unit is treating; or any action deemed necessary by the Water Supplier for the on-going proper operation of a treatment unit.

6.2.1.1 All maintenance will be conducted by a properly trained and certified person.

6.2.2 Regular Maintenance. The owner of the premises or residential users will provide the Water Supplier access to the treatment units on a regular basis so that the Water Supplier can maintain the treatment units.

6.2.2.1 The Water Supplier will periodically notify the owner of the premises or residential users of the intention to provide maintenance to a treatment unit. Notification will be provided in the water bill *(or INSERT OTHER MEANS OF NOTIFICATION)*.

6.2.2.2 Regular maintenance will be provided during normal business hours or as arranged between the Water Supplier and Residential User. Sampling will occur approximately every *INSERT TIME FRAME FOR SAMPLING IN ACCORDANCE WITH FEDERAL AND STATE REGULATIONS AND MANUFACTURERS SPECIFICATIONS.*

6.2.2.3 In the event that the owner of the premises or the residential users will not be able to provide access to a treatment unit on the date and time specified in the notification, the residential user will schedule an alternative time with the Water Supplier.

6.2.3 Emergency Repairs or Replacement. Residential users must provide access to the treatment units for emergency or unexpected repairs or replacements. Refusal to allow entry may result in termination of service in accordance with Section 8 of this Ordinance.

6.2.4 Residential users must notify the Water Supplier of any observed leaks or defects immediately. The Water Supplier shall arrange to repair the leak or other defect within *INSERT REPAIR TIME FRAME (i.e., two consecutive calendar days upon receipt of notice, four business days from receiving notice, etc.)*

6.2.5 The owner of the premises and residential users shall not adjust, modify, repair, replace, remove, disconnect, bypass, or otherwise tamper with a treatment unit.

6.2.5.1 Customers shall pay the Water Supplier for any costs incurred due to the owner of the premises or the residential user adjusting, modifying, by-passing, tampering with, or removing a treatment unit or any ancillary equipment.

6.2.6 *INSERT ANY MAINTENANCE CONDITION SPECIFIC TO THE TYPE OF TREATMENT UNIT INSTALLED. FOR EXAMPLE, "RESIDENTIAL USERS SHALL ENSURE THAT THE TREATMENT UNIT REMAINS PLUGGED INTO AN OPERATIONAL OUTLET."*

Section 7. Non-Residential Users

7.1 *Installation*

7.1.1 The owner of the premises or non-residential users will allow the Water Supplier to install *INSERT TYPE OF TREATMENT UNIT* and all ancillary equipment needed for the proper operation of the treatment units.

7.1.2 Treatment units will be installed on locations with separate taps designated for drinking water.

7.1.3 Treatment units will be installed by a properly trained and certified person. All units will be installed in accordance with State and local codes, if any, and in accordance with the manufacturer's specifications.

7.1.4 Title to the treatment units remains with the Water Supplier. While in effect, this Ordinance shall run with the land and shall be enforceable on all parties having or acquiring any right, title, or interest in any premises.

7.2 Maintenance

7.2.1 The Water Supplier will maintain the treatment units. Maintenance may include, but is not limited to: any required repair to, or replacement of a treatment unit; any sampling of a treatment unit or the water a treatment unit is treating; or any action deemed necessary by the Water Supplier for the on-going proper operation of a treatment unit.

7.2.1.1 All maintenance will be conducted by a properly trained and certified person.

7.2.2 Regular Maintenance. The owner of the premises or non-residential users will provide the Water Supplier access to the treatment units on a regular basis so that the Water Supplier can maintain the treatment units.

7.2.2.1 The Water Supplier will periodically notify the owner of the premises, his agent, his authorized representative, or the non-residential users of the intention to provide maintenance to a treatment unit. Notification will be provided in the monthly water bill *(or INSERT OTHER MEANS OF NOTIFICATION)*.

7.2.2.2 Regular maintenance will be provided during normal business hours or as arranged between the Water Supplier and owner of the premises. Sampling will occur approximately every *INSERT TIME FRAME FOR SAMPLING IN*

ACCORDANCE WITH FEDERAL AND STATE REGULATIONS AND MANUFACTURERS SPECIFICATIONS.

7.2.2.3 In the event that the owner of the premises or non-residential users will not be able to provide access to a treatment unit on the date and time specified in the notification, the owner of the premises or the non-residential users will schedule an alternative time with the Water Supplier.

7.2.3 Emergency Repairs or Replacement. The non-residential users must provide access to the treatment units for emergency or unexpected repairs or replacements. Refusal to allow entry may result in termination of service in accordance with Section 8 of this Ordinance.

7.2.4 In the event that a leak or other defect is detected, the non-residential user will: notify the Water Supplier at *INSERT TELEPHONE NUMBER* within 24 hours of noticing the leak or other defect and follow all directions given by the Water Supplier. The Water Supplier shall arrange to repair the leak or other defect within *INSERT REPAIR TIME FRAME (i.e., two consecutive calendar days upon receipt of notice, four business days from receiving notice, etc.)*

7.2.5 The owner of the premises and the non-residential user shall not adjust, modify, repair, replace, remove, disconnect, bypass, or otherwise tamper with a treatment unit.

7.2.5.1 The Customer shall pay the Water Supplier for any costs incurred due to the adjusting, modifying, by-passing, tampering with, or removing a treatment unit or any ancillary equipment.

7.2.6 *INSERT ANY MAINTENANCE CONDITION SPECIFIC TO THE TYPE OF TREATMENT UNIT INSTALLED. FOR EXAMPLE, "NON-RESIDENTIAL USERS SHALL ENSURE THAT THE TREATMENT UNIT REMAINS PLUGGED INTO AN OPERATIONAL OUTLET."*

Section 8. Emergency Suspension of Utility Service

8.1 The Water Supplier may, without prior notice, suspend water service to any premises when such suspension is necessary to prevent or stop an actual or threatened imminent and substantial danger to the Water Supplier's public water supply.

8.2 The Water Supplier may, without prior notice, suspend water service to any premises when such suspension is necessary to prevent or stop an actual or threatened imminent and substantial danger to the environment or to the health or welfare of any person.

8.3 As soon as practicable after the emergency suspension of service, the Water Supplier will notify Customers of the suspension. Notice will be provided in person or by certified mail, return receipt requested.

8.4 The Water Supplier will not reinstate service until the actual or threatened danger has been eliminated and its cause determined and corrected.

8.4.1 The Customer shall pay the Water Supplier for any costs incurred for suspending service: responding to, eliminating, determining the cause of, and correcting actual or threatened dangers; and reinstating service, if the actual or threatened danger was caused by persons other than the Water Supplier.

Section 9. Non-Emergency Suspension of Utility Service

9.1 The Water Supplier may terminate, after notice and opportunity for a hearing, the water service of any Customer who:

- Fails or refuses to allow the installation of treatment units as required by this Ordinance.
- Fails or refuses to allow the Water Supplier access to the premises to conduct regular or emergency maintenance.
- Adjusts, modifies, repairs, replaces, removes, disconnects, bypasses, or otherwise tampers with a treatment unit without prior written permission from the Water Supplier.

9.2 Except in accordance with Section 8 of this Ordinance, the Water Supplier will notify the Customer of the proposed termination of water service at least 30 days before the proposed termination. Notice will be provided in person or by certified mail, return receipt requested.

9.2.1 The Customer may request a hearing on the proposed termination by filing a written request for a hearing with the Water Supplier, not more than 10 consecutive calendar days after receipt of notice of the proposed termination.

9.3 If water service is terminated, the Water Supplier will not reinstate water service until the Customer and owner of the premises allows for the installation of treatment units.

9.3.1 The Customer and the owner of the premises must enter into a written agreement to allow the Water Supplier access to the premises to conduct regular or emergency maintenance.

9.4 The Customer shall pay all costs incurred by the Water Supplier to reinstate service.

Section 10. Installation and Maintenance Charges

10.1 Customers may be charged *INSERT COST OF INSTALLATION* for the installation of a treatment unit. Customers may be charged in equal increments every month for one year.

10.1.1 Customers may be charged for all costs incurred by the Water Supplier to make any required modifications to existing plumbing in order to install the treatment unit. Customers may be charged in equal increments every month for one year.

10.2 Customers may be charged a monthly maintenance charge of *INSERT MONTHLY MAINTENANCE CHARGE* for as long as the treatment unit remains installed on the premises.

10.3 Any installation and maintenance charges collected by the Water Supplier shall be deposited in the operating budget of the Water Supplier. Such funds shall be used for the purchase of new treatment units and to help defray the costs associated with purchasing, installing, maintaining, and removing the treatment units.

10.4 The *INSERT NAME OF PUBLIC WATER SYSTEM* reserves the right to increase or decrease the installation and maintenance charges as deemed appropriate through an amendment to this ordinance.

Section 11. Enforcement

11.1 All users of water supplied by the Water Supplier shall abide by the provisions of this Ordinance and any such rules, regulations, and ordinances promulgated for the improvement and maintenance of the quality of the water intended for human consumption supplied by the Water Supplier.

11.2 Failure to abide by the provision of this Ordinance may result in the termination of service as described in Section 8 or 9 or in the imposition of service charges.

11.2.1 The Water Supplier may charge the customer *INSERT AMOUNT OF SERVICE CHARGE FOR EACH FAILURE* for failure to allow access for the installation of the treatment unit.

11.2.2 The Water Supplier may charge the customer *INSERT AMOUNT OF SERVICE CHARGE FOR EACH FAILURE* for failure to allow access for the maintenance of the treatment unit.

11.2.3 In the event that the Customer, owner of the premises, residential user, or non-residential user fails to allow access to the premises for the purpose of removing the treatment unit, the Water Supplier may apply to the *INSERT COURT OF JURISDICTION (e.g., District Court, County Sheriff)* for an order permitting entry onto the premises and for the removal of the treatment unit.

11.3 Any service charges imposed and collected by the Water Supplier shall be deposited in the operating budget of the Water Supplier. Such funds shall be used for the purchase of new treatment units and to help defray the costs associated with purchasing, installing, maintaining, and removing the treatment units.

11.4 The *INSERT NAME OF PUBLIC WATER SYSTEM* reserves the right to increase or decrease the service charges as deemed appropriate through an amendment to this ordinance.

Section 12. Liability

12.1 The Customer, owner of the premises, residential user, and non-residential user shall indemnify and hold harmless the Water Supplier for any injury or damage which may occur as a result of:

1. The installation, maintenance, operation, sampling, monitoring, or removal of a treatment unit.

2. The adjusting, modifying, repairing, replacing, removing, disconnecting, bypassing, or otherwise tampering with a treatment unit.

3. The failure to inspect, detect, and report, in accordance with the Ordinance, any leaks or other defects which could have reasonably been detected by the required inspection.

12.2 The Customer or the owner of the premises shall be liable for any damage to a treatment unit resulting from fire, theft, or impact. Note that the water system may wish to obtain the advice of local legal counsel before including this provision.

Section 13. Severability

13.1 If any provision or provisions of this Ordinance is held to be invalid, illegal, unenforceable or in conflict with the law of any jurisdiction, the validity, legality and enforceability of the remaining provisions shall not in any way be affected or impaired thereby.

Adopted this _____day of _____________ by the *INSERT NAME OF BODY PASSING THE ORDINANCE*.

____

Authorized Signatory

____

Witness

Appendix D. Sample Access and Maintenance Agreement

Following is an example access and maintenance agreement that may be needed between the PWS and homeowners. Water systems should amend this agreement to meet their particular needs. Water systems should seek legal assistance prior to preparing an agreement based on this model.

INSERT NAME OF PUBLIC WATER SYSTEM has decided to install *INSERT TYPE OF POU OR POE TREATMENT DEVICE* to treat for *INSERT CONTAMINANT(S) BEING REMOVED.*

We have chosen to use this treatment technology as an effective means of removing this type of contamination from our drinking water in a cost-efficient manner. Installation of this technology will help to ensure the delivery of safe water to your home or business. Failure to properly operate and maintain these units may produce water with new or higher levels of contamination.

The undersigned are the current legal owners of, and can provide access to, the following property: ____.[2]

The undersigned agree:

1. To allow the *INSERT NAME OF PUBLIC WATER SYSTEM*, its employees, authorized representatives, and others under agreement with the *INSERT NAME OF PUBLIC WATER SYSTEM*, to enter the aforementioned property to:

   a. Install, replace, maintain, or remove the treatment unit and any ancillary equipment.

   b. Maintain the treatment unit and any ancillary equipment. Maintenance may include periodic testing of the unit as well as the collection of samples. Any maintenance, testing, or sample collection will occur during normal business hours or as arranged between the *INSERT NAME OF PUBLIC WATER SYSTEM* and property owner: ____.[3]

2. To not adjust, modify, tamper with, bypass, or remove the treatment unit or any ancillary equipment.

3. To, within a reasonable period of time, notify the *INSERT NAME OF PUBLIC WATER SYSTEM* of:

---

[2] Insert a description of the property here. This description should include the full address and, if known, the legal description provided in land records (e.g., Map 52, Parcel 40, Town X). Ensure that the undersigned owns the structure (e.g., house, business, office, other building) and not just the land that the structure is on.

[3] Insert a description of the frequency of sampling and maintenance activities (e.g., the first of each month, once per calendar quarter, twice a year, etc.)

a. Any problems, concerns, or questions concerning the treatment unit or any ancillary equipment.

b. The rental, lease, sale, or other transfer of the aforementioned property.

4. To indemnify and hold harmless the _*INSERT NAME OF PUBLIC WATER SYSTEM*_ for any injury or damage which may occur as a result of the installation, maintenance, operation, monitoring, or removal of the treatment unit or any ancillary equipment.

All equipment shall remain the property of the _*INSERT NAME OF PUBLIC WATER SYSTEM*_. The undersigned agree to reimburse the _*INSERT NAME OF PUBLIC WATER SYSTEM*_ for any costs incurred because the undersigned adjusted, modified, bypassed, tampered with, or removed the treatment unit or any ancillary equipment.

This agreement remains in effect: ____.[4]

While in effect, this agreement shall run with the land and shall be binding on all parties having or acquiring any right, title, or interest in the property described herein.

This written permission is given by the undersigned voluntarily with knowledge of legal rights and without threat or promise of any kind.

Owners:		**Witnesses:**	
______________________		______________________	
Name	Date	Name	Date
______________________		______________________	
Name	Date	Name	Date

[4] Insert the length of time that the agreement is to remain in effect. For example, "for a period of one year from the date of installation; until the Public Water System determines that the treatment system is no longer necessary, or until the treatment unit is removed from the property."

Appendix E. Sample Monitoring Log for POU or POE Devices

Following is a sample monitoring log systems may find useful to track monitoring of POU and POE devices throughout the system. Both a completed example log and blank log are provided. Systems should contact their State to see if this reporting form is acceptable. This log can also be modified to be used on an individual unit basis.

Example Monitoring Log

System Name: Valley Water System
Type of POU or POE Device: RO units with pre and post GAC cartridges.

Sample Date	**Location**	**Contaminant(s) Monitored**	**Certified Lab or Field Test Kit**	**Results**	**Notes**
4/4/04	*1111 Home St. Location #3*	*Arsenic*	*Certified Lab*	*0.004 mg/L*	*Sample taken by J. Smith, Operator*
4/4/04	*2222 State St. Location #7*	*Arsenic*	*Certified Lab*	*0.003 mg/L*	*Sample taken by J. Smith, Operator*
4/4/04	*3333 Main St. Location #10*	*Arsenic*	*Certified Lab*	*0.004 mg/L*	*Sample taken by J. Smith, Operator*
4/4/04	*44 College St. Location #18*	*Arsenic*	*Certified Lab*	*0.070 mg/L*	*Sample taken by J. Smith, Operator. The unit was replaced within 24 hours of receiving sample results. New RO unit was resampled after installation and arsenic was 0.003 mg/L.*
5/10/04	*122 Home St. Location #2*	*Arsenic*	*Certified Lab*	*0.005 mg/L*	*Sample taken by J. Smith, Operator*
5/10/04	*223 State St. Location #8*	*Arsenic*	*Certified Lab*	*0.004 mg/L*	*Sample taken by J. Smith, Operator*
5/10/04	*334 Main St. Location #12*	*Arsenic*	*Certified Lab*	*0.006 mg/L*	*Sample taken by J. Smith, Operator*
5/10/04	*85 College St. Location #25*	*Arsenic*	*Certified Lab*	*0.005 mg/L*	*Sample taken by J. Smith, Operator*

Monitoring Log

System Name ____________________________

Type of POU or POE Device ____

Sample Date	Location	Contaminant(s) Monitored	Certified Lab or Field Test Kit	Results	Notes

Appendix F. Sample Maintenance Log for POU or POE Devices

This appendix contains a sample maintenance log systems may find useful to track maintenance of POU and POE devices. The sample maintenance log is designed to be used for each individual POU or POE device to allow the system to track maintenance at each individual unit. Maintenance logs are important since they will provide information on when components were replaced, how often the alarm was triggered, and if the unit is problematic. Detailed records may be useful to systems to justify to a vendor that certain devices are not functioning and require replacement. The system will want to keep these maintenance logs in a central office, have the records located with each individual unit, or both. Keeping the maintenance logs at the unit location may result in damage to the records and the system may want to keep copies at a central office.

Following is a completed sample maintenance log and a blank maintenance log that systems may want to use. Systems should contact their State to see if this reporting form is acceptable for reporting purposes.

Example Maintenance Log

System Name: Valley Water System
Type of POU or POE Device: RO units with pre and post GAC cartridges.
Device Location: 228 State St. Unit #11 **Date Installed:** 1/5/04

Date and Time of Service Call	Reason for Service Call	Services Provided	Service Provider	Notes
2/5/04 4:00 pm	*Follow-up installation visit to inspect all components.*	*Checked all components and discussed unit operation with customer.*	*J. Jones, Vendor providing services under contract.*	*Customer seemed satisfied with unit and water quality and quantity.*
7/9/05 4:30 pm	*Routine check-up*	*Checked all components, changed out carbon pre-filter.*	*J. Jones, Vendor providing services under contract.*	*Customer had no complaints.*
2/20/05 4:00 pm	*Routine check-up*	*Checked all components, changed out all cartridges.*	*J. Jones, Vendor providing services under contract.*	*Customer had no complaints.*
6/15/05 12:00 pm	*Response to call from customer on 6/14/05 about water quality concerns*	*Checked all components. Changed out carbon pre-filter and took arsenic sample.*	*J. Smith, Operator for system*	*Arsenic sample result was 0.004 mg/L.*

Maintenance Log

System Name:___________________________________
Type of POU or POE Device: _______________________________
Device Location: _________________________ **Date Installed:** _______________

Date and Time of Service Call	Reason for Service Call	Services Provided	Service Provider	Notes

Appendix G. Sample Public Education Notice for Systems Using POU Devices for Nitrate Removal

The following page contains a sample public education flyer that can be included in mailings to customers or posted throughout the service community when POU devices are used for nitrate removal. Continued public education is important when POU devices are used for nitrate removal to educate the community on the health risks associated with nitrate, particularly for infants. Systems should check with their State prior to using this notice to verify whether it is suitable or if additional information should be included. If necessary, this flyer should also be translated into appropriate languages depending on the needs of the service community.

Sample Public Education Flyer for Nitrate Contamination

Your Tap Water and Point-of-Use Treatment Devices

Why have I received a point-of-use device?

Your water system has installed a point-of-use (POU) treatment device under your kitchen sink to remove nitrate from your water. Treatment is necessary because nitrate levels in your water exceed the standard of 10 milligrams per liter. Because centralized treatment at the water treatment plant is very expensive, your system is instead providing POU devices to all households and other connections.

What health effects does nitrate have?

Only water from a tap with a POU device should be used to prepare infant formula, juice, or other foods for children less than six months old.

Nitrate in drinking water can come from natural, industrial, or agricultural sources. These include septic systems and run-off from farms. Nitrate in drinking water is a serious health concern for infants less than six months old, because their bodies cannot process nitrates as well as older children and adults can.

Infants below the age of six months who drink water containing nitrate in excess of the limit could become seriously ill and, if untreated, may die. Symptoms include shortness of breath and blue baby syndrome. Blue baby syndrome is indicated by blueness of the skin and means that the blood is unable to absorb oxygen. Symptoms in infants can develop rapidly, with health deteriorating over a period of days. If symptoms occur, seek medical attention immediately.

What steps should I take?

Use water from the tap with the POU device to prepare infant formula, juice, or other foods for children less than six months old. Water from other taps in your house is NOT treated for nitrates; do not use water from those taps to prepare food for infants.

Water from other taps may safely be used for bathing infants. Adults and children older than six months can drink water from any tap, although use of the tap with the POU device is recommended.

Appendix H. Sample Public Education Notice for Systems Using POU Devices for Chronic Contaminant Removal

The following page contains a sample public education flyer that can be included in mailings to customers or posted throughout the service community when POU devices are used for contaminant removal for contaminants besides nitrate. Continued public education is important when POU devices are used for nitrate removal to educate the community on the health risks associated with nitrate. Systems should check with their States prior to using this notice to verify whether it is suitable or if additional information should be included.

Sample Public Education Flyer for Chronic Contaminants

Your Tap Water and Point-of-Use Treatment Devices

Why have I received a point-of-use device?

Your water system has installed a point-of-use (POU) treatment device under your kitchen sink to remove chronic contaminants from your water. Treatment is necessary because contaminant levels in your source water exceed an EPA limit. Health effects from chronic contaminants vary depending on the contaminant but can include things like cancer and liver damage. These health effects occur only after chronic exposure (drinking the water over many years).

Because centralized treatment at the water treatment plant is very expensive, your system is instead providing POU devices to all households and buildings. By treating only the water used for drinking and cooking, the water system can save money and pass the savings on to its customers.

What steps should I take?

Use water from the tap with the POU device for drinking and cooking. In your kitchen, use the untreated tap for washing dishes. Water from other taps in your house is NOT treated; do not use water from those taps for drinking or for brushing teeth. Untreated water may be safely used for bathing and laundry.

In addition, the water system needs your cooperation to properly maintain the POU device. Maintenance ensures that the device is working correctly and that your water is safe. Please allow water system personnel into your home to take water samples or replace devices.