

# A System's Guide to the Management of Radioactive Residuals from Drinking Water Treatment Technologies



Community water systems (CWSs) that use source water containing radium-226 (Ra-226), radium-228 (Ra-228), gross alpha particle activity, beta particle and photon radioactivity, or uranium must comply with the Radionuclides Rule (see [www.epa.gov/safewater/radionuc.html](http://www.epa.gov/safewater/radionuc.html)). This document provides general information to CWSs on: the available treatment technologies for the removal of radium, uranium, and gross alpha particle activity; the residuals produced by each technology; disposal options; and, the regulations governing these options. These requirements are described here in summary form only and there may be additional federal or state laws or regulations that apply to you beyond those described in this document. You need to consult the statutory and regulatory provisions that apply to the waste you generate or manage in order to determine the requirements with which you must comply. This document also provides additional recommendations and information on possible options; these are not regulatory requirements and are provided for your information only. This document does not cover residuals from treatment of beta particle or photon radioactivity. Information on those radionuclides can be obtained from your primary agency. EPA will continue to review and update this Guide as necessary and appropriate. For additional, more detailed information see *A Regulators' Guide to the Management of Radioactive Residuals from Drinking Water Treatment Technologies* (EPA 816-R-05-004, July 2005).

## Treatment Technologies

In the Radionuclides Rule, EPA has listed Best Available Technologies (BATs) and Small System Compliance Technologies (SSCTs) for radionuclide treatment based on their efficiency at removing radionuclides from drinking water, taking cost into consideration. You are not required to use a listed BAT or a SSCT. Any technology that is accepted by your primacy agency and achieves compliance with the maximum contaminant level (MCL) is allowed.

These technologies produce different types of waste with varying contaminant concentrations and restrictions on disposal options. It is important that systems carefully investigate treatment and waste disposal options before installing new or upgrading existing treatment. If possible, pilot tests are a good way to determine how much waste your system will produce and whether your system will be able to dispose of the amount, concentration, and type of waste.

## Treatment and Disposal Considerations

### *Treatment Residual Characteristics*

Each treatment technology will produce solid residuals (spent resins, spent filter media, spent membranes, and sludge) and liquid residuals (brine, backwash water, rinse water, acid neutralization streams, and concentrates). The characteristics of the residuals can be affected by:

- The concentration of radionuclides in the source water
- Frequency of resin/media/membrane replacement
- How efficient the treatment is at removing radionuclides
- Loading to the treatment unit
- Frequency of regeneration (for ion exchange and activated alumina)
- Frequency of filter backwash (for treatment processes using granular media filters)

### *TENORM*

Treating water containing naturally occurring radionuclides increases the radionuclide concentrations in the residual streams. These residual streams are called Technologically Enhanced Naturally Occurring Radioactive Materials (TENORM), or naturally occurring materials whose radionuclide concentrations or potential for exposure to

humans or the environment are enhanced as a result of human activities. The concentration of TENORM in the waste stream, the type of waste produced (liquid or solid), and federal and state regulations will affect what disposal options are available to your system.<sup>1</sup>

### *Nuclear Regulatory Commission Licensing*

If your system generates water treatment residuals containing uranium or thorium, this uranium or thorium is considered “source material” and may be subject to the Nuclear Regulatory Commission’s (NRC’s) licensing requirements under the Atomic Energy Act (AEA). Licenses are issued either directly by the NRC or by “Agreement States” that have entered into agreements with the NRC to regulate source material. If you think your system may require a license, contact your primacy agency.

*Exempt Material:* If the uranium or thorium makes up less than 0.05 percent by weight of the residuals it is **exempt** from NRC regulations because it is considered an “unimportant quantity” (10 CFR 40.13). For perspective, for a system with filter media weighing 30,000 pounds, 0.05 percent by weight would be equal to 15 pounds of uranium.

*General License:* If the source material is greater than 0.05 percent by weight (or about 335 picocuries per gram [pCi/g] for natural uranium), and the total amount in your possession at any time is less than 15 pounds or no more than 150 pounds in any one calendar year, you have a “small quantity” of source material that is subject to a general license (10 CFR 40.22).

*Specific License:* If your system exceeds this small quantity threshold, you must apply for a specific license from the NRC or Agreement State.

### *Resource Conservation and Recovery Act Requirements*

Also, since many of the treatment technologies that are efficient at removing radionuclides are also efficient at removing co-occurring contaminants, your TENORM residuals may also be classified as hazardous waste if they contain high enough levels of certain co-occurring contaminants, like arsenic. Under the Resource Conservation and Recovery Act (RCRA), a waste is considered hazardous if it exhibits a certain characteristic (i.e., toxicity, ignitability, corrosivity, or reactivity) or if it is included on a specific list of wastes. Water treatment plant residuals are most likely to exhibit the toxicity characteristic. For more information, see *A System’s Guide to the Identification and Disposal of Hazardous and Non-Hazardous Water Treatment Plant Residuals* (EPA 816-F-06-011).

<sup>1</sup> The pH and total dissolved solids (TDS), total suspended solids (TSS), and concentrations of other contaminants in the waste stream can also limit disposal options.

*Mixed Waste*

If your treatment residuals contain hazardous waste and a “small quantity” of uranium or thorium, you have a mixed waste and you must comply with both RCRA hazardous waste regulations and NRC’s licensing requirements. These requirements also apply to the recipient of the material (i.e., a hazardous waste landfill). You do not have a mixed waste if the uranium or thorium is of an “unimportant quantity” (uranium or thorium makes up less than 0.05 percent by weight of the material), or if the waste contains only radium. Radium is not considered source or by-product material when present in water treatment residuals unless it co-occurs with licensable source material such as uranium or thorium.

**Table 1** lists the BATs and SSCTs listed in the Radionuclides Rule and includes information on the operator skill required to effectively operate each technology, the residuals produced, and intermediate processing options. Intermediate processing can increase the disposal options available to your system and in some cases, can reduce the volume of waste produced. Systems can also consider several alternative compliance options including: developing a new source, blending source waters, connecting with a nearby system, or optimizing existing treatment.

**Disposal Options**

Your disposal options will vary according to: primacy agency regulations; your system’s location; and the type, volume, and concentration of residuals your system produces. There are numerous state and local regulations that govern the disposal of waste streams containing radionuclides (although there are no federal waste disposal regulations specifically for TENORM wastes), and their interaction is complex. Primacy agencies and disposal facilities can impose additional restrictions on your system’s disposal options. **Check with your primacy agency to verify which disposal options are available to your system.**

**Table 2** provides additional general information on disposal options for water treatment plant wastes containing radionuclides.

**Table 1: BATs and SSCTs for the Removal of Radionuclides**

Treatment	BAT and/or SSCT?	Customers Served (SSCTs only)	Tr
			Ra 226/228
Ion Exchange (IX)	BAT & SSCT	25 - 10,000	●
Point of Use (POU) IX	SSCT	25 - 10,000	●
Reverse Osmosis (RO)	BAT & SSCT	25 - 10,000 (Ra, G A) 501 - 10,000 (U)	●
POU RO	SSCT	25 - 10,000	●
Lime Softening	BAT & SSCT	25 - 10,000 (Ra) 501 - 10,000 (U)	●
Green Sand Filtration	SSCT	25 - 10,000	●
Co-precipitation with Barium Sulfate			●
Pre-formed Hydrous Manganese Oxide Filtration			●
Coagulation/Filtration	BAT & SSCT	25 - 10,000	
Activated Alumina (AA)	SSCT	25 - 10,000	
Electrodialysis/ Electrodialysis Reversal			●

from Drinking Water

Treats For...		Source Water	Operator Skill Required	Solid Residuals	Intermediate Process Options	Liquid Residuals	Intermediate Process Options
U	Gross Alpha (GA)						
●		Ground	Intermediate	Spent resins	Regeneration prior to disposal	Backwash water, brine, and rinse water	Flow equalization, chemical precipitation/pH adjustment, thickening, dewatering, recycle
●			Basic				
●	●	Surface	Advanced	Spent membranes	Dewatering, regeneration prior to disposal	Concentrated waste stream	Chemical precipitation/pH adjustment, thickening, dewatering, recycle
●	●		Basic				
●		All	Advanced	Spent filter media, sludge	Spent filter media: Regeneration prior to disposal Sludge: Thickening, dewatering, recycle	Spent filter backwash water	Flow equalization, chemical precipitation/pH adjustment, thickening, dewatering, recycle
		Ground	Basic				
			Intermediate to Advanced				
			Intermediate				
●		All	Advanced	Filter media: Dewatering, regeneration prior to disposal Sludge: Thickening, dewatering, recycle	Spent filter backwash water, filter-to-waste (if practiced)	Flow equalization, chemical precipitation/pH adjustment, thickening, dewatering, recycle	
●		Ground	Advanced	Dewatering, regeneration prior to disposal	Backwash water, brine, rinse water, acid neutralization water		
			Basic to Intermediate	Spent membranes	Regeneration prior to disposal	Concentrated waste stream	Chemical precipitation/pH adjustment, thickening, dewatering, recycle

## Table 2: Options for Residual Disposal

Below is general information on the basic disposal requirements. Always contact your primacy agency before choosing a disposal option, as additional requirements may apply depending on primacy agency regulations, disposal facility restrictions, and the type and characteristics of the waste. *A Regulators' Guide to the Management of Radioactive Residuals from Drinking Water Treatment Technologies* (EPA 816-R-05-004, July 2005) includes two decision trees (see pages 17 and 21) that can also help you.

### Options for Solid Residuals<sup>1</sup>

For landfill disposal, solid wastes must not contain free liquids<sup>2</sup> and may need to be dewatered prior to disposal.

#### Disposal Option 1: Municipal & Industrial Solid Waste Landfill

1. Regulated under RCRA, Subtitle D
2. Ability to dispose of hazardous waste depends on generator class; contact your primacy agency for more information
3. Industrial solid waste landfills may be better equipped to dispose of TENORM wastes than municipal landfills, which may have restrictions on the amount of radioactivity they can accept
4. Some landfills may use monitors to scan incoming trucks for radiation

#### Disposal Option 2: Hazardous Waste Landfill

1. Regulated under RCRA, Subtitle C
2. Not all hazardous waste landfills accept TENORM waste
3. Certain generator classes must meet Land Disposal Restrictions in 40 CFR Part 268; contact your primacy agency for more information<sup>3</sup>

#### Disposal Option 3: Low-Level Radioactive Waste (LLRW) Landfill

1. Regulated by the NRC or Agreement State
2. May accept wastes with radionuclide concentrations too high for disposal at a solid or hazardous waste landfill
3. Guidelines for disposal are more stringent than in a standard landfill
4. Currently, only three LLRW landfills are operating, with differing restrictions on waste disposal (e.g., which states can dispose of waste, types of wastes accepted, etc.); contact your primacy agency for more information

### Options for Liquid Residuals

#### Disposal Option 1: Direct Discharge to Waters of the U.S.<sup>4</sup>

1. Regulated under the Clean Water Act (CWA)
2. Must have a National Pollutant Discharge Elimination System (NPDES) permit
3. Need an appropriate and accessible receiving body
4. Must meet primacy agency water quality limits for radionuclides

#### Disposal Option 2: Discharge to a Publicly Owned Treatment Works (POTW)

1. Regulated under the CWA
2. Must meet Pretreatment Program prohibitions and the Technically Based Local Limits (TBLs) established by your state or the POTW (i.e., discharge cannot cause a NPDES violation)
3. Must meet any POTW requirements
4. Must meet state permitting requirements
5. Additional conditions apply to systems that combine liquid wastes with domestic sewage prior to discharge; contact your primacy agency for more information

#### Disposal Option 3: Underground Injection

1. Regulated under the Safe Drinking Water Act (SDWA)
2. In accordance with UIC regulations (10 CFR 20 Appendix B, Table 2, Column 2), EPA considers wastes with the following concentrations of radium and uranium to be radioactive: 60 pCi/L for radium-226, 60 pCi/L for radium-228, and 300 pCi/L for uranium

##### Class I Well Considerations

1. May be an option for hazardous and radioactive wastes, but very few Class I facilities accept hazardous or mixed waste generated off-site
2. Wells have stringent protective requirements
3. Can be expensive to construct, operate, and monitor
4. Acceptable geology not always available
5. States may be more stringent or may prohibit such class of injection well

##### Class V Well Considerations

1. Not an option for wastes considered hazardous
2. Most likely not an option for radioactive waste, because demonstration of the non-endangerment standard (40 CFR 144.12) for shallow injection will be difficult

<sup>1</sup> Discharge to a POTW and underground injection are also possible options for sludge disposal.

<sup>2</sup> See 40 CFR 264.314(b) and (e) and 40 CFR 265.314(b) and (f).

<sup>3</sup> For more information on the disposal of hazardous waste, see EPA's *A System's Guide to the Identification and Disposal of Hazardous and Non-Hazardous Water Treatment Plant Residuals* (EPA 816-F-06-011).

<sup>4</sup> Direct discharges subject to NPDES permits are not solid or hazardous waste under RCRA. However, wastewater that is stored before discharge is considered solid waste, may be hazardous, and is thus regulated by RCRA.

## Transporting Waste

The U.S. Department of Transportation (DOT) regulates the safe transport of all hazardous materials, including radioactive material. DOT has set radionuclide-specific thresholds to determine when a material containing radionuclides is subject to requirements for transporting radioactive material. The exemption values (listed in 49 CFR 173.436) consist of activity concentrations and total consignment activities; a material containing a single radionuclide has to be above both exemption values for that nuclide to be subject to DOT requirements. If the activity concentration or total consignment activity is below the exemption value, that material is exempt from the DOT requirements for transporting radioactive material. If more than one radionuclide is present, the exemption values must be determined as described in 49 CFR 173.433.

DOT also exempts “natural material and ores containing naturally occurring radionuclides which are not intended to be processed for use of these radionuclides” if their activity concentrations and consignment activities do not exceed 10 times the levels in 49 CFR 173.436 or calculated using 49 CFR 173.433. For example, the exempt activity concentration for uranium is listed as 27 pCi/g, and those for radium-226 and radium-228 are 270 pCi/g. Therefore, if your system transports more than 270 pCi/g of uranium or 2,700 pCi/g of radium, you must comply with DOT’s requirements for radioactive material transport (unless consignment activities are below the consignment activity exemption). For more information, see [http:// hazmat.dot.gov](http://hazmat.dot.gov).

## Additional Resources

### *Documents and Web Sites*

EPA Office of Ground Water and Drinking Water:

- Radionuclides in Drinking Water: [www.epa.gov/safewater/radionuc.html](http://www.epa.gov/safewater/radionuc.html)
  - *Radionuclides Rule (Final)*, Federal Register, Vol. 65, No. 236, December 7, 2000
- Radionuclides Rule Implementation and Guidance: [www.epa.gov/safewater/rads/implement.html](http://www.epa.gov/safewater/rads/implement.html)
  - *Implementation Guidance for Radionuclides*, EPA 816-F-00-002, March 2002
  - *Radionuclides in Drinking Water: A Small Entity Compliance Guide*, EPA 815-R-02-001, February 2002
  - *Radionuclides Rule: A Quick Reference Guide*, EPA 816-F-01-003, June 2001
  - *A Regulators’ Guide to the Management of Radioactive Residuals from Drinking Water Treatment Technologies*, EPA 816-R-05-004, July 2005
- Underground Injection Control: [www.epa.gov/safewater/uic.html](http://www.epa.gov/safewater/uic.html)

EPA Office of Air and Radiation:

- Radiation Protection Division: [www.epa.gov/radiation/index.html](http://www.epa.gov/radiation/index.html)
- TENORM: [www.epa.gov/radiation/tenorm/index.html](http://www.epa.gov/radiation/tenorm/index.html)

EPA Office of Solid Waste: [www.epa.gov/osw](http://www.epa.gov/osw)

EPA Office of Wastewater Management, NPDES: [cfpub.epa.gov/npdes](http://cfpub.epa.gov/npdes)

RCRA Online: [www.epa.gov/rcraonline](http://www.epa.gov/rcraonline)

The TENORM Page: [www.tenorm.com](http://www.tenorm.com)

U.S. Nuclear Regulatory Commission: [www.nrc.gov](http://www.nrc.gov)

## **Safe Drinking Water Hotline 1-800-426-4791**

Office of Water (4606M)

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[www.epa.gov](http://www.epa.gov)

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