Appendix C - Interim Measures and Point-of-Use and Point-of-Entry Treatment Evaluation Report

Colorado Department of Public Health and Environment

Colorado Department of Public Health and Environment

Colorado Radionuclide Abatement and Disposal Strategy (CO-RADS)

Final Interim Measures and Point-of-Use and Point-of-Entry Treatment Evaluation Report

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1. Introduction

1.1. CO-RADS Background

The Water Quality Control Division (WQCD) of the Colorado Department of Public Health and Environment (CDPHE) regulates public water systems (PWSs) under the Colorado Primary Drinking Water Regulations (CPDWR). The maximum contaminant levels (MCLs) the U.S. Environmental Protection Agency (EPA) has established for radionuclides have been adopted by WQCD as part of the CPDWRs. The regulated radionuclides and the corresponding MCL values are as follows:

- Gross alpha particle activity: 15 picoCuries per liter (pCi/L)
- Combined radium 226/228: 5 pCi/L
- Uranium: 30 micrograms per liter (μg/L)
- Beta and photon particle activity: 4 millirems per year (mrem/yr)

The maximum contaminant level goal (MCLG) established for radionuclides by the EPA is zero.

Radionuclides are naturally present in the environment, including groundwater sources. Typically, the levels of naturally occurring radioactive material (NORM) are not a significant health concern in drinking water; however, Colorado has over 40 water systems that are currently or expected to be in violation of one or more of the radionuclide MCLs. This presents a health concern for nearly 40,000 consumers.

Treatment techniques are available for the removal of these contaminants from water supplies, but for small drinking water systems, the cost of treatment and disposal may be substantial. Additionally, environmental and worker safety concerns arise from the removal of radionuclides from drinking water. NORM accumulates in treatment residuals and is classified as Technologically Enhanced Naturally Occurring Radioactive Material (TENORM). Worker exposure and disposal of these residuals is also a potential issue.

The systems affected by radionuclides in Colorado are small groundwater systems with limited resources that may struggle to find feasible compliance options. WQCD has initiated the Colorado Radionuclide Abatement and Disposal Strategy (CO-RADS) to address the issues associated with removal of radionuclides from drinking water and offer compliance and technical assistance to the communities affected by these contaminants. The ultimate goal of this project is to resolve drinking water radionuclide violations. The project has been structured to include 5 distinct phases, as outlined below:

- Phase 1 – Review existing data and identify affected systems
- Phase 2 – Sample affected sources to characterize water quality
- Phase 3 – Perform engineering analyses and pilot-studies of treatment and disposal options
- Phase 4 – Offer financial and compliance assistance to affected systems
- Phase 5 – Provide recommendations and implementation assistance for affected systems

Malcolm Pirnie, Inc. (MPI) in conjunction with the Colorado School of Mines (CSM) has been contracted by WQCD to perform Phases 2 and 3. This report presents the results of Task 1: Policy Development Assistance.

1.2. CO-RADS Task 1 Objectives

As part of the CO-RADS project, CDPHE is developing policy for the following:

- The necessary degree of protection that water systems must provide, on an interim basis, before a long-term compliance option is successfully implemented; including the identification and evaluation of appropriate interim compliance measures and associated requirements.
- The ability of water systems to implement point-of-use (POU) or point-of-entry (POE) treatment technologies for long-term compliance with the Radionuclide Rule.

Interim treatment requirements are a concern for water systems that are planning to implement compliance solutions that will take a significant amount of time to implement. In particular, some of the interim measures may present a financial burden to water systems that could ultimately impact their selection of long-term compliance solutions. WQCD recognizes these challenges and has decided to further evaluate the interim exposure to radionuclides and associated interim alternatives as described in this document.

In addition to the interim public health protection analysis, WQCD understands that POU/POE treatment may be an attractive Radionuclide Rule compliance option for some small water systems in Colorado. However, certain issues associated with POU/POE treatment options have not been fully investigated or resolved and need additional evaluation before WQCD can establish a position on the acceptability of such options.

As part of this Task 1: Policy Development Assistance, WQCD asked Malcolm Pirnie to investigate and summarize information that WQCD will use to support decision making processes for WQCD. In addition, Malcolm Pirnie will facilitate a workshop with

WQCD to present the results of the study and identify additional steps in the policy development process.

In particular, as described further in the subsequent sections of this document, Malcolm Pirnie performed the following investigative activities to assist WQCD in the policy development process:

- Identified and evaluated potential interim health protection measures
- Evaluated POU and POE treatment solutions for long-term compliance with the Radionuclides Rule

More information on Task 1 can be found in the Memorandum of Understanding (MOU #CD-2007-208) dated August 24, 2007. This report summarizes the methodology, results, and observations of Malcolm Pirnie's policy assessment work for the CO-RADS project.

2. Interim Health Protection Measures

2.1. Methodology

MPI worked with CDPHE to identify and evaluate several interim measures that could be implemented by water systems to reduce the interim exposure to radionuclides, before a long-term compliance strategy for the Radionuclides Rule is implemented. Descriptions of the interim compliance measures considered in this evaluation follow:

- ***Public awareness and education –*** educate consumers on water quality and the impacts/risks associated with water contaminated with radionuclides and let them determine whether or not to pursue an option to mitigate exposure. Public education will also be a component of the following interim measures.

- ***Bottled water –*** either the consumers purchase bottled water for consumption or the water system purchases the bottled water for the consumers.

- ***Purchase and delivery of bottled water by the system –*** the water system purchases and delivers drinking water to the consumer via a delivery service.

- ***Point-of-use (POU) treatment –*** the water system pays for a POU system to be installed on a tap (or taps) in consumers' homes. POU systems only treat water to one faucet and this evaluation assumed the POU treatment system would be installed under the kitchen sink to provide drinking water in the kitchen of a home.

- ***Point-of-entry (POE) treatment –*** the water system pays for POE treatment for each consumer. POE treatment treats all water that enters an individual building and may be located in the garage, yard or other location at a residence or commercial site.

Treatment processes that are incorporated into POU or POE treatment units and were considered in this analysis include ion exchange and reverse osmosis. Ion exchange and reverse osmosis are capable of removing the following radionuclides:

- Ion exchange – uranium (anion), combined radium (cation), and beta and photon particle activity
- Reverse osmosis – uranium, combined radium, beta and photon particle activity, gross alpha particle activity

In order to evaluate the interim compliance measures described above, Malcolm Pirnie conducted a preliminary, conceptual-level evaluation of each option. Using information gathered in this analysis, Malcolm Pirnie worked with CDPHE to identify the most

promising options to be included in a more detailed feasibility study that quantifies the benefits and challenges associated with each option. Malcolm Pirnie compiled, reviewed, and evaluated in-house and industry resources from the following sources for this analysis:

- Point of-Use or Point-of-Entry Treatment Options for Small Drinking Water Systems, USEPA 2006
- POU/POE Implementation Feasibility Study for Arsenic Treatment, AwwaRF 2005
- Radionuclides Notice of Data Availability Technical Support Document, USEPA 2000
- Radionuclides in Drinking Water: A Small Entity Compliance Guide, USEPA 2002a
- National Science Foundation,
- Communication with vendors
    - Culligan
    - Kinetico

The following sections summarize the results of these analyses and present some observations for CDPHE to consider when reviewing potential interim compliance measures.

2.2. Identification and Conceptual Evaluation of Interim Compliance Measures

For this analysis, MPI evaluated interim compliance options at a conceptual level for their effectiveness in reducing public health risks. This analysis included a high-level assessment of the following criteria for each compliance option:

- Protection of public health
- Capital costs to the water system
- Operation and maintenance (O&M) costs (assumes 1 year of O&M for comparative purposes)
- General O&M requirements for water system staff
- Regulatory categorization (i.e., whether or not the option is identified by the EPA as a small system compliance technology (SSCT))
- Federal regulatory requirements

Results of the evaluation of potential interim measures using the criteria above are provided in Table 1.

Table 1. Conceptual level comparison of potential interim compliance measures

Interim Measure	Potential Public Health Protection[1]	Capital Cost to Water System	O&M Cost to Water System (assume 1 year)	O&M Requirements for Water System Staff	SSCT (systems <10,000)	Federal Regulatory Requirements
Public Awareness and Education	***Low*** - May not directly provide any protection to the consumer	***Low***	***Low***	***None***	***No***	***Not a long-term compliance option***
Bottled Water (either paid for by customer or water systm)	***Medium*** - Only provides protection for exposure by ingestion - Water may still be consumed from taps in the home	***None***	***Medium (if water system pays)*** ***None (if customer pays)***	***None***	***No***	***Not a long-term compliance option***
Purchase and Delivery of Bottled Water by Water System	***Medium*** - Only provides protection for exposure by ingestion - Water may still be consumed from taps in the home	***Medium***	***High***	***Low***	***No***	***Not a long-term compliance option***
POU	***Medium*** - Only provides protection for exposure by ingestion - Water to only one faucet is treated and water may be consumed from other faucets in the home	***Medium***	***Medium***	***Medium***	***Yes***	***Medium*** 1. Must be NSF/ANSI certified 2. Must have mechanical warnings to notify customer of operational problems 3. Must be owned, controlled and maintained by the PWS or a contractor under contract with the water system

Interim Measure	Potential Public Health Protection[1]	Capital Cost to Water System	O&M Cost to Water System (assume 1 year)	O&M Requirements for Water System Staff	SSCT (systems <10,000)	Federal Regulatory Requirements
POE	***High***	***High***	***Medium***	***Medium***	***No*** - POEs have not been identified as SSCTs due to cost and waste disposal issues	***Medium*** 1. Must be NSF/ANSI certified 2. Must have mechanical warnings to notify customer of operational problems 3. Must be owned, controlled and maintained by the PWS or a contractor under contract with the water system

[1] Exposure routes considered include direct ingestion, direct inhalation, and ingestion via food watered with contaminated water.

Interim treatment measures that are not SSCTs will not be given variances if the treatment technology is installed and the treated water does not comply with the MCL. A variance provides more time to get into compliance, but requires a compliance schedule approved by CDPHE and delivery of water that does not result in an unreasonable exposure to radionuclides. Using the information provided in Table 6, Malcolm Pirnie worked with CDPHE to identify the following interim measures for further evaluation through a more detailed feasibility study:

- POU reverse osmosis
- POU ion exchange
- Bottled water

POE treatment technologies are not recommended as interim measures because they are not currently listed as SSCTs and a public awareness and education program does not guarantee or directly provide protection of public health. However, it should be noted that all interim compliance alternatives require some degree of a public awareness and education program to make them successful.

2.3. Feasibility Assessment of Select Interim Compliance Measures

Malcolm Pirnie conducted a more detailed evaluation of the list of potential interim treatment measures that were selected by CDPHE: POU reverse osmosis, POU ion exchange, and bottled water. Although the feasibility assessment efforts were focused on these three interim measures, Malcolm Pirnie also compiled less comprehensive information for the other potential options (including public awareness and education and POE treatment systems) for comparative purposes. This evaluation included the following criteria:

- Public health protection
- O&M requirements for water systems
- Operator skill level required
- NSF/ANSI certification
- SSCT
- Radionuclides removed
- Additional water quality parameters of interest
- Potential water quality issues

- Waste disposal
- Environmental impacts
- Other considerations

Results of this evaluation are summarized in Table 2.

Table 2. Detailed comparison of potential interim compliance measures (per CDPHE guidance, shaded items were not included in the feasibility evaluation, but information is included in the table for comparative purposes)

	Potential Public Health Protection (see comments in Table 1)	O&M Requirements for Water System	Operator Skill Level Required	NSF/ANSI Certified Units?	Small Systems Compliance Technology (SSCT)?	Radionuclides Removed	Additional Water Quality Parameters of Interest	Potential Water Quality Issues to Consider	Waste Disposal	Environmental Impacts	Other Considerations
Bottled Water (Delivered or Purchased)	Medium	None	None	Some bottled waters are NSF/ANSI certified	No	Bottled water should have very low concentrations or no radionuclides	Lack of fluoride in most bottled waters; bottled water regulated by FDA, not EPA	Lack of disinfectant residual may cause concern regarding microbial contamination	Waste from bottles may burden landfills (under purchased water scenario)	Waste from bottles may burden landfills (under purchased water scenario)	
POU RO	Medium	- Need long-term O&M and monitoring plans to ensure proper performance - Replacement of exhausted membranes, particulate pre-filters, and pre- and post-treatment GAC filters (if necessary) - Maintenance and cleaning of storage tank - Maintenance of (re) pressurization pumps (if used)	Basic	Yes - Standard 58 for reverse osmosis - Reduction claim for radium	Yes	Combined radium, beta and photon activity, gross alpha, and uranium	Hardness, iron, manganese, chlorine	Fouling; chlorine can harm membranes in some RO units; typically add calcite or soda ash to effluent to raise pH and prevent corrosion in pipes; RO treated water is low in sodium and other essential nutrients	Reject stream (must have a drain or tank to discharge to) and spent membranes	Low production rate (around 20-30%), storage is typically needed, may not be the optimal treatment technology in arid or water-limited regions due to low recovery rate	- Membranes and GAC media (if used) may be susceptible to microbial colonization - Entry into customers' homes is required for installation, operation, and maintenance; may complicate insurance agreements - Plumbing and/or electrical supply in the homes may need to be updated before installation - Some homes may require extra construction if the treatment unit does not fit in the existing space - State will need to determine level of operator certification required
POU IX	Medium	- Need long-term O&M and monitoring plans to ensure proper performance - Replacement of spent resin cartridges and particulate pre-filters (if used)	Basic	No	Yes	Combined radium (cation IX), beta and photon activity, and uranium (anion IX) (not a compliance technology for gross alpha)	Iron, manganese, copper, TSS	Fouling, competing ions: may shorten media life since POU IX cannot be backwashed	Regenerant brine, backwash water, and rinse water , resin		- Media may be susceptible to microbial colonization - Plumbing and/or electrical supply in the homes may need to be updated before installation - Some homes may require extra construction if the treatment unit does not fit in the existing space - Potential exposure to radionuclides in the treatment device may be an issue - Entry into customers' homes is required for installation, operation, and maintenance; may complicate insurance agreements - State will need to determine level of operator certification required

	Potential Public Health Protection (see comments in Table 1)	O&M Requirements for Water System	Operator Skill Level Required	NSF/ANSI Certified Units?	Small Systems Compliance Technology (SSCT)?	Radionuclides Removed	Additional Water Quality Parameters of Interest	Potential Water Quality Issues to Consider	Waste Disposal	Environmental Impacts	Other Considerations
Public Awareness and Education	Low	Educational flyers and regulatory updates	None	Not Applicable	No	None – no control over how consumer chooses to address the issue	Not applicable		None		Not an approved EPA compliance alternative; will be an important component of any interim measure
POE RO	High	- Need long-term O&M and monitoring plans to ensure proper performance - Replacement of exhausted membranes, particulate pre-filters, and pre- and post-treatment GAC filters (if necessary) - Maintenance and cleaning of storage tank - Maintenance of (re) pressurization pumps (if used)	Intermediate	No	No, due to concerns about cost and waste disposal	All (combined radium, beta and photon activity, gross alpha, and uranium)	Hardness, iron, manganese, chlorine	Fouling; chlorine can harm membranes in some RO units; typically add calcite or soda ash to effluent to raise pH and prevent corrosion in pipes; RO treated water is low in sodium and other essential nutrients	Reject stream and used membranes	Low production rate (around 20-30%), storage is typically needed, may not be the optimal treatment technology in arid or water-limited regions due to low recovery rate	- Membranes and GAC media (if used) may be susceptible to microbial colonization - Plumbing and/or electrical supply in the homes may need to be updated before installation of system - Some homes may require extra construction if the treatment unit does not fit in the existing space - State will need to determine level of operator certification required
POE IX	High	- Need long-term O&M and monitoring plans to ensure proper performance - 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.	Intermediate	Yes - Standard 44 for cation exchange	No, due to concerns about cost and waste disposal	Combined radium (cation IX), beta and photon activity, and uranium (anion IX) (not a compliance technology for gross alpha)	Iron, manganese, copper	Fouling, competing ions	Regenerant brine, backwash water, and rinse water		- Media may be susceptible to microbial colonization - Plumbing and/or electrical supply in the homes may need to be updated before installation - Some homes may require extra construction if the treatment unit does not fit in the existing space - Potential exposure to radionuclides in the treatment device may be an issue - State will need to determine level of operator certification required

Waste disposal is a particular concern for POU or POE treatment options. CDPHE has developed guidance on disposal of radioactive waste, where general disposal options for liquid, solids/sludge, and spent resins or media are summarized in Table 3 (CDPHE, 2007). Issues regarding disposal of radioactive waste will be further evaluated in Tasks 3 and 4 of this CO-RADS Study.

An item noted under the "Other Considerations" criterion, potential microbial colonization of POU/POE treatment units, requires further explanation. While water entering the treatment units will likely comply with the EPA's surface water treatment rule, which requires a heterotrophic plate count (HPC) of 500 colony forming units per milliliter (CFU/mL) or less for surface water or groundwater under the direct influence (GWUDI), HPCs in the POU/POE treatment unit effluent may be higher. Increased HPCs in the effluent is not surprising given that POU/POE treatment units often reduce or remove the disinfectant residual. While the value of HPC analyses as an indicator of drinking water quality is debated in the drinking water community, it is unlikely that regulators and customers will accept a lesser water quality than they are currently receiving. Proper operation and maintenance of POU/POE treatment units (which would be the responsibility of the utility) will minimize increases in HPC in treatment unit effluents. Brief flushing (5 to 10 seconds) of the POU/POE tap may also be sufficient to lower HPC levels (Raucher et al., 2004). To reduce waste of water due to flushing, the water could be collected and used for non-potable purposes (e.g., watering plants).

Table 3. Summary of disposal options for radioactive wastes (taken from Interim Policy and Guidance Pending Rulemaking for Control and Disposition of Technologically-Enhanced Naturally Occurring Radioactive Materials in Colorado – Final Draft for Comment)

	Direct Discharge[1]	**Discharge to Sanitary Sewer[2]**	**Beneficial Reuse**	**Underground Injection**	**Disposal**
Liquid Wastes	X	X	X	X	X
Solids and Sludges		X	X		X
Spent Resins and other Media					X

[1]May require a National Pollutant Discharge Elimination Permit (NPDES)
[2]Must be approved by the local publicly owned treatment works (POTW)

Approximate costs for potential interim measures were obtained from several different sources, as shown in Table 4. These feasibility level estimated costs are provided for comparative purposes only and are not specific to water systems in Colorado. Cost estimates do not include residuals disposal and insurance coverage.

Table 4. Approximate costs for potential interim measures

Treatment Technology	Approx. Capital Cost	Estimated Cost Per Household	Assumptions/Comments	Source
Purchase of POU RO	$112,000	-$32/household/ month - Average annual cost per household = $380	- 3 persons per household - Each person consumes 2 liters per day Treatment of groundwater containing radium at 112 households - Capital discounted at 7% over 5 years - Capital cost includes one water quality sample/household in the first year - O&M costs (average annual cost per household) include radionuclides sampling at 1/3 of households each year assuming an analytical cost of $257.50 and $28.18 for shipping and laboratory fees - Includes installation, educational program, and maintenance - Permitting, pilot testing, and legal as 3% each of capital - Engineering as 15% of capital - 10% contingency - $650 for public education	EPA Cost Estimating Tool for Point-of-Use and Point-of-Entry Devices, Final Version December 19, 2006
POU RO Rental	$28,000	- $31/household /month - Average annual cost per household = $370	- 3 persons per household - Each person consumes 2 liters per day Treatment of groundwater containing radium at 112 households - 5-year rental period - Capital cost includes one water quality sample/household in the first year - O&M costs (average annual cost per household) include radionuclides sampling at 1/3 of households each year assuming an analytical cost of $257.50 and $28.18 for shipping and laboratory fees - Includes installation, educational program, and maintenance - Permitting, pilot testing, and legal as 3% each of capital - Engineering as 15% of capital - 10% contingency - $650 for public education	EPA Cost Estimating Tool for Point-of-Use and Point-of-Entry Devices, Final Version December 19, 2006
POU IX	$37,000	Not available	- Source of estimated capital cost is for arsenic removal with activated alumina (2005 US dollars) - Assumed purchase of POU treatment units for 112 homes	POU/POE Implementation Feasibility Study for Arsenic Treatment (2005) AwwaRF

Treatment Technology	Approx. Capital Cost	Estimated Cost Per Household	Assumptions/Comments	Source
POE IX	$175,000	- $47/household /month - Average annual cost per household = $570	- 3 persons per household - Each person consumes 2 liters per day Treatment of groundwater containing radium at 112 households - Capital discounted at 7% over 5 years - Capital cost includes one water quality sample/household in the first year - O&M costs (average annual cost per household) include radionuclides sampling at 1/3 of households each year assuming an analytical cost of $257.50 and $28.18 for shipping and laboratory fees - Includes installation, educational program, and maintenance - Permitting, pilot testing, and legal as 3% each of capital - Engineering as 15% of capital - 10% contingency - $650 for public education	EPA Cost Estimating Tool for Point-of-Use and Point-of-Entry Devices, Final Version December 19, 2006
POE RO	Not available	Not available		
Bottled Water (purchased from store)	NA	$38/household /month	- 3 persons per household - Each person consumes 2 liters per day - $0.80/gallon of water	
Bottled Water (delivered)	NA	$77/household/ month	- 3 persons per household - Each person consumes 2 liters per day - Cooler is rented - Does not include any potential discounts for large contracts	Rocky Mountain Bottled Water (Jeff Spencer - Southern Colorado Distributer, phone conversation October 2007)

Two vendors were contacted to request cost information for POE RO systems for radionuclides treatment. One vendor indicated they typically install POU RO, not POE RO, but can install a POE system if needed. However, cost information could not be provided due to unknowns regarding operation and maintenance requirements and waste disposal issues that may arise for a radionuclides treatment system. The second vendor indicated the company has three radionuclides treatment systems installed in private homes in Colorado for uranium removal. However, the company did not want to be involved in any discussions about POU/POE for radionuclides treatment and would not provide any cost estimates.

2.4. Observations

Some observations from the feasibility assessment of select interim compliance measures include:

- Public awareness and education may be a viable option for systems that plan to install a long-term compliance option in the near future; however, this option by itself guarantees no additional public health protection. An active public education and awareness program will have to be implemented with any of the potential interim measures to inform customers of the reason for the measure and any associated risks.

- For a short-term solution, purchase of bottled water provides a relatively low-cost interim measure to reduce public health risks associated with ingestion of water contaminated with radionuclides. Note that the POU/POE options have significant upfront capital expenditures and that there is a payback period associated with those compliance options that bottled water does not incur. However, bottled water does not protect from exposure to inhalation or ingestion of water from taps in a residence; in addition, there are also questions about how diligent consumers will be about only ingesting bottled water, especially if they purchase it themselves.

  Another concern associated with bottled water (if purchased) is the waste produced from the bottles; therefore, a recycling program should be considered as part of this strategy. Whether or not the water system reimburses the customer for the water would likely depend on the system's financial situation and the public health risk associated with its water supply. Bottled water delivery provides similar health protection and does not pose a waste concern, though the transportation of water in this manner is not as efficient as providing water through local sources. It is also the most expensive option based on monthly costs per household.

- POU treatment technologies can provide a mid-range cost interim measure; however, waste disposal may be an issue and radionuclides exposure due to build-up in the treatment device needs to be further evaluated. POU treatment options also require entry into a customer's home for installation, operation, and maintenance, which may make it challenging to achieve 100% customer participation in a POU treatment program and present a liability issue. Other potential liability associated with POU treatment includes failure of the device that results in water that exceeds an MCL. Furthermore, only POU reverse osmosis systems, not ion exchange systems, are NSF/ANSI certified as required by federal regulations, though reverse osmosis is a treatment option for all the radionuclide MCLs. Programs to install POU devices are also eligible for Drinking Water State Revolving Fund (DWSRF) funds to comply with the

Radionuclides Rule (USEPA, 2002b) (see Section 3 for additional information on this item).

- POE treatment technologies provide the highest degree of potential public health protection due to reduction of risks associated with ingestion and inhalation, though they require the highest capital cost. O&M costs are similar to that of POU systems. POE systems are not considered an SSCT, which may have regulatory implications for systems if they install POE treatment, but cannot comply with the MCL. Waste disposal and radionuclide exposure from these systems is also a concern. POE treatment may not require entry into a customer's home for operation and maintenance tasks, but 100% participation in a POE treatment program may still be hard to achieve (see Section 3 for additional information on this item).

  Based on the vendors contacted in this study, POE RO treatment for radionuclides may require more research and analysis to determine under what situations it should be implemented. The vendors contacted in this study were reluctant to describe potential POE RO systems or associated costs for radionuclides treatment. More information needs to be made available regarding RO rejection predictions for radionuclides.

Multiple types of radionuclide contamination should be considered for any POU or POE treatment technology. For example, cation exchange will remove radium, but not uranium, anion exchange must be used.

3. Evaluation of POU/POE for Long-Term Treatment

3.1. Methodology

POU and POE treatment technologies were evaluated as potential long-term compliance options for small water systems. POU and POE systems were evaluated on similar criteria described in Section 2, but potential longer-term implications were further analyzed. Specifically, Malcolm Pirnie performed the following:

- Evaluated costs to determine at what point POE or POE was more cost-effective than centralized treatment for a long-term compliance strategy

- Conducted research on other States' policies regarding the use of POE or POE for long-term compliance. Specifically, MPI reviewed existing information and contacted four State regulators (November 2007) to determine their current situation regarding POU/POE treatment programs:
    - Arizona Department of Environmental Quality (ADEQ)
    - Illinois Environmental Protection Agency
    - Texas Commission on Environmental Quality
    - Wisconsin Department of Natural Resources

3.2. State of the Industry

Multiple States have POU and/or POE rules or guidance in place including Arizona, California, Delaware, Florida, Idaho, Illinois, Massachusetts, New York, Pennsylvania, South Carolina, Utah, Vermont, Virginia, Washington, and Wisconsin, where several allow POU and/or POE treatment for compliance with the radionuclides rule (Narasimhan et al, 2005). At the time of the referenced study, several states had water systems with POU or POE in place; however, it was not clear for what type of contamination they were installed. A summary of the information collected from State regulators via phone conversations is provided in Table 5 below.

Table 5. Selected summary of States' POU/POE policies as of October 2007

States that allow POU/POE for Radionuclides Treatment	Additional State Requirements over CFR	Contaminants	Size of systems allowed to use POUs	Size of Systems using POUs	Info on Systems currently using POEs for compliance
Arizona	Arizona regulations require the water system to develop and have approved a written monitoring plan, obtain ADEQ approval of design of the POU device, install a sufficient # of devices to ensure every person served by the system is protected, and that the rights and responsibilities of persons served by the water system convey with title upon sale of property.	Radionuclides, As, Cr, VOCs	All	About 18 systems (<50 connections) have POU and/or POE in place for arsenic or fluoride for long-term treatment	~3 systems have POE or POU and POE in place for arsenic and/or fluoride
Illinois	POU and POE are not allowed for municipalities, only private systems such as home owner's associations (HOAs); must have 100% participation	Only radium	None	None	Two small HOAs with less than 60 homes currenlly have POE cation exchange (water softeners) installed for removal of radium

States that allow POU/POE for Radionuclides Treatment	Additional State Requirements over CFR	Contaminants	Size of systems allowed to use POUs	Size of Systems using POUs	Info on Systems currently using POEs for compliance
Texas	When POU/POE devices are used for compliance, the water system must develop a program for the long-term operation, maintenance, and monitoring of the devices to ensure adequate performance.	Any non-microbial contaminant violating the MCL	<10,000	None, though an application from a public school is under review (Source: conversation with Mike Howell, Texas Commission of Environmental Quality)	None used
Wisconsin	The Wisconsin Department of Commerce requires installation of POU on all faucets in a home; cannot install POU on only one faucet (Source: phone conversation with Wisconsin Department of Natural Resources)	Radionuclides, Total Coliform Rule, and nitrate	All	None	Small non-community GW systems for TCR compliance

Source: Phone conversations and POU/POE Implementation Feasibility Study for Arsenic Treatment. Narasimhan, et al. 2005. American Water Works Association Research Foundation (AwwaRF)

As shown in Table 5, only Illinois currently has water systems (2 HOAs) using POE for compliance for radionuclides, while Arizona has almost 20 systems using POU and/or POE for arsenic and fluoride compliance. Arizona anticipated having more systems with POU/POE installed; however, water systems have experienced insurance issues with having treatment devices installed in private homes, but owned and operated by the water system.

3.3. Long-Term POU/POE Evaluation Results

POU/POE may be an attractive solution to systems for which there would be a cost-saving compared to centralized treatment. A recent study on POU for arsenic removal (Narasimhan et al, 2005) found that the annualized cost breakpoint for POU reverse osmosis and POU adsorption compared to centralized treatment (adsorption using throw away media) was 120 and 200 connections, respectively. Annual O&M costs for POU RO and POU adsorption units were found to be higher than for central treatment for systems serving greater than 50 and 60 connections, respectively. A similar analysis conducted for POE in this study showed that POE treatment would not be competitive with centralized treatment, even for the smallest systems (20 connections). A cost analysis performed by EPA (Preamble to Final Arsenic Rule, USEPA, 2001) shows significantly lower costs for POE systems, with a cost breakpoint compared to centralized treatment at 53 connections. However, EPA's costs do not include waste disposal issues, labor, operations, or management of a POE treatment program.

POU/POE treatment costs provided in Section 2 for radionuclides are similar to those provided in the study above for arsenic (± 10% accounting for the cost difference for arsenic and radionuclides water sample analyses); however, centralized treatment costs for radionclides may be much different, depending on the type of contamination and treatment technology selected.

Public participation in a POU/POE treatment program may be a challenge. Whereas customers might accept water system employees in their homes or on their property to operate and maintain POU and POE systems on a temporary basis, long-term participation may be more challenging, especially for POU systems that require entry into a customer's home.

Potential future contaminants should be considered when evaluating POU/POE treatment options. For example, if a water system is contaminated with radium above the MCL, but gross alpha may be a concern in the future, then the system should elect reverse osmosis treatment to remove both contaminants. Contaminants not included under the radionuclides rule, such as nitrate, should also be considered.

Waste disposal may also present a long-term implementation challenge. Many small water systems in Colorado use Individual Sewage Disposal Systems (ISDSs), where storage and accumulation of solid radioactive waste may pose a public health threat (liquid waste would be released through the subsurface soil).

The fact that POEs are not identified as SSCTs, may also be problematic for long-term compliance.

3.4. Observations

Some observations from the evaluation of POU/POE for long-term treatment include:

- Although it appears that some states are allowing POU/POE as compliance solutions to select drinking water regulations, there are very few water systems that are choosing to implement POU/POE technologies for compliance. In particular, there are limited cases of water systems complying with the Radionuclides Rule with POU/POU technologies. Specific challenges that seem to be most impacting the use of these systems include the following:
    - 100% customer participation, especially for systems that require allowing a PWS employee or contracted person into the homes to maintain the systems
    - Insurance issues associated with having the systems installed in or at private residences
    - Unknowns regarding radionuclides waste disposal policies
- There are many challenges associated with the long-term POU/POE compliance strategies, from both a regulatory oversight standpoint and a water system implementation/oversight standpoint. To make this a viable alternative, significant work will need to be done by both CDPHE and individual water systems to plan, implement, and oversee POU/POE devices.

CDPHE has already developed draft guidance regarding POU or POE implementation (CDEPHE, 2003). If CDPHE decides to allow POU/POE for long-term compliance, other states are requiring some important items that CDPHE may also want to consider requiring as part of their policy, such as:

- State approved system design
- State approved monitoring plan
- State approved public education program
- Specific requirements and/or a State approved testing plan for field/pilot testing of treatment technologies on a case-by-case basis

Systems considering implementation of POU or POE treatment units also need to consider other drinking water regulations. For example, the Radon Rule may be promulgated in the future and radionuclides treatment may not be a compliance option for the Radon Rule without addition to the treatment process.

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