

Disposal of Uranium Removed from Drinking Water

As a result of U.S. Environmental Protection Agency (EPA) regulations for the treatment of radionuclides in drinking water, some water treatment facilities may be required to treat drinking water for uranium. Drinking water facilities that are required to be licensed by the U.S. Nuclear Regulatory Commission (NRC) or the Agreement States, because they concentrate uranium above 0.05 percent by weight of the material, will be required to ensure that their wastes containing uranium are properly disposed.¹ The concentration and quantity of waste material containing uranium, the material's characteristics, and the presence of other contaminants may all play a role in determining the appropriate disposal method. Depending upon the number of drinking water treatment facilities using technologies that will require NRC or Agreement State licensing, the concentration of uranium in the water being treated, and the amount of water being treated, there is the potential for relatively large quantities of uranium that may be removed from drinking water and require proper disposal. The potential issues related to the proper disposal of material from drinking water treatment facilities licensed by NRC or the Agreement States under existing regulations are discussed below.

EPA's 2000 Radionuclides Rule *Federal Register* notice [65 FR 76708] provides limited information for the purposes of determining the amount of uranium recovered nationwide. A more detailed analysis supporting the rule is found in the notice of data availability (NODA). The NODA is an analysis of the effects of a uranium maximum contaminant level (MCL) of 20, 40, and 80 micrograms per liter ($\mu\text{g/L}$), but not the actual maximum contaminant level (MCL) of 30 $\mu\text{g/L}$. The following analysis first defers to the data presented in the *Federal Register* notice and, if not otherwise presented, then defers to interpolations of the data provided in the NODA.

Amount of Uranium Recovered Nationwide

EPA estimates that approximately 500 systems will be impacted by this rule, serving approximately 620,000 people. Given that the average person requires approximately 160 gallons of water per day,² it is estimated that approximately 36 billion gallons per year could be produced from these drinking water systems. It is estimated that about one-third of systems will not treat for uranium,³ but will develop/purchase alternative sources of water. Therefore, it is estimated that roughly 24 billion gallons (91 billion L) of water will be treated to remove uranium annually.

¹Disposal is used in this paper to indicate a removal of the uranium from the facility's license. This could be through a transfer to a licensed burial facility, transfer to another licensed facility for further processing, or through some other method approved of by the NRC or Agreement State.

²Note that the average per capita water produced at a drinking water treatment facility, 160 gallons/d (600 L/d), is considerably more than the average per capita water drinking (ingestion) rate, which is less than 1 gallon/d (1.11 L/d).

³NODA, table VII-13.

Of the affected drinking water treatment systems, it is estimated that the average untreated water contains uranium at a concentration of about 40 µg/L.⁴ Therefore, for compliance with the 30 µg/L uranium MCL, at least 10 µg/L will be removed from 24 billion gallons, for a total of about 1,000 kg uranium per year. If the drinking water is treated by high-efficiency processes such as ion exchange or reverse osmosis, it is possible that 4,000 kg of uranium will be removed from drinking water treatment plants nationwide per year.

The recovered uranium will not be in a pure form, but will be diluted according to many factors that are unknown at this time. However, if this quantity of uranium is diluted to the minimum licensable concentration (0.05 percent by weight, or a factor of 2,000), the nationwide impact would require the licensed disposal of approximately 2,000 to 8000 metric tons (2 to 8 million kg) of uranium-bearing wastes per year.

Waste Stream Characteristics

Regardless of the technology used to comply with EPA's drinking water MCL, the process of removing uranium from drinking water will generate a waste stream, also called residuals, containing concentrated uranium. There are many site-specific variables that can affect the ultimate concentration of uranium in the residuals, and the resulting health and safety risks they pose. Only certain technologies are approved by EPA for removing uranium from drinking water, and given a few process variables the waste stream characteristics may be calculated with some degree of confidence.

However, some facilities may undertake intermediate processing of the residuals in order to lower the costs of residual disposal. Intermediate processing may also be used to reduce the volume of waste or to increase the disposal options available to a particular facility. The intermediate processing options available to a particular drinking water treatment system vary in complexity from simple processes such as collecting residuals for direct disposal, or may involve complex treatment technologies that involve chemical or physical reactions.

Due to various combinations of water characteristics, treatment technologies, and intermediate processing options that will be present at the various drinking water treatment systems across the country, the residual characteristics are difficult to predict. Generally, however, the residual disposal options are governed by three factors: (1) the solid content of the uranium-bearing waste stream, (2) the concentration of uranium, and (3) the presence of other chemical or radiological contaminants.

Disposal Considerations for Solid and Liquid Residuals

Solid residuals are generated in bulk by adsorption or precipitation, and to a lesser extent as a result of other processes such as reverse osmosis. Liquid residuals can be generated from all of the available treatment technologies. For the most part, uranium in a solid can be changed

⁴This value is presented in the NODA (pp VI-9), and estimated from the National Inorganics and Radionuclide Survey (NIRS). The NIRS data is the best survey available, however the use of this data for these purposes introduces considerable uncertainty as some early findings indicate that some facilities could treat water containing 20 times (800 Fg/L) or more uranium.

to a liquid, and vice-versa, using intermediate processing. The likelihood and extent of intermediate processing will depend on the residuals disposal methods preferred by the drinking water treatment facility. For example, uranium in a solid form is more stable for land disposal; other disposal pathways such as discharge to sanitary sewer or underground injection require that the uranium be in a liquid form.

The adsorption of uranium to solid media (such as an ion-exchange resin) may be partially reversed through a process called "regeneration." Regeneration removes some of the adsorbed uranium from the adsorptive media and dissolves it into a highly-concentrated liquid waste stream. After regeneration, the media can be re-used to remove more uranium from the drinking water, however the media cannot be completely regenerated and at some point will become exhausted. Exhausted media will be contaminated with uranium and likely will have to be disposed of by land burial or milled.

Precipitation involves some manipulation of the drinking water, usually by processes such as chemical addition and pH manipulation, in order to convert the dissolved uranium into an insoluble chemical form. The uranium precipitate is then separated from the drinking water via physical means such as filtration or clarification. Specific technologies approved by EPA for removing uranium from drinking water via precipitation are coagulation/filtration and lime softening. The solid residuals created from precipitation are in the form of a sludge. The uranium is not permanently bound by these processes, however, and through intermediate processing, it may be dissolved into a liquid waste stream.

Liquid residuals are created when the uranium remains dissolved in the water, albeit at a higher concentration than before the treatment. Liquid residuals arise from the membrane reject stream from reverse osmosis, the brine regeneration waste stream from ion exchange, and the various rinses and backwashes required for ion exchange and treatment methods utilizing precipitation.

Disposal Considerations due to the Uranium Concentration

The concentration of uranium will vary due to site-specific characteristics, such as the natural concentration of uranium in the drinking water and the ultimate treatment efficiency. From a licensing standpoint, uranium in excess of 0.05 percent by weight will require a license from the NRC. Along with the amount of material handling necessary for disposal, health and safety concerns will generally increase with higher uranium concentrations. A drinking water treatment facility is unlikely to further concentrate uranium in liquid waste streams if the disposal option is underground injection or direct discharge to sanitary sewer. However, if the residuals must be transported, such as for land burial or milling, the treatment facility will have incentive to increase the concentration of uranium in the transported waste.

Disposal Considerations due to Other Chemicals and Radionuclides

Some chemical and radionuclide contaminants may be found in the groundwater along with uranium, such as lead, radium, and arsenic. Their effect on disposal options would be to limit disposition pathways, and in the worst-case scenario, to create a mixed waste. However, their effect would be best dealt with on a case-by-case basis because their removal and concentration from groundwater will vary considerably due to the operations of the water treatment facility. Some processes, particularly absorptive media regeneration and

precipitation, will add process chemicals which could also limit disposition options because of their hazardous or other undesirable nature in and of themselves. For example, without intermediate processing, lime softening will generate residuals with extreme pH values. This may affect certain disposal pathways if a neutral pH is desired, as in discharge to sewer or underground injection; or if stability is desired, as in land burial. The presence of other radiological contaminants may also affect the residual disposal options if the resulting waste is excessively radioactive.

Waste Classification

The disposal of uranium recovered from drinking water by an NRC licensee will be in accordance with the provisions of the license and ultimately the regulations as set forth in 10 CFR Part 61. This discussion of waste classification is only valid if the uranium recovered from drinking water is categorized as "radioactive waste," and can be processed into a stable physical and chemical form. In accordance with 10 CFR 61.55(a)(6), by definition the uranium-bearing wastes will be classified as "Class A," because it will not contain any radionuclide enumerated in Table 1 or Table 2 of 10 CFR 61.55.⁵

Economic Considerations and Milling

Once removed from drinking water, it is conceivable that the uranium could be milled as alternative feed material. The residuals, or tailings, that will result from ion exchange processes used at drinking water treatment facilities, and if milled as alternative feed stocks, are expected to be physically, chemically, and radiologically similar to existing tailings produced from the processing of conventional ores at in-situ leach facilities. As a result, some facilities, if they concentrate enough uranium and have significant volumes of material, may find it economically beneficial to sell the uranium as an alternate feed rather than disposing of it through a burial method.

⁵In CLI-05-20, the Commission directed the staff to consider whether the quantities of depleted uranium at issue in the waste stream from uranium enrichment facilities warrant amending section 61.55(a)(6) or the section 61.55(a) waste classification tables. Because drinking water treatment facilities will not be concentrating depleted uranium (the facilities will concentrate natural uranium), changes as a result of this direction should not impact the waste classification of uranium bearing wastes from drinking water treatment facilities.