



Illinois Emergency Management Agency

Division of Nuclear Safety

Jonathon E. Monken, Director
Joseph Klinger, Assistant Director

Implementation Guidance for 32 Illinois Administrative Code 330.40(d)

May 2011



Acknowledgements

This guide was adapted from "*A Regulators' Guide to the Management of Radioactive Residuals from Drinking Water Treatment Technologies*, EPA 816-R-05-004, July 2005" (as prepared for the U.S. Environmental Protection Agency, by the Cadmus Group, Inc. under contract No. 68-C-02-069) and *ISCORS Assessment of Radioactivity in Sewage Sludge: Recommendations on Management of Radioactive Materials in Sewage Sludge and Ash at Publicly Owned Treatment Works*. ISCORS Technical Report 2004-04, February 2005. Additional incorporations are listed by reference. The contributing documents have been modified for the inclusion of 32 Illinois Administrative Code 330.40(d), "Exempt Material", and to specifically address the water and sewage treatment facilities within the State of Illinois.

Disclaimer

Please note that the statutes and regulations described in this document contain legally binding requirements. The recommendations contained in this document are not substitutes for those statutes or regulations, nor is this document a regulation. This guide is strictly voluntary and does not impose legally-binding requirements on U.S. EPA, the State of Illinois, Illinois Emergency Management Agency, Illinois Environmental Protection Agency, local or tribal governments, or members of the public, and may not apply to a particular situation based upon the circumstances. Although the Illinois Emergency Management Agency (IEMA) recommends the approaches outlined in this document, local decision makers may adopt approaches that differ from those presented in this guide provided they comply with all parts of applicable regulations. Interested parties may direct questions concerning this guide to IEMA, LLRW Section, Treatment Residuals Exemption, 1035 Outer Park Dr, Springfield IL 62704. Any IEMA decisions regarding a particular water system or waste stream will be made based on the applicable statutes and regulations. IEMA will continue to review and update this guide as appropriate.

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Acronyms

AA	Activated Alumina
AEA	Atomic Energy Act
ALARA	As Low as Reasonably Achievable
AX	Anion Exchange
BAT	Best Available Technology
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CESQG	Conditionally Exempt Small Quantity Generator
CWA	Clean Water Act
CWS	Community Water System
CX	Cation Exchange
DOT	Department of Transportation
DWB	Dry Weight Basis
FBRR	Filter Backwash Recycling Rule
HMO	Hydrous Manganese Oxide
ICRP	International Commission on Radiological Protection
IEMA	Illinois Emergency Management Agency
IEPA	Illinois Environmental Protection Agency
ISCORS	Interagency Steering Committee on Radiation Standards
IX	Ion Exchange
LLRW	Low-Level Radioactive Waste
MARLAP	Multi-Agency Radiological Laboratory Analytical Protocols Manual
MARSSIM	Multi-Agency Radiation Survey and Site Investigation Manual
MCL	Maximum Contaminant Level
MPRSA	Marine Protection, Research, and Sanctuaries Act
MSWLF	Municipal Solid Waste Landfill
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NCRP	National Council on Radiation Protection and Measurements
NPDES	National Pollutant Discharge Elimination System
NRC	Nuclear Regulatory Commission
OGWDW	Office of Ground Water and Drinking Water
OSHA	Occupational Safety and Health Administration
PFLT	Paint Filter Liquids Test
POTW	Publicly Owned Treatment Works
POU	Point of Use
PPE	Personal Protection Equipment
RCRA	Resource Conservation and Recovery Act
RO	Reverse Osmosis
SDWA	Safe Drinking Water Act
SPARRC	Spreadsheet Program to Ascertain Radionuclides Residuals Concentration
SSCT	Small System Compliance Technology
TBLL	Technically Based Local Limit
TCLP	Toxicity Characteristic Leaching Procedure
TDS	Total Dissolved Solids
TSS	Total Suspended Solids
TENORM	Technologically Enhanced Naturally Occurring Radioactive Materials
UIC	Underground Injection Control
USDW	Underground Source of Drinking Water
US EPA	United States Environmental Protection Agency
WWTP	Wastewater Treatment Plant

Definitions

Activated Carbon - A highly adsorbent form of carbon used to remove odors and toxic substances from liquid or gaseous emissions. In waste treatment, it is used to remove dissolved organic matter from waste drinking water.

Agency – When not otherwise specifically stated, 'Agency' refers to the Illinois Emergency Management Agency

Agreement State – A State that has signed an agreement with the NRC authorizing the State to regulate certain uses of radioactive materials within the State.

Aliquot - A measured portion of a sample taken for analysis. One or more aliquots make up a sample.

Analytical Result – A formal numerical estimate of the concentration of an analyte in a sample, which is obtained by carrying out once following the procedure specified in an analytical method.

Aqueous - Something made up of water.

Aquifer - An underground geological formation, or group of formations, containing water. Sources of groundwater for wells and springs.

Background Level - The concentration of a substance in the environment that occurs naturally or is not the result of human activities.

Backwashing - Reversing the flow of water back through the filter media to remove entrapped solids.

Biosolids – Sewage sludge that has been treated and stabilized as to meet land application criteria under US EPA Part 503 Biosolid regulations.

Code of Federal Regulations (CFR) - Document that codifies all rules of the executive departments and agencies of the federal government. It is divided into fifty volumes, known as titles. Title 40 of the CFR (referenced as 40 CFR) lists all environmental regulations.

Combined radium – The sum of radium-226 and radium-228 concentrations. May be used interchangeable with 'Total Radium'.

Community Water System - A public water system which serves at least 15 service connections used by year-round residents or regularly serves at least 25 year-round residents.

Concentration - The relative amount of a substance mixed with another substance. An example is five ppm of carbon monoxide in air or 1 mg/l of iron in water.

Decay Products - Degraded radioactive materials, often referred to as "daughters" or "progeny"; radon decay products of most concern from a public health standpoint are polonium-214 and polonium-218.

Detection – To have obtained experimental evidence that the analyte concentration is greater than zero.

Detection Limit (DL) – The minimum concentration of an analyte that can be identified, measured, and reported with 99% confidence that the analyte concentration is greater than zero.

Dose Rate - In exposure assessment, dose per time unit (e.g. mg/day), sometimes also called dosage.

Drinking Water Treatment Media – Filters, resins, sand, gravel, or any substrate in which raw water is moved over or through for the purpose of treatment. This definition is not to be interpreted as exhaustive, only to provide explanation for the context in which it is used in this guidance.

Duplicate Samples – Second identical sample collected from a specific location and submitted for analysis as a check on laboratory accuracy, possible sample error or method variability.

Effluent - Wastewater--treated or untreated--that flows out of a treatment plant, sewer, or industrial outfall. Generally refers to wastes discharged into surface waters.

Environment - The sum of all external conditions affecting the life, development and survival of an organism.

Environmental Laboratory Advisory Board (ELAB) – A Federal Advisory Committee, with members appointed by EPA and composed of a balance of non-state, non-federal representatives, from the environmental laboratory community, and chaired by an ELAB member.

Exceedance - Violation of the pollutant levels permitted by environmental protection standards.

Fields Currently in Use - fields which, in 2011, are being land applied with treatment residuals containing radium.

Filtration - A treatment process, under the control of qualified operators, for removing solid (particulate) matter from water by means of porous media such as sand or a man-made filter; often used to remove particles that contain pathogens.

Finished Water - Water is "finished" when it has passed through all the processes in a water treatment plant and is ready to be delivered to consumers.

Definitions (Continued)

Generator - Any person whose act or process of treating groundwater for drinking water usage or treating the resulting wastewater, concentrates radium-226 and/or radium-228 in a treatment residual. This definition is not to be interpreted as exhaustive, only to provide explanation for the context in which it is used in this guidance.

Gross Alpha/Beta Particle Activity - The total radioactivity due to alpha or beta particle emissions as inferred from measurements on a dry sample.

Ground Water - The supply of fresh water found beneath the Earth's surface, usually in aquifers, which supply wells and springs.

Ground Water Under the Direct Influence (GUI) of Surface Water - Any water beneath the surface of the ground with: 1. significant occurrence of insects or other microorganisms, algae, or large-diameter pathogens; 2. significant and relatively rapid shifts in water characteristics such as turbidity, temperature, conductivity, or pH which closely correlate to climatological or surface water conditions. Direct influence is determined for individual sources in accordance with criteria established by a state.

Half-Life - The time required for half of the atoms of a radioactive element to undergo self-transmutation or decay (half-life of radium is 1620 years).

Hazardous Waste - By-products of society that can pose a substantial or potential hazard to human health or the environment when improperly managed. Possesses at least one of four characteristics (ignitability, corrosivity, reactivity, or toxicity), or appears on special EPA lists.

Hazardous Waste Landfill - An excavated or engineered site where hazardous waste is deposited and covered.

Homogenous - Having a uniform or consistent set of characteristics throughout.

Influent - Water, wastewater, or other liquid flowing into a reservoir, basin, or treatment plant.

Ion Exchange Treatment - A common water-softening method often found on a large scale at water purification plants that remove some organics and radium by adding calcium oxide or calcium hydroxide to increase the pH to a level where the metals will precipitate out.

Lagoon - A shallow pond where sunlight, bacterial action, and oxygen work to purify wastewater.

Land Application - Discharge of wastewater or treatment residuals onto the ground for treatment or reuse.

Landfills - 1. Sanitary landfills are disposal sites for non-hazardous solid wastes spread in layers, compacted to the smallest practical volume, and covered by material applied at the end of each operating day. 2. Secure chemical landfills are disposal sites for hazardous waste, selected and designed to minimize the chance of release of hazardous substances into the environment.

Laboratory split sample or Laboratory Duplicate - The analysis performed identically on two sub-samples of the same sample, usually taken from the same container. The results from duplicate analyses are used to evaluate analytical or measurement precision and include variability associated with sub-sampling and the matrix, but not the precision of field sampling, preservation, or storage internal to the laboratory.

Low-Level Radioactive Waste - Radioactively contaminated industrial, municipal, or research waste such as paper, rags, plastic bags, or water-treatment residues. It is waste that does not meet the criteria for any of three other categories of radioactive waste: spent nuclear fuel and high-level radioactive waste; transuranic radioactive waste; or uranium mill tailings. Its categorization does not depend on the level of radioactivity it contains. With regards to 32 IAC Section 330.40(d), low-level radioactive waste includes treatment residuals containing radium whose combined radium concentration exceeds 200 pCi/g on a dry weight basis.

Maximum Contaminant Level - The maximum permissible level of a contaminant in water delivered to any user of a public system. MCLs are enforceable standards.

Method Uncertainty - Defined as the "predicted uncertainty of a result that would be measured if a method were applied to a hypothetical laboratory sample with a specified radionuclide activity or concentration.

Measurement Uncertainty or Uncertainty of Measurement - A parameter associated with the result of a measurement that characterizes the dispersion of the values that could reasonably be attributed to the measurement.

Measurand - A quantity that is being determined by measurement. When interpreting results, it is the number preceding the measurement uncertainty ($\bar{x} \pm .2$)

Method Detection Limit - The minimum concentration of a substance that can be measured and reported with 99% confidence that the analyte concentration is greater than zero and is determined from analysis of a sample in a given matrix containing the analyte.

Definitions (Continued)

National Pollutant Discharge Elimination System (NPDES) - A provision of the Clean Water Act which prohibits discharge of pollutants into waters of the United States unless a special permit is issued by EPA, a state, or, where delegated, a tribal government on an Indian reservation.

National Environmental Laboratory Accreditation Conference (NELAC) – A voluntary organization of State and Federal environmental officials and interest groups purposed primarily to establish mutually acceptable standards for accrediting environmental laboratories.

National Environmental Laboratory Accreditation Program (NELAP) – The overall National Environmental Laboratory Accreditation Program of which NELAC is a part.

pH - An expression of the intensity of the basic or acid condition of a liquid; may range from 0 to 14, where 0 is the most acid and 7 is neutral. Natural waters usually have a pH between 6.5 and 8.5.

picoCuries - A rate of radioactive decay equal to one trillionth the decay rate of the fundamental unit, the Curie. One picoCurie represents 2.2 radioactive disintegrations per minute.

Picocuries Per Gram (pCi/g) - A unit of measure for levels of radioactivity in soil or other dry solids; becquerels per cubic meter is metric equivalent.

Picocuries Per Liter (pCi/L): A unit of measure for levels of radioactivity in water or other aqueous liquids; becquerels per cubic meter is metric equivalent.

Public Water System - A system that provides piped water for human consumption to at least 15 service connections or regularly serves 25 individuals.

Publicly Owned Treatment Works (POTWs) - A waste-treatment works owned by a state, unit of local government, or Indian tribe, usually designed to treat domestic wastewaters.

Quality Control Sample (QCS) or Quality Control Check Sample – (1) A sample prepared from method analytes that are obtained from a source external to the laboratory and different from the source of calibration standards. The QCS is used to check calibration standard integrity.

Radium-226 and Radium-228 - Radium is a naturally-occurring radioactive metal formed by the decay of uranium and thorium in the environment. It occurs at low levels in virtually all rock, soil, water, plants, and animals. Radon is a decay product of radium-226. Its most common isotopes are radium-226, radium 224, and radium-228.

Radon - Radon is a naturally occurring radioactive gas found in soils, rock, and water throughout the U.S. Radon is the largest source of exposure to naturally occurring radiation.

Raw Water - Intake water prior to any treatment or use.

Receiving Waters - A river, lake, ocean, stream or other watercourse into which wastewater or treated effluent is discharged.

Reverse Osmosis - A treatment process used in water systems by adding pressure to force water through a semi-permeable membrane. Reverse osmosis removes most drinking water contaminants. Also used in wastewater treatment. Large-scale reverse osmosis plants are being developed.

Sewage - The waste and wastewater produced by residential and commercial sources and discharged into sewers. solid, semi-solid, or liquid residue generated during the treatment of domestic sewage in a treatment works. It includes, but is not limited to: domestic septage; scum or solids removed in primary, secondary, or advanced wastewater treatment processes; and material derived from sewage sludge. It does not include ash generated during the incineration of sewage sludge or grit and screenings generated during preliminary treatment of domestic sewage in a treatment works.

Sludge or Sewage Sludge - For the purposes of this guidance and Section 330.40(d): A semi-solid residue from any of a number of water treatment processes at any stage of treatment or processing. (I.e., inclusive of biosolids). Can be a hazardous waste. In accordance with IEPA Part 391 sludge regulations, IEMA has retained the terminology of “sludge” throughout this document for consistency. Sludge may be used interchangeable with biosolids throughout this document.

Superfund - The program operated under the legislative authority of CERCLA and SARA that funds and carries out EPA solid waste emergency and long-term removal and remedial activities. These activities include establishing the National Priorities List, investigating sites for inclusion on the list, determining their priority, and conducting and/or supervising cleanup and other remedial actions.

Definitions (Continued)

TENORM - Technologically-Enhanced, Naturally-Occurring Radioactive Material (TENORM) is produced when activities such as uranium mining, drinking water treatment, or sewage sludge treatment, concentrate or expose radioactive materials that occur naturally in ores, soils, water, or other natural materials. View US EPA's TENORM webpage, <http://www.epa.gov/radiation/tenorm/> for further information.

Treatment Residual – As used within the context of this implementation guidance: Spent medias, resins, slurries, sludges, or any solid or semisolid utilized at a drinking water treatment plant which has been used for the removal of contaminants or to improve water quality. This also includes sewage sludge or biosolids resulting from the treatment of waste water.

Treatment Residuals containing radium – All treatment residuals will contain at least a small amount of radium. For the purposes of this implementation guidance; A treatment residual in which the concentration of radium-226 and/or radium-228 has been technologically enhanced as a result of the treatment of ground water and/or wastewater.

Treated Wastewater - Wastewater that has been subjected to one or more physical, chemical, and biological processes to reduce its potential of being health hazard.

Treatment - As used in the context of this implementation guidance: Any method, technique, or process designed to remove solids and/or pollutants from drinking water, solid waste, waste-streams, effluents, and discharges.

Treatment Plant - A structure built to treat drinking water or wastewater.

Wastewater - The spent or used water from a home, community, farm, or industry that contains dissolved or suspended matter.

Water Table - The level of groundwater.

Section I. Introduction

The purpose of this guidance is to assist registrants in the implementation of 32 Illinois Administrative Code 330.40(d), hereafter referred to as “Section 330.40(d)”. Section 330.40(d) exempts entities possessing, generating, storing, or transporting groundwater treatment residuals with elevated levels of radium-226 and radium-228 from the licensing and reporting requirements set forth in 32 Illinois Administrative Code 330. While those entities producing these residuals as a result of the treatment of drinking water or wastewater are exempted from licensing, there are specific sampling, reporting and disposal conditions that now exist. This guidance is designed to assist municipal drinking water and wastewater plants, land applicators, Illinois Environmental Protection Agency permitted landfills, haulers of treatment residuals, and other entities in determining if they qualify for exempt status and what minimum requirements are necessary to demonstrate compliance with Section 330.40(d).

The following sections discuss the origin of radium-226 and radium-228 (naturally occurring radioactive materials) in treatment residuals and why the Section 330.40(d) exemption was promulgated. Discussion on the applicable statutes and regulations that pertain to treatment residuals and their impact on Section 330.40(d) are contained in Appendix A.

A. The Radionuclides Rule

The revised Radionuclides Rule, 40 CFR 141, became effective on December 8, 2003. U.S. Environmental Protection Agency’s revisions to the Rule provided standards intended to ensure that all customers served by community water systems (CWSs) receive water that meets the Maximum Contaminant Levels (MCL) for radionuclides in drinking water. Regulated radionuclides include radium-226, radium-228, gross alpha particle activity, uranium, and beta particle and photon radioactivity. According to the Rule, CWSs in Illinois should have completed initial compliance monitoring by December 8, 2007.

While most systems were in compliance with the revised Rule; some systems, primarily those located in the northern third of the state, had elevated levels of naturally occurring radionuclides and were required to install new or upgrade existing treatment systems or technologies to meet these revised standards. The treatment processes necessary to remove radium from the drinking water produced residuals containing elevated concentrations of those regulated radionuclides. This phenomenon is commonly associated with sewage sludge. However, communities should also be aware that in the process of treating drinking water, the radionuclides will also accumulate in the drinking water treatment media (spent resins, spent filter media, spent membranes, and lime sludge) – often at much higher concentrations than that found in the wastewater treatment plant (WWTP) sludge itself.

B. 32 Illinois Administrative Code 330

The Division of Nuclear Safety, within the Illinois Emergency Management Agency (IEMA), is mandated to protect Illinois residents from the potentially harmful effects of ionizing radiation. The protection of both public health and the environment from the accumulation and uncontrolled release of radioactive materials is addressed, in part, through 32 Illinois Administrative Code 330 by requiring registration/licensure of radioactive materials. Hereafter, 32 Illinois Administrative Code 330 will be referred to simply as “Part 330”. Note this is the larger set of regulations of which Section 330.40(d) is a subsection.

Treating water or sewage containing naturally occurring radionuclides increases the radionuclide concentrations in the residual streams. These residual streams are called Technologically Enhanced Naturally Occurring Radioactive Materials (TENORM): naturally occurring materials whose radionuclide concentrations or potential for exposure to humans or the environment are enhanced as a result of human activities. When radium-226 and radium-228 are concentrated and, consequently, TENORM is produced under the circumstances above, it falls under the scope of oversight and regulation of Part 330. In the absence of the Section 330.40(d) exemption, there is no quantity or concentration of radium-226 or radium-228 that is excluded from regulation and ultimately, licensure.

C. 32 Illinois Administrative Code 330.40(d) – Exempt Material

Section 330.40(d) provides exemption criteria for those entities possessing, generating, storing, or transporting treatment residuals with technologically enhanced radium-226 and radium-228. Residuals produced through the treatment of drinking water or wastewater that contain less than or equal to 200 picocuries/gram (dry weight basis or “DWB”) are exempt from the licensing requirements otherwise imposed by Part 330. Section 330.40(d) specifies conditions for disposal, transport, sampling, and reporting of these treatment residuals that must be followed in order to demonstrate compliance and remain an exempt entity. In addition to serving as regulatory relief from licensure, Section 330.40(d) is also designed to prevent the accumulation of radium-226 and radium-228 in the environment to levels that could cause worker exposure issues and/or potentially impact the future use of contaminated properties or land application sites. As such, Section 330.40(d) details specific requirements on the disposal of treatment residuals containing combined radium (the sum of radium-226 and radium-228). The remainder of this guidance is dedicated to assisting the regulated community in reaching compliance with the provisions of this section. If persons are producing or in possession of treatment residuals or sludge resulting from the treatment of water or sewage containing radium-226 and radium-228 in excess of 200 pCi/g (dry weight basis), they are not exempt and must comply with the requirements in Part 330. Unless explicitly stated otherwise, all activity concentration values described herein are in picocuries per gram (pCi/g) and are on a DWB.

D. Applicable Statutes and Regulations

Several regulating authorities have statutory responsibility regarding the disposal of treatment residuals as they pertain to contaminant levels, site runoff, groundwater contamination, vector attraction, setbacks, and waste classification. Treated water pH, total dissolved solids (TDS), total suspended solids (TSS), and heavy metal concentrations in the waste stream can also limit disposal options. Analogous to the metals loadings and restrictions placed on land application by the IEPA and the USEPA, IEMA has a regulatory requirement to track and limit the amount of combined radium accumulated in the environment.

This guidance explains a uniform approach to disposal of treatment residuals containing radium that will meet all applicable Federal and State regulations. The descriptions of the statutes and regulations in Appendix A are a paraphrased summary of specific portions of those rules as they pertain to Section 330.40(d). The guidance does not address each statute/regulation in its entirety and encourages the regulated community to pursue additional information. *(The interpretation of the following by IEMA for the purposes of this guidance does not preclude the responsible regulating authority from implementation in a manner contrary to this interpretation).* The regulations discussed in this guide set the minimum standards by which systems must operate. WWTPs (by virtue of pretreatment standards) and municipalities have the authority to set more stringent standards. Local treatment and landfill disposal requirements may be stricter and significantly more complex than those presented in this guide. Persons producing or possessing treatment residuals containing radium are reminded to check with IEPA, IEMA, and receiving WWTPs before proceeding with treatment installation or modification and waste disposal processes to ensure they are meeting all relevant Federal, State, and local requirements.

Section II. Registration

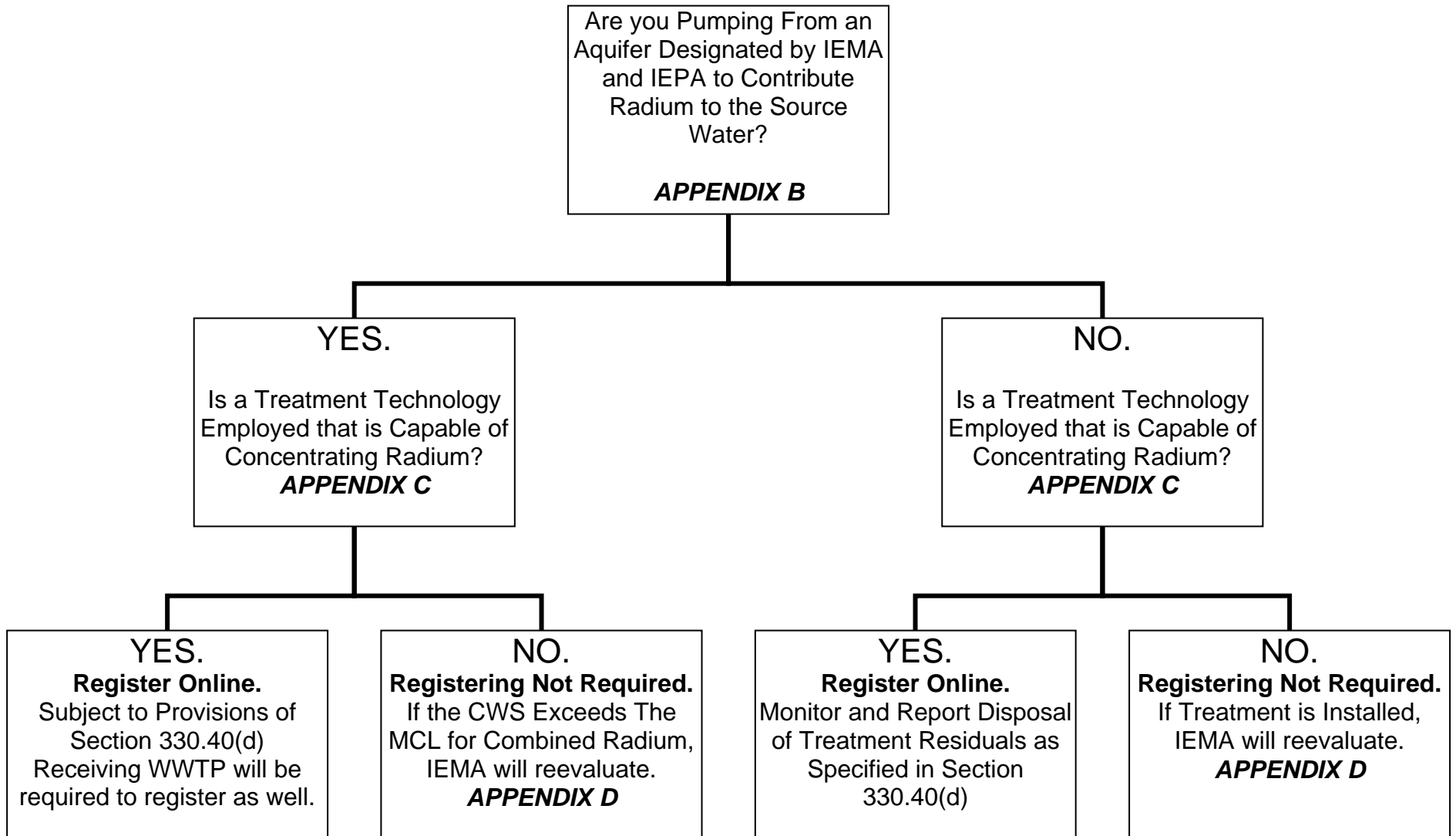
In order for a generator, applicator, or recipient of treatment residuals containing radium to be exempt from the licensing and reporting requirements of Part 330, they must register directly with IEMA as specified in Section 330.40(d)(2). Specifically, [those]...”producing or in possession of residuals or sludge resulting from the treatment of water and sewage and containing naturally occurring radium from groundwater with concentrations of combined radium less than or equal to 200 pCi per gram (dry weight basis) must register directly with the Agency.” There is no fee associated with registration under Section 330.40(d).

A. Do I Need to Register?

The flow chart below is provided to assist drinking water treatment facilities, or CWSs, in determining if they are subject to the provisions of Section 330.40(d). Once a CWS has determined their need to register, those “downstream” from the resulting waste stream or those who receive and handle treatment residuals (WWTPs, land applicators, and landfills) can determine their need to register as well. Additional information on each branch of the flow chart is available in the referenced Appendix.

A. Do I Need to Register? (continued)

1. Drinking Water Treatment Facilities (CWS)



Refer to the Appendix listed in each box for assistance in making this determination or for more information.

A. Do I Need to Register? (continued)

2. Wastewater Treatment Plant (WWTP)

If a wastewater treatment facility receives a waste stream from a CWS designated in Table 1 (above) as “Drawing From An Aquifer Designated By IEMA and IEPA to Contribute Radium to the Source Water” and “Employs A Treatment Technology Capable Of Concentrating Radium”, the wastewater facility must register with IEMA and is subject to the provisions of Section 330.40(d). The flow chart and resulting generators identified are a guideline only; and IEMA may require additional generators to register or may relax registration requirements based on site-specific conditions.

3. Land Applicators of Treatment Residuals

Land Applicators who apply treatment residuals containing radium (resulting from the treatment of water or sewage containing radium) to agricultural lands are required to register with IEMA and are subject to the provisions of Section 330.40(d). Generally speaking, if the treatment residuals being land applied are sourced from a generator identified above as being required to register – the land applicator is also required to register.

4. IEPA Permitted Landfills

Owners and operators of IEPA permitted landfills that receive residuals or sludge resulting from the treatment of water or sewage and containing radium occurring naturally from groundwater must register with IEMA. Generally speaking, if the landfill accepts treatment residuals from a generator identified above as being required to register – the landfill is also required to register.

5. Others

Additional persons may be required to register and comply with the provisions of Section 330.40(d) should it be determined that they produce or are in possession of residuals or sludges resulting from the treatment of water or sewage and containing radium occurring naturally from groundwater.

B. How Do I Register?

IEMA will mail a notification letter to persons it has identified as subject to the provisions of Section 330.40(d). A response, which constitutes registration, is requested either in writing or, preferably, online. (*Web address is provided in the notification letter and on the IEMA, Bureau of Environmental Safety website.*) Failure to receive a notification letter from IEMA does not relieve persons regulated under Section 330.40(d) from the registration requirements. Alternatively, the information identified in the following sections can be mailed to:

Illinois Emergency Management Agency
Attn: Treatment Residual Exemption Registration
1035 Outer Park Dr.
Springfield, IL 62704

An example copy of the notification letter, sent to those persons regulated under Section 330.40(d) is attached to this guidance as Addendum 2. A letter sent to community water supplies is attached. WWTP, land applicators, and landfills have similar language and are available upon request.

1. Drinking Water Treatment Facilities (CWS)

IEMA will mail notification letters to community water supplies it has identified as subject to the provisions of Section 330.40(d) (see Appendix B and C). A response is requested either in writing or, preferably, online. Community water supplies are asked to confirm, as applicable, treatment technology and the wastewater treatment plant(s) receiving a waste stream. A response containing the information specified below, either in writing or online, constitutes registration. Failure to receive a notification letter from IEMA does not relieve community water supplies regulated under Section 330.40(d) from the registration requirements. The minimum information required is specified below:

- IEPA facility identification number (example, IL2000050)
- Name and phone number of the owner and principle operator
- Mailing address and contact phone number of the facility
- Type of system, treatment technology, and anticipated media type (sludge, spent resins, etc.)
- WWTP (IEPA Permit ID #) receiving the resulting waste stream (if any)

2. Wastewater Treatment Plants (WWTP)

IEMA will utilize the survey information collected from community water supplies to determine the wastewater treatment plants required to register. Notification letters will be mailed to the facilities identified. A response containing the specified information below, either written or online, will constitute registration. Failure to receive a notification letter from IEMA does not relieve wastewater treatment facilities regulated under Section 330.40(d) from the registration requirements. The minimum information required is specified below:

- IEPA NPDES or Sludge permit number (as applicable)
- Name and phone number of the Owner and Principle Operator
- Mailing Address and contact phone number of the facility
- Type of system, treatment technology, and anticipated media type (sludge, spent resins, etc.)

3. Land Applicators

IEMA will mail notification letters to IEPA permitted land applicators. A response is requested either in writing or, preferably, online. A response containing the specified information below, either in writing or online, constitutes registration. Failure to receive a notification letter from IEMA does not relieve land applicators regulated under Section 330.40(d) from the registration requirements. The minimum information required is specified below:

- IEPA Permit Number
- Name and contact phone number for the Owner and/or Principle Operators
- Mailing address and contact phone number of the facility
- Types of treatment residuals applied

4. IEPA Permitted Landfills

IEMA will mail notification letters to IEPA permitted landfills. A response containing the specified information below, either in writing or online, constitutes registration. Failure to receive a notification letter from IEMA does not relieve landfill facilities regulated under

Section 330.40(d) from the registration requirements. The minimum information required is specified below:

- Name of the Owner and/or Principle Operator
- IEPA, Bureau of Land Ten Digit Inventory Identification Number
- Landfill classification
- Address, contact phone number
- Anticipated treatment residuals encountered

5. Other

Should IEMA identify any other person or entity that the Agency determines is required to register under the provisions of the Radiation Protection Act, a notification letter will be mailed. A response containing the specified information below, either in writing or online, constitutes registration. Failure to receive a notification letter from IEMA does not relieve persons regulated under Section 330.40(d) from the registration requirements. The minimum information required is specified below:

- Name and contact phone number for the Owner and/or Principle Operators
- Mailing address and contact phone number of the facility
- Types of treatment residuals involved
- Description of involvement.

Section III. Samples

The combined radium (the sum of radium-226 and radium-228) concentration of the treatment residuals dictates not only disposal options, but exemption status as well. Producing treatment residuals with a concentration of greater than 200 pCi/g (DWB) combined radium will require management and disposal as low-level radioactive waste (LLRW). Additionally, the generator will be required to comply with the licensing requirements set forth in Part 330. Therefore, it benefits generators to sample their treatment residuals often in order to know disposal options and to verify they are not loading the treatment residuals beyond 200 pCi/g (DWB). Frequent sampling will allow the implementation of changes to operations, land application or media exchange (as applicable), prior to reaching a concentration that would mandate a more expensive disposal option. Therefore, after registering with IEMA, WWTPs and CWSs producing treatment residuals or spent media with radium should perform analyses to determine their radium concentration.

Fields that will receive land applications of treatment residuals containing radium must be sampled to determine the initial radium concentration of the soil. Persons that are currently applying treatment residuals containing radium to land in 2011 must sample the receiving fields by **June 1, 2011**. Fields not sampled in 2011, must be sampled prior to receiving land application of treatment residuals containing radium.

The following sections discuss the methods of sampling, acceptable methods of analysis, and reporting data to IEMA. If you plan to land apply treatment residuals containing radium-226 and radium-228, field sampling will be a necessary component. Section III.A.2 addresses the proper method to sample fields to both determine background and check compliance with cumulative radium loading.

Users that wish to land apply treatment residuals containing radium should make additional considerations when sampling fields. Section 330.40(d) specifies criteria for a receiving field. A user should sample for these parameters as well (acquire clay content via soil survey):

- pH. Fields must have a pH greater than 6.0 to receive land applications under Section 330.40(d).
- Clay Content. Fields must have a layer of soil with a clay content of at least 18% within the first five feet of a soil profile. This layer must be above the local water table and bedrock. The user may elect to sample soil profiles; however, IEMA will accept data published in the county soil survey or acceptable equivalent.
- Organic Matter. Fields must have a layer of soil containing at least 12 tons/acre of organic matter (roughly 1.2% depending on soil density). This layer must be within the top five feet of the soil profile and lie above the local water table and bedrock.

Therefore, soil samples (if not already combined with sampling for agronomic need) should be analyzed for pH and the content of organic matter.

A. Sampling

The following section discusses the minimum necessary requirements to collect and submit samples for radium-226 and radium-228 analysis. Individual laboratory requirements and sample collection procedures may vary and may warrant additional considerations.

For the purposes of all analytical testing performed to determine radium-226 and radium-228 concentrations required under Section 330.40(d); analysis must be performed under an approved method in Section III (B) of this guidance by a laboratory certified by the USEPA or the National Environmental Laboratory Accreditation Conference (NELAC) to perform radiological analysis. The American Association of Laboratory Accreditation (A2LA) is a long-standing nationally recognized laboratory accreditation program equivalent to the NELAC Institute. Both are recognized by USEPA as environmental laboratory accreditation programs and require conformance to ISO/IEC 17025, General requirements for the competence of testing and calibration laboratories. A2LA accreditation will be given equal consideration when reviewed by IEMA. The laboratory contracted to perform analyses should be contacted in advance to determine sample turn-around times, minimum sample size, sample preparation, and storage requirements.

1. Sampling Procedures for Treatment Residuals containing Radium

When to Sample Treatment Residuals

A generator must know the concentration of radium-226 and radium-228 in the treatment residual(s) prior to disposal. With regards to wastewater treatment facilities, ideally, the dried and dewatered 'cake', or the liquid treatment residual would be collected and analyzed immediately prior to land application or disposal. IEMA is aware of process and lab turn-around limitations that may make this impractical (reference Section IIIB). In lieu of sampling the actual treatment residuals immediately preceding disposal, a facility may elect to composite samples over a predetermined and consistent period of time (and number of contributing sources) that represent the contents of the treatment residuals that will be disposed. In general, sampling frequency and sample quantity taken as discrete samples for inclusion in a composite for analysis; in compliance with 40 CFR 503 or 35 Illinois Administrative Code 391.502, albeit for determination of radium concentration, will meet Section 330.40(d) requirements while ensuring representative samples of treatment residuals.

Section 330.40(d) does not specify the frequency of discrete treatment residual sampling (*samples used to constitute a composite*) and leaves this flexibility to the operator(s) in an effort to avoid unnecessary testing costs and allowing operational changes to avoid over-

concentrating the treatment residuals with radium. This is due, in part, to the diversity of wastewater treatment plants and the frequency at which they accumulate residuals. Operational procedures and frequency of sludge disposal will further dictate different sampling strategies. Discrete samples should be taken over a long enough period of time to represent all operational characteristics that would manifest a change in radium concentrations in the treatment residuals (backwashes, chemical additions, rain influxes, etc.).

Once a representative composite is accumulated, the sample may be submitted for a single analysis. The following section describes the method prescribed by IEPA to obtain sludge samples and details the compositing rules for metals that may be adopted for use in compositing for radium analysis.

A comprehensive guidance on sludge sampling is available as 'POTW Sludge Sampling and Analysis Guidance Document'. US EPA 833-B-89-100, August 1989. For additional information on sampling biosolids or sludge, consult Chapter 6 of the USEPA Guide to the Part 503 Rule available at:

http://water.epa.gov/scitech/wastetech/biosolids/503pe_index.cfm.

Treatment Residual and Sludge Sampling Methods

Sampling of sludge or treatment residuals should be conducted in a manner to ensure the sample is representative of the material to be land applied or disposed.

Regarding the actual physical methods for retrieving a sludge sample, IEMA recommends procedures established in IEPA 35 Illinois Administrative Code 391.502 as outlined, in part, below (parenthetical inserts were added for application to radium-226 and radium-228 analysis). Long-term composites are acceptable for radium-226 and radium-228 analysis.

“Collect samples during dry periods, and not sooner than 48 hours after the last precipitation. Do not collect samples during freezing periods or sooner than 48 hours after a thaw. Collect samples as follows:

a) Dried sludge: Collect 100 grams of dried material or a core sample (whichever is greater) from each of 6 locations which include the perimeter and inner portions of the drying bed or lagoon, then composite these samples. For mechanical dewatering facilities, collect 100 grams, 6-8 times at hourly intervals during a normal day's operating period and composite these samples.

b) Liquid sludge outside digester: At each of 6 locations equally spaced along the perimeter of the storage area collect a core sample representing the top, middle, and bottom. Composite the 6 samples [as instructed by the laboratory performing the radium analysis].” (If splitting the sample between laboratories, with the intent of analyzing for several contaminants, consult the laboratories. Adjustments may be necessary in sample volume and preservation.)

c) Digester Contents: If analyses are required on a quarterly or more frequent interval [*due to disposal of treatment residuals*], samples...are to be collected weekly and composited. If analyses are required on a semi-annual interval, three two-month composites are required each 6 months. If analyses are required on an annual interval, three two-month composites are required; the first composite must be collected in the first 6 month interval. One quart of each composited sample, [preserved as

indicated by the laboratory performing radium analysis], shall be collected for the analyses.”

If sludge samples are being analyzed for additional parameters, the analytical procedures specific to those parameters may require additional handling and collection procedures. If collecting samples for multiple analyses, the user should consult the specific regulations (35 Illinois Administrative Code 391 or 40 CFR 503) for additional sample handling instructions.

Drinking water treatment media can be difficult to sample given the closed-system nature of many treatment technologies. Refer to Section V for methods to model and predict radium loading on media, which may assist CWSs in determining when a media exchange is appropriate. If spent media is removed from a CWS that has radium in the raw water and utilizes a treatment technology capable of concentrating radium, testing of the media is required prior to disposal. Allow the media to dry and collect a sample as per 35 Illinois Administrative Code 391.502(a). If a particular media proves inaccessible or a sampling method is not readily available, contact IEMA and a representative may be available to assist on site.

2. Sampling Procedures for Fields

When to Sample Fields

Section 330.40(d) specifies that a field must be sampled to determine the concentration of combined radium (radium-226 and radium-228) at three specific timeframes:

- Fields that are currently being land applied treatment residuals containing radium (land applications in 2011) must be sampled and tested to determine the soil concentration of combined radium by June 1, 2011. The sample results are then submitted to IEMA. Fields that exceed 3.0 pCi/g (DWB) combined radium concentration are no longer to be used for the land application of treatment residuals or sewage containing radium.
- Prior to using a parcel of land for the application of treatment residuals containing radium, the user must determine the combined radium concentration in the soil (background).
- Once the calculated cumulative loading of the field is determined by IEMA to have been increased by 0.8 pCi/g (DWB) or that the soil has a concentration of 2.8 pCi/g (DWB); the user must sample the field to determine the soil concentration of combined radium in order to continue use of the field.

In contrast to 35 Illinois Administrative Code 391.430(a), despite the length of the land application project, analysis of radium in the receiving field and the treatment residual is required.

Background Soil Sampling Methods

Background soil sampling is performed using the soil sampling protocols outlined below:

- The tools utilized for collecting soil subsamples (spade, auger, soil probe, etc) are acceptable as described by the 24th edition of the Illinois Agronomy Handbook. However, the use of a soil probe rather than a spade or auger in the collection of subsamples is encouraged due to the fact the variability in subsample size is eliminated – consequently, reducing bias in sample results.

- Although not required in Section 330.40(d), IEMA recommends quality control samples taken at the rate of one extra sample for each ten collected. This provides an indicator of the variation in lab sample analyses and the overall quality of the data collected. Quality control samples are obtained as follows: once the discrete sub-samples have been collected and composited, an aliquot is drawn and packaged for transport to the laboratory. To obtain a quality control sample, a second aliquot is taken from the composited soil and similarly packaged for the lab. Two laboratory analyses are performed on the same composited soil.
- IEMA has adopted the soil sampling protocols stated in 35 Illinois Administrative Code 391.510(a) as of February 28, 2011, as an acceptable method for the collection of soil samples from the plow zone. Soil sample collection shall be conducted so as to be representative of the entire sludge application site. One soil sample shall be collected per 8 acres of sludge application site area to a depth of 12 inches. Each soil sample shall be taken as a homogeneous mixture composed of at least 10 subsamples randomly collected within the 8 acre area. *I.e., A 40 acre field would have 5 composite samples. Each of the five samples is a composite of 10 subsamples.*

Alternatively, the user may elect to sample fields in accordance with the 24th edition of the Illinois Agronomy Handbook, pages 92 & 93 provided sampling depth is increased to 12":

- *Whole-field uniform fertilizer applications.* For this approach, sampling at the rate of one composite from each 2 ½ acre area is allowed.
- *Site specific applications for fields where large variations in test values over a short distance are suspected.* This approach submits a sample for analysis for each 1.1 acre area.
- *Zones with common characteristics.* Should the user wish to establish sampling zones with common characteristics, the contributing data characteristics should be submitted to IEMA to support the sampling strategy. Compliance with Section 330.40(d) necessitates sampling zones not exceed 8 acres.
- *Conservation tillage fields with fertilizer band applications.* This approach compensates for fields in which fertilizer is applied directly to crop rows in order to avoid sampling directly in a fertilizer band. Should the user utilize this method of sampling, it should be noted in the submitted sample results and no less than one composite collected per 8 acres.

Any of the above sampling processes will yield multiple composite samples per field (ranging from 1 composite sample per 8 acres, to 1 composite sample per 1.1 acres). If the field sampled is under a single ownership, is continuous, and if the crop and past management history indicate a 'zone with common characteristics' as specified in the 24th edition of the Illinois Agronomy Handbook, then IEMA will allow the multiple composites from each field to be combined and a single analysis performed for radium concentration. This combination of composite samples is only allowed for background determinations and NOT for the determination of incremental increases in radium concentration. For the determination of incremental increases in radium concentration (sampling at 80% of the limits), all composite samples collected per field are to be analyzed for radium content and a field average established. Given the likelihood of multiple generators contributing to a single field, the variability of other soil characteristics as they impact radium accumulation, and the inability to accurately track the radium concentration uniformly applied to all portions of a field, sampling to determine incremental increases (sampling at 80% of the limits) cannot be performed with a single analysis.

Sampling for Compliance

When the incremental increase of the radium concentration in the soil is determined by calculation to be 0.8 pCi/g or when the combined radium in soil is calculated to be 2.8 pCi/g (based on initial background testing and subsequent applications of residuals or sludge containing radium), the user must repeat the soil sampling and analysis to determine the actual combined radium concentration in the soil and report the findings to IEMA. The site life remaining, if any, will be determined by the analytical results received from proper sampling. Treatment residuals containing radium may not be applied to that piece of land until the confirmatory soil tests are performed. Should the user decline to perform confirmatory soil testing, the field may no longer be used for land applications of treatment residuals containing radium. For the purposes of confirmatory testing, the sampling methods outlined for background determinations (35 Illinois Administrative Code 391.510(a) or 24th Edition of the Illinois Agronomy Handbook) are to be used. IEMA will not consider fields that have received land applications of treatment residuals containing radium a 'zone with common characteristics'. Specifically, the composites collected from the soil sampling protocols above may not be combined for a single analysis. The composite samples must be individually analyzed to determine if 'hot spots' have developed in the field due to inconsistencies in land application rate, concentration, or soil characteristics.

3. Sample Preservation and Transport

"Liquid" Sludge Sample Preservation and Storage

Contact the laboratory performing the analysis as sample preservation or acidification may be necessary. In addition to sample preservation, other sampling requirements may be specified by the laboratory such as the type of container, the storage temperature, and the storage period⁵. *For example, some glass containers may contain NORM and can contribute to the overall radioactivity of the sample when preserved with acid.* Low storage temperatures may be mandated when biological activity stands to alter the chemical species of the radionuclides.⁵

Soil Sample Preservation and Storage

Consult the laboratory contracted for radio-analysis for specific soil sample preservation and storage requirements. The considerations given below are guidelines only and are not a requirement for sample collection under Section 330.40(d). Additional, detailed information on sample preservation and transport is available from the referenced document or the analytical laboratory selected by the generator.

"Generally, there are no specific requirements for sample preservation for soil samples. However, two items should be considered before the start of any project. The first is to minimize the amount of air space that is in the sample container. This will minimize the potential for volatilization / oxidation of certain species. The second is to reduce the sample temperature to 4 degrees Celsius as soon as possible to minimize any biological activity participating in elemental oxidation-reduction."⁵

B. Approved Sample Analysis Methods

Section 330.40(d) specifies that treatment residuals and soils must be analyzed for radium-226 and radium-228 in accordance with testing procedures approved by IEMA. Appendix E details the

specific methods afforded municipalities by 35 Illinois Administrative Code 391 and Section 330.40(d) as well as suggesting additional methods that may be applicable. Detailed discussions on method uncertainties, detection limits, minimum detectable concentrations, as well as sample preservation and methods, can be obtained in 'Inventory of Radiological Methodologies For Sites Contaminated With Radioactive Materials'⁵ Should the soil or treatment residuals collected be analyzed for additional contaminants, nutrients, or characteristics (i.e., a "split" sample); the analytical methods for parameters other than radium should be chosen in accordance with 35 Illinois Administrative Code 391.511 or as otherwise directed by the IEPA.

C. Reporting Results to IEMA

35 Illinois Administrative Code 391 and 40 CFR 503 both contain reporting requirements for the land application of sludges. Individual operating permits may contain reporting requirements in addition to these regulations. Section 330.40(d) requires persons producing or in possession of treatment residuals containing radium, that wish to be exempt from the licensing provisions of Part 330, to report specific information regarding the analysis and disposition of those treatment residuals. These requirements pertain to both landfill disposal and land application. Efforts have been made to consolidate reporting requirements and eliminate duplicate testing and reporting for compliance with multiple regulating authorities. In many cases, the information required by IEMA and IEPA will be the same (Schedule G for the IEPA may fulfill many of the Section 330.40(d) requirements if accompanied by radium analyses). In which case, copies of a single report furnished to both agencies is sufficient. A simplified, online, annual report is in development and is not yet available. Upon availability of web-based reporting, IEMA will notify the regulated community.

Until such time that consolidated reporting is available, generators and applicators of treatment residuals containing radium are required to report analytical test results, concentrations, quantities and disposition of sludges. Reporting requirements specific to each group and the frequency of reporting is detailed in the following sections. For the purposes of all analytical testing, performed to determine radium-226 and radium-228 concentrations, required under Section 330.40(d); analysis must be performed under an approved method in Section III(B) of this guidance and by a laboratory certified by the USEPA or the National Environmental Laboratory Accreditation Conference (NELAC) to perform radiological analysis.

All test results and reports submitted in accordance with Section 330.40(d), should be sent to:

Illinois Emergency Management Agency
Attn: Treatment Residuals Exemption
1035 Outer Park Dr.
Springfield, IL 62704

Alternatively, when available, data may be electronically transferred to IEMA under arrangements made via telephone. (i.e., call for an email address, fax number, or available web-based data entry system). Registrants may direct phone inquiries to (217) 782-1326.

Reporting Units

Laboratory analyses are reported on either a wet weight ("as-received") basis or on a dry weight basis. Radium-226 and radium-228 are expressed in units of activity, commonly picocuries. (*Curies, Ci, are the actual unit and the pico- prefix gives an appropriate whole number for measurements at or near environmentally encountered levels.*) At environmental levels, the units for a wet weight basis are, typically, picocuries per liter (pCi/L - activity per volume). The units for a dry weight basis are picocuries per gram of solids (picocuries/gram – pCi/g). "Sludge represents a material in which most of the solid matter is undissolved and the dissolved fraction is of minor importance."²⁰ Requirements for Section 330.40(d) are based upon dry weight basis. Therefore, 'wet weight' results must ultimately be expressed in dry weight units to be accepted.

All the sample calculations are worked on a dry weight basis. However, since laboratories may report results on a wet weight basis, conversion relationships are provided below and in 35 Illinois Administrative Code 391.Appendix D. Be aware that some laboratories report results on an "as-received" basis. Registrants should consult the laboratory to confirm, convert the units to a dry weight basis, and report combined radium (radium-226 and radium-228) in units of pCi/g. In accordance with 35 Illinois Administrative Code 391, IEMA allows the assumption that the specific gravity of liquid and most dry sludges to be 1.0 (equal to water).

- A) The decimal equivalent (DE) of the percent Total Solids (TS) equals the percentage divided by 100.

$$\frac{\% \text{ TS}}{100} = \text{DE of Total Solids}$$

$$\text{Example: } \frac{5\% \text{ TS}}{100} = 0.05 \text{ DE}$$

- B) Wet Weight to Dry Weight Basis

$$\frac{\text{pCi/L}}{\text{DE}} = \text{pCi/g (dry weight basis)}$$

$$\text{Example: } \frac{0.88 \text{ pCi/L Ra}^{226} + 0.07 \text{ pCi/L Ra}^{228}}{.05 \text{ DE}} = 19 \text{ pCi/g combined radium (DWB)}$$

D. Interpretation of Results

Radium-226 and radium-228 concentrations are reported as a numerical result (i.e., the measurand: 2 pCi/g) and an estimate of the associated measurement uncertainty (example: +/- 0.2). If the analytical method used has been approved by IEMA as having a proper method uncertainty at a specific radionuclide concentration and an appropriate minimum detectable activity, then the measurand (2 pCi/g in this example) is solely used for compliance determinations, i.e., the measurement uncertainty (+/- 0.2) is neither added nor subtracted from the measurand. If multiple results are submitted, as is the case for determining a field's background or cumulative radium concentration, the mathematical average of all reported measurands will be utilized for compliance.

Section IV. Use or Disposal of Treatment Residuals containing Radium

The concentration of radionuclides in the waste stream, the type of waste produced, concentration of other contaminants, and federal and state regulations are among the factors that dictate which disposal options are available to a system. Forgoing a classification as hazardous or mixed waste under RCRA, Section 330.40(d) authorizes the landfill disposal, land application, and low level radioactive waste disposal given concentrations beneath 200 pCi/g (DWB) combined radium. Each of these disposal options are addressed individually in this section accompanied by the maximum allowable radium concentration and method-specific requirements.

Additional discussions, intended as guidance on disposal options for systems that have elevated levels of radium-226 and radium-228 in their treatment residuals, are available in A System's Guide to the Management of Radioactive Residuals from Drinking Water Treatment Technologies, USEPA. August 2006. and A Regulators' Guide to the Management of Radioactive Residuals from Drinking Water Treatment Technologies (EPA 816-R-05-004, July 2005).

A. Landfill Disposal

Treatment residuals containing concentrations of combined radium at and below 100 pCi/g (DWB), may be disposed of in municipal solid waste landfills according to the provisions contained in Section 330.40(d). Treatment residuals with concentrations of combined radium above 100 pCi/g (DWB) and at or below 200 pCi/g (DWB), require IEMA evaluation of the treatment residuals prior to placement in a landfill to ensure additional measures are not necessary to protect worker health or environmental impact.

Generators of treatment residuals should also be aware that landfill owners can refuse to accept any waste and have the discretion to return any waste to the generator. As landfills become more aware of issues surrounding disposal of radioactive materials, many are now using monitors to scan incoming trucks for radiation. In some cases, wastes that had previously been accepted were found to contain elevated levels of TENORM. If the monitors are triggered, the source must be identified and evaluated.

The following provisions are the minimum necessary, in addition to any other State or Federal requirement, in order to dispose of treatment residuals containing radium in a landfill in accordance with Section 330.40(d):

1. Testing for free liquids

Generators must ensure that the treatment residuals they are disposing of meet IEPA disposal requirements. Systems must perform the Paint Filter Liquids Test (or PFLT; EPA SW 846 Method 9095) to determine if the waste contains any “free liquids” because solid waste landfills cannot accept waste that contains free liquids. If free liquids are present, the system will need to employ an intermediate processing method and determine an appropriate method of disposal for the liquid residuals generated by dewatering.

2. Identify the appropriate landfill

If RCRA contaminants are found in concentrations that dictate hazardous waste disposal, contact the Illinois EPA for further instruction. If the concentration of treatment residuals exceed 200 pCi/g, disposal may be necessary at a low level radioactive waste facility. Contact IEMA for further instruction. (*Information on low level radioactive waste facilities is contained in Section IV.C*)

- **Solid waste landfills**

Municipal solid waste landfills may have restrictions on the amount of radioactivity they accept. Their ability to accept specific wastes should therefore be verified. These landfills may accept non-hazardous, solid, and TENORM wastes from all water systems, and hazardous waste from Conditionally Exempt Small Quantity Generators (see the MSWLF requirements at 40 CFR 258). Industrial solid waste landfills may also accept non-hazardous solid TENORM waste, and may be better equipped to handle such waste as it is more like the waste that industrial landfills typically handle (e.g., sludges and ash). A list of municipal solid waste landfills (for non-hazardous waste) can be found at <http://www.epa.state.il.us/land/landfill-capacity/index.html>.

- **Hazardous waste landfills**

Systems using treatment technologies that remove contaminants such as arsenic, in addition to radionuclides, could potentially generate hazardous waste. Hazardous waste from Large and Small Quantity Generators must meet RCRA Land Disposal Restriction treatment standards (40 CFR 268.40) prior to disposal in a hazardous waste landfill. Facilities permitted under Subtitle C may accept

hazardous waste (though not mixed waste) from all generator classes, and vary in their ability to accept treatment residuals containing radium. If hazardous residuals contain source material above 0.05% in weight or other AEA materials they must be disposed of at a facility authorized to accept mixed waste.

3. Covered Transport

Treatment residuals must be covered during transport to a landfill. This prohibits contaminated material from becoming airborne.

4. Stabilization in Landfills

Treatment residuals that are easily dispersed or wind blown must be packaged or stabilized to prevent dispersion during transportation and / or landfill placement. This may be as simple as covering the transport as specified above or placement in a sack for disposal. Typically, the higher moisture content of sludge will negate the need for additional controls on transport and storage. These controls become more necessary if the concentration of treatment residuals exceeds 100 pCi/g.

5. Landfill Overburden

Landfill operators must place at least ten feet of non-contaminated overburden between the treatment residuals or sludge and grade level at the time of landfill closure. "Closure" is not meant to imply time outside the business hours of operation for landfill employees, but the point in time at which a particular IEPA permitted site no longer accepts waste and is deemed to be at capacity.

6. Annual Reporting

On an annual basis (or more frequently if agreed upon by IEMA and the regulated persons) each person who disposes of water treatment residuals or sewage treatment sludge containing radium in a landfill must report to IEMA:

:

- The total quantity of treatment residuals disposed of in landfills since the last report. (gallons or tons as appropriate)
- The concentration of treatment residuals disposed, on a dry weight basis in picocuries per gram (pCi/g).
- Date of disposal(s).
- Name, location, and IEPA Bureau of Land Ten Digit ID for the landfill at which the treatment residuals were disposed.
- Other information requested by IEMA to determine compliance with Section 330.40(d).

Generators or haulers of treatment residuals containing radium may find that the information required above, is similar to that requested for IEPA requirements. Therefore, compliance may be met with IEPA Section 330.40(d) by submitting a copy of reports generated for IEPA (*provided they contain the information above as well*), to both agencies.

7. Disposal Requiring IEMA Review

Landfill disposal of treatment residuals with concentrations greater than 100 pCi/g and less than or equal to 200 pCi/g, require IEMA review prior to disposal. A generator may elect to have the residuals disposed of at a low level radioactive waste facility; however, they are then subject to the registration requirements specified in Section 4 and the fees specified in Section 13 of the Illinois Low Level Radioactive Waste Management Act [420

ILCS 20/13], and are subject to the reporting requirements of 32 Illinois Administrative Code 609 and 620. The review for alternative disposals (i.e., not in a low level radioactive waste facility) will follow methodology specified under 32 Illinois Administrative Code 330.1020:

A Section 330.40(d) registrant may apply to IEMA for approval of proposed procedures, not otherwise authorized in 32 Ill. Adm. Code: Chapter II, Subchapters b and d. Each application shall include:

- a) A description of the [treatment residuals containing radium] to be disposed of, including the physical and chemical properties that have an impact on risk evaluation, and the proposed manner and conditions of waste disposal;
- b) An analysis and evaluation of pertinent information on the nature of the environment;
- c) The nature and location of other potentially affected facilities; and
- d) Analyses and procedures to ensure that doses are maintained ALARA and within the dose limits in this Part.

B. Land Application

As stated by US EPA in “*The Regulator’s Guide to the Management of Radioactive Residuals from Drinking Water Treatment Technologies*”¹, “[USEPA]...is aware that some states allow land spreading or soil mixing as an alternative to landfill disposal for water treatment residuals (for example, as a soil amendment on farm fields). One central concern with land spreading is the potential for build-up or movement of radionuclides to create contaminated sites that would require remediation and/or use of institutional and engineering controls. Other factors to take into account include the physical and chemical attributes of the material, the amount of radiation introduced into the soil over time, the mobility of radionuclides and their decay products along multiple pathways of exposure, and the consideration of future controls and future land use.”

For the reasons stated above, the Section 330.40(d) exemption places specific requirements not only on the characteristics of the treatment residuals, but on the receiving fields themselves. This Section discusses the requirements for land application of treatment residuals containing concentrations of radium-226 and radium-228 less than or equal to 100 pCi/g (DWB).

40 CFR 503 and 35 Illinois Administrative Code 391 require specific receiving field characteristics, treatment residual quality, and reporting procedures for compliance. This guidance seeks to outline methods land applicators and generators may follow to meet compliance with the multiple regulations. As regulations change and specific operating requirements of facilities necessitate, this guidance will be revisited by IEMA. Entities producing or in possession of treatment residuals containing radium that wish to land apply are encouraged to contact IEMA with questions concerning the requirements of Section 330.40(d). Phone (217) 782-1326.

The following provisions are the minimum necessary, in addition to any other State or Federal requirement, in order to utilize treatment residuals containing radium for land application in accordance with Section 330.40(d):

1. Sample Fields Prior to Use

By June 1, 2011, all persons applying treatment residuals containing radium to land in Illinois must sample the fields projected for use in 2011 according to methods in Section III.A(2). “Projected for use” is utilized here to define a field which is to receive land application of treatment residuals containing radium. Fields not sampled in 2011 must be sampled prior to receiving land application of treatment residuals containing radium. The

radium-226 and radium-228 concentration of the soil must be determined in pCi/g and reported to IEMA.

Review Section III.A(2) for the number of composite sample to be submitted to the lab for analysis during background sampling. If the field can be considered a 'zone with common characteristics' in accordance with the 24th edition of the Illinois Agronomy Handbook, composites may be combined and a single, representative sample may be submitted for lab analysis.

In addition to testing soil radium concentrations, receiving fields must meet the following requirements:

- Cumulative soil concentration (from the sum of all land applications) of radium-226 and radium-228 must not be greater than 3.0 pCi/g. Compliance with this provision is determined by field specific testing.
- pH must be equal to or greater than 6.0. Compliance with this provision is determined by field specific testing.
- A soil layer, with a minimum depth of six inches, of at least 18% clay content must exist in the top five feet of the soil profile and lie above bedrock and the local groundwater level. Compliance with this provision may be determined by submitting soil profile results, or data from the County Soil Survey book (or equivalent).
- A soil layer, with a minimum depth of six inches, of at least 12 tons per acre of organic matter, must exist in the top five feet of the soil profile and lie above bedrock and the local groundwater level. Compliance with this provision is determined by field specific testing.
- Lands receiving treatment residuals containing radium shall not be used for the cultivation of tobacco. (*Tobacco will uptake radium from the soil*).
- Adequate description of the field must be provided to IEMA for the purposes of tracking combined radium accumulation. The description should include, at a minimum:
 - Township
 - Section
 - Range
 - Latitude and Longitude of a point nearest the middle of the field.
 - Number of acres within that field.

Therefore, when sampling fields, minimally, the generator or applicator must analyze for pH, organic matter, radium-226 and radium-228.

2. Sample Treatment Residuals

As stated throughout this guidance, the combined radium concentration of the drinking water or wastewater treatment residuals dictate disposal options. Prior to land application, the generator and/or applicator must verify through certified lab results, that the concentration of the treatment residuals are less than or equal to 100 pCi/g (dry weight basis). Treatment residuals with concentrations in excess of 100 pCi/g of combined radium require IEMA review prior to disposal. Facilities may composite tributary waste streams and analyze a final, representative sample in accordance with Section III.A or may collect composites directly from the treatment residuals prior to land application. Turn around times of analytical methods may dictate the sampling approach selected by facilities.

3. Identify and Sample New Fields to receive land applications

On an ongoing basis, when a generator or applicator wishes to use a new field for the land application of treatment residuals containing radium, the sampling identified in Section III.A(2) must be performed. The data and field characteristics should be submitted to IEMA. This information may accompany or be included in 35 Illinois Administrative Code 391-Schedule G and submitted to both agencies to meet compliance with both respective reporting requirements. The site requirements specified in Section IV.B(1) apply to all fields that are to receive land application of treatment residuals containing radium. As specified in Section III.A(2), if the field can be characterized as a 'zone with common characteristics' per the 24th edition of the Illinois Agronomy Handbook, all composites collected from a single, continuous field may be combined for a single analysis.

4. 1.0 pCi/g Radium-226 and Radium-228 Cumulative Soil Concentration Increase

The total cumulative increase in the soil from the sum of all land applications shall not exceed 1.0 pCi/g (DWB) of radium-226 and radium-228. This 1.0 pCi/g (DWB) increase is calculated from the initial 'background' result(s) determined in Section IV(B)1. Cumulative radium loading is calculated using a soil density of 90 pounds per cubic foot and a mixing depth of one foot. The following sample calculations are an adaption from 35 Illinois Administrative Code 391 appendices. Assumptions afforded by IEPA for loading rates of metals and land application rates are, likewise, afforded by IEMA: (density of dry weight sludge = density of water) and are reflected in the example calculations below:

Increase in Soil Radium Concentration	=	$\frac{\text{Total picoCuries (pCi) Applied per Acre (DWB)}}{(1,778,293,440 \text{ grams soil/acre} + \text{Grams of Sludge Applied per Acre})}$
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Grams of Soil per Acre					
43,560 ft ² /acre	x	1 Foot Mixing Depth	x	90 lbs/ft ³ (Density of Soil)	x 453.60 grams/lb = 1,778,293,440 grams soil/acre

* IEMA notes the inconsistency in significant figures above and displays contributing variables only to show the derivation of the constant to be used in calculations: 1,778,293,440 grams soil/acre .

Grams of Sludge Applied per Acre***					
Wet Basis					
Gallons Sludge Applied per Acre	x	DE**	x	8.345 lbs/gallon (Assumed density of sludge)	x 453.60 grams/lb = Dry grams of Sludge Applied per Acre

Dry Basis					
Dry Tons Applied per Acre	x	2000 lbs/ton	x	453.60 grams/lb	= Dry grams of Sludge Applied per Acre

Total picoCuries (pCi) Applied per Acre (DWB)					
Ra ²²⁶ pCi/g + Ra ²²⁸ pCi/g from Composite Sludge Result (DWB)	x	Dry grams of Sludge Applied per Acre (obtained from above)	=	Total pCi Applied per Acre (DWB)	

* If it is necessary to convert laboratory results from a wet basis to a dry basis, see Section III.C

** DE = Decimal Equivalent. The total % Solids divided by 100. (i.e., 5% total solids = 0.05 DE)

*** The intent of the formula above was to arrive at a number of “grams of sludge applied per acre” based upon the dry weight of the sludge in which the technologically enhanced radium is distributed. If a land applicator or generator wishes to instead use the cumulative dry weight of all sludges applied per acre (“Grams of Sludge Applied per Acre” in the denominator of the formula is calculated from all the sludge applied to the field not just the sludge with technologically enhanced levels of radium) , the overall concentration of combined radium would be reduced. IEMA has considered two factors that indicate either method of calculation is acceptable:

- First, if an additional sludge mass with non-technologically enhanced concentrations of radium is used to, effectively, dilute the concentration of radium in the treatment residuals; there would be a corresponding increase in overall volume. Due to the fact the number of dry or wet tons applied per acre is still limited by agronomic usage, there is a corresponding decrease in the amount of radium applied *per acre*.
- Second, a field receiving the land application of treatment residuals containing radium is ultimately limited by a maximum of 1778 microCuries of combined radium per acre (corresponding to 3.0 pCi/g). For the purposes of compliance with Section 330.40(d), the lifetime maximum 1778 microCuries of combined radium per acre can be applied as 19.6 tons (17,780,000 grams) at 100 pCi/g or 196 tons at 10 pCi/g.

IEMA does not advocate the blending of sludges to afford a generator land application of a treatment residual with an initial concentration above 100 pCi/g (DWB). However, due to common practice of aggregate application from multiple generators, this scenario may arrive by consequence. If the combined radium applied per acre is calculated and tracked in accordance with Section 330.40(d), the environmental deposition of combined radium is maintained within regulatory limits.

5. 3.0 pCi/g Radium-226 and Radium-228 Ceiling Soil Concentration Limit

Sites receiving land applications of treatment residuals containing radium are limited to a 1.0 pCi/g cumulative increase over background as specified in the previous section. However, a ceiling limit is set at 3.0 pCi/g (the mean natural background as determined by the Agency of 2.0 pCi/g and the soil concentration increase limit of 1.0 pCi/g due to treatment residual land application). This ceiling takes precedence over the 1.0 pCi/g increase. Therefore, if a field’s background radium concentration is determined to be 2.7 pCi/g, the site has only a 0.3 pCi/g cumulative increase remaining. Land applications on fields with concentrations (based on an average of composites received) greater than 3.0 pCi/g are prohibited under Section 330.40(d).

6. Landowner Acknowledgement Form

Section 330.40(d) requires that the landowner or an authorized agent must acknowledge, on a form issued by IEMA, that they are aware that treatment residuals containing radium are being applied to their land. This form is available as Addendum 1 to this guidance. The Landowner Acknowledgement Form is specific to the application of treatment residuals containing radium and is additive to any notification forms currently required under separate regulations. Additionally, 35 Illinois Administrative Code 391 releases generators or applicators from notifying landowners in contractual situations – there is no such release of notification requirements in Section 330.40(d). This form must be submitted at the time of registering a new field with IEMA (and/or IEPA), and be updated as land ownership changes. The landowner acknowledgement form may be printed and used as an addendum to current contracts or replicated in it’s entirety (legibly and in font size 8 or larger) for inclusion in existing contractual documents.

7. Tobacco prohibition

Due to the documented propensity of tobacco to uptake radium-226 in the plant leaf and the resulting exposure pathway to man^{22, 23, 24}, the cultivation of tobacco plants on fields receiving land applications of treatment residuals containing radium is prohibited under Section 330.40(d).

8. Required Field Sampling at 80% of Limits

When the cumulative increase of the radium concentration in the soil is determined by calculation (per Section IV.B(4)) to be 0.8 pCi/g or when the combined radium in soil is calculated to be 2.8 pCi/g (based on initial testing and subsequent applications of treatment residuals containing radium), the generator must repeat the soil sampling (as prescribed in Section III.A(2)) and analyze each composite to determine the actual combined radium concentration in the soil and report the findings to the Agency. Should soil sampling, analysis, and result submittal not be completed for the subject parcel(s); land application of treatment residuals containing radium must cease. Analytical test results provided by soil sampling will dictate the remaining site life, if any.

All data from the reporting laboratory must be reported (each composite value) and not an overall average or a single analysis. IEMA will calculate an average concentration for the field based upon the composite samples received. An applicator or generator may not include additional acreage (*that has not been included in previous land applications*) in the sampling plan to artificially lower the average of a land-applied area. Averages of fields are taken (rather than discrete values from each composite) to alleviate the land applicator and/or generators from the burden of tracking and land applying around small portions of fields. Additionally, the nature of land application currently does not allow the exact location within a field to be known, for the location of a specific generator's residuals. However, if large areas (several composites worth) of a field exhibit concentrations of combined radium in excess of 3.0 pCi/g – IEMA may restrict further applications of treatment residuals containing radium to that area. This method of 'field averaging' will be employed for compliance determinations with other field characteristics (pH, organic matter), and ultimately, compliance with the 3.0 pCi/g combined radium soil concentration ceiling limit.

9. Annual Reporting

On an annual basis (or more frequently if agreed upon by IEMA and the registrant) each person who land applies water treatment residuals containing radium must report to IEMA:

- The identification, location, and background radium concentrations, as determined prior to use for land application, of the field receiving the land application of treatment residuals containing radium. This information would have been required at the establishment of the field with IEMA as in Section IV.B(1). It is requested in the annual report to positively identify the field(s) being utilized and the acreage thereof receiving land application. At a minimum, the following information is required for each field utilized for the land application of treatment residuals containing radium to fulfill this reporting requirement:
 - Township
 - Section
 - Range
 - Latitude and Longitude of a point nearest the middle of the field.
 - Number of acres within that field.

- Background radium concentration established when field was first registered with IEMA. (Average field value in pCi/g, based upon the initial sampling and composite analyses).
- The concentration of combined radium (radium-226 + radium-228) in pCi/g (DWB) in the residuals or sludge.
- Date of land application(s). If a land application occurs over a series of days (but involves a single representative treatment residual*), a date range is sufficient.
- Application rate in dry tons per acre.
- Date of land application(s) that occurred throughout the reporting period.
- Any other information requested by IEMA to ensure compliance with Section 330.40(d).

*For compliance with this part, the combined radium concentration of each treatment residual needs to be reported for each time the residuals are tested for combined radium during the calendar year. This reporting needs to occur at least on an annual basis. Once the combined radium laboratory results are received by the generator or land applier of the residuals those results shall be used starting no later than the first day of the next calendar month to calculate combined radium application to the field. The combined radium application from treatment residuals containing radium will be calculated based on the combined radium applied from all treatment residuals containing radium divided by the total acres of the field that was applied with all treatment residuals. Dry tons/acre of an individual treatment residual containing radium will be calculated by dividing the dry tons of that residual applied to the field by the total acres of the field that was applied with all treatment residuals. This calculation is performed for each field receiving land application of treatment residuals containing radium.

Generators or applicators of treatment residuals containing radium may find that the information required above, is similar to that requested for IEPA requirements. Therefore, compliance may be met with Section 330.40(d) by submitting a copy of reports generated for IEPA (*provided they contain the information above as well*), to both agencies.

10. Disposal Requiring IEMA Review

Land applications of treatment residuals with a combined radium concentration greater than 100 pCi/g (DWB) are generally prohibited under Section 330.40(d). The alternative disposal or reuse of these treatment residuals are evaluated by IEMA under Section 330.40(d)4.B. This may include scenarios such as mixing treatment residuals with lower concentrations of radium to ensure the land application rate is beneath 100 pCi/g (DWB). Such proposals are to be reviewed and approved by IEMA in advance. The review for reuse or disposal of treatment residuals above 100 pCi/g (DWB) and at or below 200 pCi/g (DWB) will follow methodology specified under Part 330.1020:

A Section 330.40(d) registrant may apply to IEMA for approval of proposed procedures, not otherwise authorized in 32 Ill. Adm. Code: Chapter II, Subchapters b and d. Each application shall include:

- a) A description of the [treatment residuals containing radium] to be [land applied], including the physical and chemical properties that have an impact on risk evaluation, and the proposed manner and conditions of waste disposal;
- b) An analysis and evaluation of pertinent information on the nature of the environment;
- c) The nature and location of other potentially affected facilities; and
- d) Analyses and procedures to ensure that doses are maintained ALARA and within

the dose limits in this Part.

Applications to IEMA under this section may be used to accommodate small variations in lab analyses that may cause undue hardship upon a generator or applicator. (For example, a treatment residual with an average concentration of 102 pCi/g). However, although Section 330.40(d)4.B affords IEMA flexibility in allowing alternative disposals, this does not negate the regulatory authority of IEMA to reject or dismiss any requests to land apply treatment residuals with concentrations above 100 pCi/g (DWB).

C. Low Level Radioactive Waste

As outlined in Section 330.40(d)(1), persons producing or in possession of residuals or sludge resulting from the treatment of water or sewage and containing naturally occurring radium from groundwater with concentrations of combined radium greater than 200 pCi/g (dry weight basis) are not exempt and shall comply with requirements in 32 Illinois Administrative Code 330. Disposal options for those facilities producing treatment residuals with concentrations greater than 200 pCi/g are often limited to a low level radioactive waste (LLRW) landfill.

LLRW landfills are licensed by the US Nuclear Regulatory Commission (NRC) or by a state under agreement with NRC, and guidelines for disposing of radioactive sludges and solids are more stringent than in a standard landfill. These facilities are licensed based on projected performance and have packaging and burial requirements that are progressively stricter as the radionuclide concentrations increase. There are additional licensure, reporting, and fee requirements concerning the disposal of LLRW. Questions concerning the disposal of treatment residuals as LLRW should be directed to IEMA, LLRW Section, (217) 785 9982.

Persons producing or possessing treatment residuals from the treatment of water or sewage containing combined radium in excess of 100 pCi/g (DWB) may elect to have the residuals disposed of at a LLRW facility. However, they are then subject to the registration requirements specified in Section 4 and the fees specified in Section 13 of the Illinois Low Level Radioactive Waste Management Act [420 ILCS 20/4 and 13], and are subject to the reporting requirements of 32 Illinois Administrative Code 609 and 620.

D. Case-Specific Disposals or Use of Treatment Residuals Containing Radium

The following subsections address case-specific disposal or reuse of treatment residuals containing radium that IEMA believes may not require the full regulatory oversight of Section 330.40(d). This listing is not exhaustive and may be added or removed as further information becomes available to IEMA. However, the following situations are preemptively addressed to provide specific regulatory relief to those persons IEMA has already considered eligible.

1. Drinking Water Treatment Residuals with High Frequency of Exchange

As specified in Section II.A, drinking water treatment facilities that utilize a treatment process capable of concentrating radium are required to register (despite using a low-radium aquifer). This is due to the fact that if media is left in service for extended periods of time, radium may accumulate to levels warranting increased controls and monitoring. Consequently, this approach requires registration of facilities that may never concentrate radium if the service life of the media is exhausted prior to accumulating radium. Length of time in service and the radium concentration of the source water will determine the extent to which radium is accumulated within treatment media. If the aquifer has not been identified by IEMA as contributing radium to the source water, then length of time in service will dictate radium concentrations in the media. Drinking water treatment facilities that can demonstrate media is exchanged at a frequency high enough to prevent radium accumulation may request that IEMA relax the radium testing requirement prior to disposal in a landfill. The facility must demonstrate that normal operating procedures

prevent the residuals from becoming technologically enhanced with radium and the disposal of the media is in compliance with State, Federal, and local requirements. Drinking water treatment facilities that fail to demonstrate preventing technological enhancement of radium in the residuals, or do not have a high frequency of media exchange must sample prior to disposal.

2. Lime Softening Facilities

The majority of spent drinking water treatment medias are not expected to have an agronomic use and disposal in a landfill satisfies compliance with Section 330.40(d) provided the concentrations are at or beneath 200 pCi/g (DWB). Lime sludges present a unique situation in that they *are* land applied and provide an agronomic benefit. Provided the lime sludges are not from a facility where groundwater is pumped from an aquifer identified to contribute radium to the source water, the receiving fields are not required to be monitored and agronomic usage, State, Federal, and local requirements will dictate land application rates. IEMA believes, at the current time, that in the absence of radium-contributing aquifers, drinking water treatment facility lime sludges will exhibit radium concentrations similar to that of lime sourced from common agricultural suppliers. Therefore, lime softening facilities that do not obtain their groundwater from an aquifer identified to contribute radium to the source water are not required to sample the lime sludge and the receiving fields.

3. Treatment Residuals Containing Combined radium Concentrations Beneath 3.0 pCi/g (DWB)

In general, if drinking water treatment residuals or WWTP sludges are analyzed and found to contain less than or equal to 3.0 pCi/g (DWB) of combined radium, the residuals may be disposed of in a landfill or land applied without further restriction by Section 330.40(d). If the treatment residuals to be land applied have a combined radium (radium-226 + radium-228) concentration of less than or equal to 3.0 pCi/g (DWB), the land application does not require any further action with regards to Section 330.40(d). This is due to the fact that land applications of treatment residuals with concentrations less than or equal to 3.0 pCi/g (DWB) are not capable of increasing the average field radium concentration above 3.0 pCi/g.

Section V. Long Term Compliance

The following section details the long term requirements for compliance with Section 330.40(d). A brief, general description of requirements are discussed and the section where additional information is available referenced.

A. Test Treatment Residuals

Sampling and testing of treatment residuals is discussed in Section III.A(1). IEMA utilizes the geographical location of a CWS's groundwater wells to determine if the source water draws from aquifers that contribute radium. When radium in the source water is combined with a treatment technology that is capable of concentrating radium (although not necessarily treating for radium), there is a high likelihood that radium may be concentrated in the treatment residuals of the drinking water treatment plant – and – the recipient of the resulting waste stream, if any.

Therefore, IEMA will notify municipalities if the conditions above exist for their facility. Such facilities would be required to sample their treatment residuals and dispose of them in accordance with the provisions of Section 330.40(d). Municipalities may already be aware of impacts to their sludges or treatment residuals due to prior IEPA permit conditions or an ongoing radium treatment process at a drinking water facility. Although the majority of facilities (CWS and WWTP) will be pre-registered by IEMA and contacted – it may benefit communities to sample their treatment residuals as soon as possible to ensure they do not exceed 200 pCi/g, thereby losing exempt status.

On an ongoing basis, sampling and analysis of treatment residuals will be necessary to ensure the desired disposal options are still available. The potential for increased radiation exposure and the high costs of disposing of low level radioactive waste also warrant a careful monitoring strategy to ensure residuals stay beneath 200 pCi/g.

B. Annual Reporting

Section 330.40(d) requires that disposals of treatment residuals containing radium be tracked and their disposition reported to IEMA. Under the provisions of 35 Illinois Administrative Code 391, generators of sludge may be required to report on a frequency other than annual. If persons are making use of a combined report that satisfies the requirements of both IEPA and IEMA, they may elect to report on a more frequent basis, consistent with IEPA requirements. Section 330.40(d) specifies that “each person producing water treatment residuals or sewage treatment sludge” report. Although this specifically states a generator; an applicator may report on their behalf if approved by IEMA. When a web-based reporting method is developed, registrants will be contacted.

The annual report (or more frequently) details the following information for the respective disposal option:

Landfill Disposals Section IV.A.

- Quantity of residuals or sludge containing radium
- Concentration of radium contained in the residuals or sludge
- Date of landfill disposal(s)
- Name and location of the landfill receiving the residuals
- Additional information requested by IEMA to determine compliance with Section 330.40(d)

Land Application Section IV.B

- Identification of the field and soil characteristics (including radium content)
- Concentration of radium in residuals
- Application Rate
- Date of Land Application(s)
- Additional information requested by IEMA to determine compliance with Section 330.40(d)

C. Land Application Site Termination

Due to the fact radium is not very mobile in the soil profile or in the uptake of plants (except tobacco), the concentrations in the soil do not diminish well over time. (the lack of high radium mobility, both affords and restricts land application). The additional controls on pH, clay content, organic matter, and water table depth further ensure that radium does not become mobile and create an exposure pathway to man. These became necessary when the exemption incremental increase of combined radium limit was raised from .1 to .4 to 1 pCi/g – outside the normal standard deviation of background. In addition, due to the radium content of phosphate fertilizers, lime, and potentially other agricultural additives; normal agricultural processes further raise the incremental radium content of soil (although minimally due to the much lower application rates).

On a practical basis, field radium concentrations cannot be managed on an individual composite result basis. The resulting patchwork of eligible ground would greatly reduce, if not eliminate, land applications to that parcel. For that reason, averaging is used to determine the overall concentration of radium in pCi/g for a field. Some results may be slightly over 3.0 pCi/g. It is important to note, at this point, that when soil reaches 5 pCi/g above background (*background has been established by IEMA in Section 330.40(d) as 2.0 pCi/g*), the site may fall under USEPA CERCLA clean up standards and require site remediation. The reasons above dictate that once a field has an overall average of 3.0 pCi/g, land application of radium-laden treatment residuals is prohibited. This prevents 'hot spots' from developing in fields which may impact ground use, market value, and clean up actions.

Although IEMA will maintain a database of fields that are no longer eligible for land application of treatment residuals containing radium, it is the responsibility of the generator and applicator to ensure their inventory of fields is managed in accordance with Section 330.40(d). Prior to the issuance of an IEPA permit for land application, the parcels of land to be utilized are designated. At this time, the background radium concentration is also determined. The land applicator utilized by the municipality may vary annually. Responsibility lies with the generator to ensure the cumulative radium loading from previous applications (and applicators) are accounted for by new contractual applicators.

Once a field is prohibited from receiving future applications of treatment residuals containing radium, land applications must use treatment residuals that do not originate from an *aquifer designated by IEMA and IEPA as contributing source water with elevated concentrations of radium* and that are further concentrated by a treatment technology (the CWS and WWTP identified in Section II.A of this guidance).

D. Reviewing Operating Procedures

While most liquid wastes (including acid neutralization water, backwash water, brine, concentrate, and rinse water) are discharged to a WWTP; systems may want to evaluate if this is the most economical course of action given the impact to solid waste residuals. In determining compliance with Section 330.40(d), systems should also keep in mind that the characteristics of, and contaminant concentrations in the residuals will help to define a system's disposal options. To a

limited extent, these characteristics can be influenced by the operation of the facility. If not influenced; they can be modeled. The characteristics and contaminant concentrations will vary according to:

- The concentration of radionuclides in the source water (sometimes varies with pumping demand and co-contaminant concentrations)
- 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)

Although not required, facilities may want to evaluate if the variables above are able to be manipulated or managed. These may provide more cost effective solutions for facilities that produce treatment residuals with very high concentrations of combined radium. The following section outlines a program developed by USEPA to model the amount of radium accumulated in treatment residuals. CWSs and WWTPs are encouraged to explore this program and, if not already, model the amount of radium accumulated. Dispose or land apply before reaching concentrations that limit disposal options or are more costly.

Modeling

USEPA has developed a Spreadsheet Program to Ascertain Radionuclides Residuals Concentration (SPARRC) model that indicates potential concentrations of radioactivity in residuals and filters at the system. USEPA began developing the model in 1998. This initial version focused on developing the contaminant mass balances in the sludge and other residuals using a complete set of input from the user. While the early version of SPARRC is useful in estimating the volume and concentrations of residuals, it lacked capabilities to estimate the removal efficiencies. The current version, SPAARC7, incorporates predictive algorithms to estimate radionuclides and co-contaminant removals, and focuses on a sound estimate of residual radionuclides concentrations and co-occurring pollutants rather than sizing and designing drinking water treatment technologies. It is a flexible and highly interactive tool requiring minimum learning time and was developed as a stand-alone desktop application using state of the art software development tools. The program allows the operator to select the type of treatment process, as well as input and output parameters such as water flows, doses of coagulant and polymer, and filter capacities. The current SPARRC model covers six technologies and associated co-contaminants including:

- Coagulation Filtration
- Lime Softening
- IX
- RO
- AA
- Green Sand Filtration

The current version of SPARRC is available at <http://www.npdespermits.com/sparrc>. For questions concerning the model, contact the US EPA's Office of Ground Water and Drinking Water at 202-564-3750 or ogwdw.web@epa.gov

E. Worker Exposure and Safety

A variety of studies conducted by USEPA between 1982 and 1995 found that commonly used filtering methods and media for radionuclides at water treatment plants may concentrate radium at highly different levels of radioactivity. Depending on the amount of radium in the source water, as well as the treatment process employed, USEPA has observed residuals and filters in the range of less than 10 pCi/g, up to thousands of pCi/g. The method chosen for treating water and/or wastewater may have a significant impact on the radiation protection program that may need to be instituted at the treatment facility and available waste disposal options. At the

concentrations covered under Section 330.40(d) for non-reviewed disposal (at or under 100 pCi/g), IEMA does not anticipate exposure levels that will warrant a worker dose protection program. When concentrations of treatment residuals exceed this level, IEMA may perform an assessment of the facility to determine if worker dose is an issue. Generation of treatment residuals above 200 pCi/g, facilities are not exempt from licensing requirements of Part 330 and worker dose protection programs are an integral component of the licensing process.

The following excerpt from USEPA's "A Regulators' Guide to the Management of Radioactive Residuals from Drinking Water Treatment Technologies" details the concerns expressed by USEPA regarding worker protection and radiation dose hazards.

"Because radiation is invisible, tasteless, and odorless, it is commonly overlooked as a potential hazard at water systems. Exposure to elevated levels of radiation at water treatment facilities may cause serious health effects. Systems need to determine whether a radiation problem exists and, if it does, take appropriate safety precautions to prevent or limit water system staff members' exposure to radiation. For example, if a system tested its treated water 2 years ago and found levels of 3pCi/L for radium-226 and 228, a radiation survey of the facility would be prudent. Water system staff can be exposed to radiation during normal treatment processes for radionuclides, through handling the residual streams generated by treatment, and during media replacement or transportation. Relatively undetectable levels of radionuclides in source waters can accumulate in measurable or hazardous quantities in piping, pumps, holding tank scale or sludge, IX and granular filters, backwash, and other residual sludge. Radon gas can accumulate in closed or poorly ventilated buildings when thorium, uranium, or radium-bearing materials (including water) are present. Naturally occurring radon gas can enter through openings in the building's concrete or foundation walls. Underground connections to manholes, piping conduits, and utility tunnels provide additional pathways for radon entry. For example, elevated gamma ray levels have been found around IX columns and associated piping at some facilities. This could result in an exceedance of public dose limits."

F. Landfill Closure

Section 330.40(d) specifies that a landfill that receives treatment residuals containing radium must cover the residuals with at least ten feet of uncontaminated overburden at the time of landfill closure. "Closure" is not meant to imply time outside the business hours of operation for landfill employees, but the point in time at which a particular burial site no longer accepts waste and is deemed to be at capacity.

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- ⁴ <http://www.epa.gov/superfund/health/contaminants/radiation/>. Radiation guidance and reports that are used frequently by Superfund Remedial Project Managers.
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- ¹⁸ POTW Sludge Sampling and Analysis Guidance Document. USEPA, EPA 833-B-89-100, Aug 1989.
- ¹⁹ Natural Resources Conservation Service Conservation Practice Standard, Waste Utilization (Acre) Code 633
- ²⁰ Title 35, Subtitle C, Chapter II, Part 391: Design Criteria For Sludge Application On Land. Illinois Environmental Protection Agency.

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- ²⁵ Standards for the Use or Disposal of Sewage Sludge; Final Rules. 40 CFR Part 257 et al. USEPA. February 1993.
- ²⁶ Compendium Of Epa-Approved Analytical Methods For Measuring Radionuclides In Drinking Water. Prepared by the Office of Environmental Policy and Assistance Air, Water and Radiation Division (EH-412), June 1998.
- ²⁷ PHMSA Interpretation #10-0106 on 173.401(b)(4), US Department of Transportation. Sept. 8, 2010. <http://www.phmsa.dot.gov/staticfiles/PHMSA/Interpretations/2010/100106.pdf>
- ²⁸ "Method Validation Guide for Qualifying Methods Used by Radiological Laboratories Participating in Incident Response Activities". EPA 402-R-09-006. June 2009

ADDENDUM 1

Radium in Treatment Residuals Landowner Acknowledgment Form

Complete this form for each land application site under differing ownership and submit to the Low Level Radioactive Waste Section at IEMA, 1035 Outer Park Dr., Springfield IL 62704.

The sludge that you are obtaining contains less than 200 pCi/g of naturally occurring radium as a result of treating drinking water.

Pursuant to 32 Illinois Administrative Code 330.40(d), this letter serves as an acknowledgment of awareness as landowner or an authorized agent of the landowner that treatment residuals ("sludge" or "biosolids") applied to your field(s) for beneficial nutrient purposes by

APPLICATOR NAME OR GENERATOR SIGNED AGREEMENT

contain a small amount of naturally occurring radioactive material that may result in a minor elevation in radium concentration in effected soils above the natural background levels. Radium is naturally occurring in the environment and is concentrated in the sludge as a result of treating drinking water. When applied in accordance with 32 Illinois Administrative Code 330.40(d), there is not a significant health, environmental, or agricultural impact.

The Illinois Emergency Management Agency monitors the cumulative amount of radium deposited on agricultural fields as a result of land applications. Should your field approach the regulatory limit of 3.0 pCi/g, alternative sources of fertilizer (i.e., sludge without technologically enhanced levels of radium) will be required.

I hereby acknowledge my awareness of the above conditions resulting from land application of treatment residuals on my property,

AUTHORIZED SIGNATURE OF LANDOWNER OR THEIR DESIGNEE

DATE

Addendum 2

Example Notification Letter to Potentially Regulated Persons under Title 32 IAC Section 330.40(d)

(Community Water Supply Example Provided)

NOTICE OF REGISTRATION REQUIREMENT

32 Illinois Administrative Code 330.40(d), Regulations Pertaining To The Generation, Handling, And Disposal Of Water Treatment Residuals Containing Radium.

The Illinois Emergency Management Agency, Division of Nuclear Safety (herein referred to as IEMA) is issuing this notification to the regulated persons involved in the generation, handling, and disposal of treatment residuals resulting from the treatment of groundwater containing radium-226 and radium-228. Radium-226 and radium-228 are naturally occurring radioactive materials found in certain deep well aquifers. Illinois community water supplies (CWS), in an effort to reach compliance with the United States Environmental Protection Agency's drinking water standard of 5 picoCuries / liter, have installed treatment technologies that remove radium-226 and radium-228 from the groundwater. The radium is removed from the drinking water and concentrated in either a residual at the drinking water treatment facility or in the sludge at a wastewater treatment plant. As a direct result of treating the groundwater for compliance with federal standards, the concentrations of radium in the spent media and sludge have created TENORM (technologically enhanced naturally occurring radioactive material). Proper management and disposal of the resulting treatment residuals ensures worker safety and minimizes environmental impact.

IEMA regulates the possession and use of radioactive material. Certain uses of radioactive material require a specific license to be issued by the Agency pursuant to 32 Illinois Administrative Code 330. In an effort to minimize the regulatory burden and financial costs imparted to Illinois communities, while affording worker and environmental protection, IEMA has promulgated an exemption from these licensing requirements. On February 28, 2011, 32 Ill. Adm. Code 330.40(d) was promulgated which provides an exemption for facilities producing treatment residuals containing radium from the treatment of groundwater. Provided the treatment residuals remain at a concentration of 200 picoCuries / gram or less (on a dry weight basis), licensure and reporting in compliance with 32 Ill. Adm. Code 330 is not required. Additionally, the disposal costs and fees associated with low-level radioactive waste management are not applicable.

Your facility has received this notification due to the fact IEMA believes that the treatment technology installed at your facility, in combination with the aquifer(s) from which the facility draws source water, have the capability to concentrate radium. Furthermore, the disposal of this media and/or any resulting backwash or reject water may concentrate radium in the resulting sludge. This may impact the disposal options available to the end users of the treatment residuals and mandates specific monitoring and reporting requirements. In accordance with 32 Ill. Adm. Code 330.40(d)2, your facility must register with the Illinois Emergency Management Agency.

The first step in registration is verifying and completing the attached contact and inventory information. Community water supplies are asked to verify (as applicable) well inventory, any treatment installed, and any wastewater treatment plant that receives a resulting waste stream. Gather the required information by May 2, 2011. On May 2, 2011, IEMA will make a registration website publicly available at: <http://tier2.iema.state.il.us/WaterTreatment/>

Appendix A

Applicable Statutes and Regulations

An overview of applicable state and federal regulations that direct the treatment residual disposal options available to systems removing radionuclides from their source water are summarized in items 1-9 below. IEMA encourages readers to become familiar with these regulations in their entirety.

1. USEPA 40 CFR 503

Part 503 of Title 40 of the Code of Federal Regulations Part 503 (hereafter referred to as Part 503) sets standards for the use or disposal of sewage sludge, establishes numeric limits, management practices, and operational standards to protect public health and the environment from adverse effects of chemical and microbiological pollutants in sewage sludge. There are no radiological requirements in Part 503. For the purposes of integration with Section 330.40(d), disposal of treatment residuals in accordance with RCRA (and 40 CFR 260-268) to an IEPA permitted landfill satisfies requirements under Part 503. "Disposal of sewage sludge in a municipal solid waste landfill unit, as defined in 40 CFR 258.2, that complies with the requirements in 40 CFR 258 constitutes compliance with section 405(d) of the CWA. Any person who prepares sewage sludge that is disposed in a municipal solid waste landfill unit shall ensure that the sewage sludge meets the requirements in 40 CFR 258 concerning the quality of materials disposed in a municipal solid waste landfill unit." Land application of treatment residuals is allowed under Part 503; however, the limitations and reporting requirements vary from IEPA procedures. IEMA has reviewed Part 503 as it pertains to management practices that may conflict to the disposal of treatment residuals under Section 330.40(d). At this time, compliance and disposal options authorized under Section 330.40(d) do not conflict with requirements set in place by the US EPA or the IEPA. IEMA will continually review guidance to ensure streamlined implementation with all State and Federal requirements.

An important note is that Part 503 does not apply to sludge generated during the treatment of either surface water or ground water used for drinking. That sludge is not generated during the treatment of domestic sewage in a treatment works.

2. 35 Illinois Administrative Code 391: Design Criteria for Sludge Application on Land

35 Illinois Administrative Code 391 regulations promulgated by IEPA identify methods of sludge transportation, handling, storage, application, and monitoring to control potential environmental problems. The regulations are not specifically written to include radium as a contaminant; and therefore, options available to municipalities prior to Section 330.40(d) promulgation may not be available. Specific situations are outlined below and other circumstances as they arrive will be evaluated on a case by case basis.

A logical approach to incorporating radium bearing treatment residuals into the current framework of 35 Illinois Administrative Code 391 and Part 503 would be to treat radium as a metal contaminant with a maximum acceptable loading rate over the life of a project site as outlined in 35 Illinois Administrative Code 391.420. In contrast to 35 Illinois Administrative Code 391, where generators of small quantities of sludge or small acreage size are not included in the permit process (35 Ill. Adm. Code 391.201(b)(3)); all land applications of treatment residuals containing radium will be sampled and the cumulative loading calculated. This also pertains to generators who land apply by contract and, currently, report on the ten largest users (35 Ill. Adm. Code 391.202(b)). All fields receiving land application of treatment residuals containing technologically enhanced combined radium must be sampled and the cumulative loading calculated. In an effort to avoid duplication of efforts and costs in sampling, the methodology for sampling accepted by IEPA has been incorporated and is discussed in Section IV. Many of the reporting requirements

established for IEPA permit compliance will satisfy Section 330.40(d) provisions and are discussed in Section V.A.

35 Illinois Administrative Code 391.404 places site criteria on the receiving field(s). It should be noted that 35 Illinois Administrative Code 391.404(d) requires a background pH of 6.5 or greater. Although the Section 330.40(d) requirement specifies a pH of greater than 6.0 and would not preclude the IEPA requirement; the possibility of using lime softening sludge containing radium is a possibility. In the event lime additions must be made to raise the pH of a field, alternative sources of lime must be sought if the receiving field is below a pH of 6.0. *The discrepancy exists due to the fact below a pH of 6.5, metals may go into solution and contaminate the water table. The 6.0 pH requirement specified by IEMA is based upon the fact that radium, also a divalent cation, has increased mobility in the soil profile below a pH of 6.0. A similar adoption of a 6.5 pH threshold by IEMA would have eliminated using lime softening sludge (containing radium) as an agronomic supplement.*

35 Illinois Administrative Code 391 specifies sampling and site monitoring requirements that may be utilized to fulfill the requirements of Section 330.40(d). The sampling and field monitoring techniques are addressed in Section III of this guidance. It should be noted that, in contrast to 35 Illinois Administrative Code 391.430(a), sludge application projects – regardless of duration – will need to establish background radium concentrations and perform soil / sludge testing.

35 Illinois Administrative Code 391 also outlines the process for land reclamation projects utilizing sludge. Although not specifically excluded by Section 330.40(d), the use of sludge for land reclamation typically results in application rates far in excess of agronomic needs. Sufficient documentation will need to be submitted to IEMA that the cumulative loading of combined radium for the site will not be exceeded (3.0 pCi/g).

Finally, 35 Illinois Administrative Code 391 specifies procedures for sampling and analysis of soils and sludge. The procedures outlined were adopted, in part, into this guidance – see Section III.

3. 32 Illinois Administrative Code 330

As an agreement state, Illinois is authorized under the Atomic Energy Act of 1954, as amended (AEA; 42 USC 2011 *et seq.*) to regulate the civilian commercial, industrial, academic, and medical use of source materials. Groundwater contains trace amounts of uranium and thorium. Although IEMA does not anticipate a problem; if the concentration of uranium and thorium in treatment residuals exceed .05% of the mixture, under NRC regulations – the treatment residuals are considered to contain 'source material'. If a treatment residual has source material that contains more than 0.05 percent uranium (or approximately 335 pCi/g for natural uranium) or thorium by weight, it is subject to the general license requirements of Part 330. In addition, although not licensable by itself, radium that co-occurs with licensable source material would be subject to the requirements of licensing as well. These limits apply to both liquid and solid residuals. For perspective, in a system with filter media weighing 30,000 pounds, 0.05 percent by weight would be equal to 15 pounds of uranium. Treatment residuals with concentrations in excess of 200 pCi/g may be evaluated by IEMA to determine the uranium and thorium content, should the 0.05 percent limit be suspect.

4. Resource Conservation and Recovery Act (RCRA) Requirements

Before land applications may proceed under Part 503, 35 Illinois Administrative Code 391, or Section 330.40(d); sludge generators, users or distributors must determine that their treatment residuals are non-hazardous and non-toxic.

The Resource Conservation and Recovery Act (40 CFR 239 to 282) establishes programs for regulating nonhazardous solid waste (Subtitle D), hazardous waste (Subtitle C), and Underground Storage Tanks (Subtitle I). RCRA governs the identification, classification, and

management of solid and hazardous wastes. Since many of the treatment technologies that are efficient at removing radionuclides are also efficient at removing co-occurring contaminants, your

Treatment residuals containing radium may also be classified as hazardous waste if they contain high enough levels of certain co-occurring contaminants, such as arsenic.

Under 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 characteristic¹.

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). Persons disposing of treatment residuals containing radium will need to determine the waste classification. If the treatment residuals contain a concentration of less than 200 pCi/g (dry weight basis) and contain contaminants that mandate RCRA disposal, the disposal of said treatment residuals must be done in compliance with RCRA. Treatment residuals containing greater than 200 pCi/g of combined radium (dry weight basis) and contaminants in quantities that dictate RCRA disposal will be disposed of in a low level radioactive waste landfill permitted for RCRA contaminants.

Prior to disposal of treatment residuals containing radium via land application or landfill disposal, a RCRA determination must be made to determine compliance with State and Federal regulations. It should be noted that one of the most overlooked aspects of treatment residual disposal is in the change out of spent drinking water treatment media. The spent media (often sand, lime, gravel, or anthracite) is used as backfill or discarded as uncontaminated media. The treatment media may fall under the requirements of not only Section 330.40(d) but the RCRA as well. IEPA requirements will dictate RCRA monitoring requirements.

5. Clean Water Act (CWA), 33 USC 1251 to 1387

USEPA establishes requirements for direct discharges of liquid waste or the discharge of a liquid waste to WWTP under the CWA. IEPA will regulate the discharge under an NPDES permit. 32 Illinois Administrative Code 340 establishes limits for the discharge of radium-226 and radium-228 to the environment and to a WWTP. Effluent concentrations discharged to a receiving body of water are covered under 32 Illinois Administrative Code 340 and limited to 60 pCi/L of radium-226 or radium-228 (120 pCi/L combined radium). Monthly average concentrations for release to a sanitary sewer is 600 pCi/L for radium-226 or radium-228 (1200 pCi/L combined radium). Although not specifically addressed in Section 330.40(d), operational adjustments by water and sewer treatment plant operators to reduce combined radium sludge concentrations may need to check requirements imposed by the CWA and 32 Illinois Administrative Code 340.

6. US Department of Transportation (USDOT) regulations (49 CFR 171 to 180)

USDOT, which governs the shipping, labeling, and transport of hazardous (including radioactive) materials establishes in 49 CFR 173.436 that radium-226 is required to be in compliance with transportation regulations (placarding, labeling, packaging, shipping manifests, etc.) when in a consignment of 270,000 pCi and a concentration greater than 270 pCi/g. (It should be noted that at a concentration of 270 pCi/g, 2.2 lbs will meet the consignment criteria). For radium-228, the concentration limit is also 270 pCi/g but the total consignment must meet 2.7 microcuries (at a concentration of 270 pCi/g of radium-228, approximately 22 lbs will meet the consignment limits). The primary transportation requirement stipulated in Section 330.40(d) is that the residuals or sludge are covered during transport. This is a requirement similar to that in 35 Illinois Administrative Code 391.301.

IEMA notes that in paragraph 49 CFR 173.401(b)(4), USDOT exempts "natural material and ores containing naturally occurring radionuclides which are not intended to be processed for use of these radionuclides" so long as their activity concentrations and consignment activities do not

exceed 10 times the levels listed in 49 CFR 173.436 or calculated using 49 CFR 173.433 (*this would then require a concentration of 2700 pCi/g radium and a consignment of 270 nanocuries*). In a September 8, 2010, letter from the US Dept. of Transportation Pipeline and Hazardous Materials Safety Administration to Mr. Charles Simmons, Interpretation #10-0106, the US DOT asserted that the 173.401 exemption does not apply "...to zeolite media used as part of a water treatment process to remove radionuclides from drinking water... [due to the fact it].. does not involve "natural material" (due to the man-made processing involved) or "ores containing naturally occurring radionuclides". For the purposes of this guidance, this interpretation is brought to the attention of the reader to avert regulatory conflict. Under the current interpretation, "due to the man-made processing involved", treatment residuals containing technologically enhanced levels of radium appear to fall under the more stringent 270 pCi/g concentration and 27 nanocurie thresholds.

7. The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA, 42 USC 9605 et seq.)

CERCLA applies to the release or threat of release of hazardous substances (including radionuclides) that may endanger human health and the environment. If disposal of radionuclide-contaminated residuals results in a release or threat of release that endangers human health or the environment, CERCLA may require cleanup of the hazardous substance. Historically established USEPA standards and 32 Illinois Administrative Code 340 establish a cleanup standard of 5 pCi/g of combined radium above background. Using the IEMA established background of 2.0 pCi/g, sites or fields that exceed 7.0 pCi/g would require site remediation.

8. USDA-NRCS Practice Standard Code 633: Waste Utilization

The United States Department of Agriculture - Natural Resource Conservation Service (USDA-NRCS) implements initiatives to improve and protect the health of select watersheds. The Mississippi River Basin Initiative is one such endeavor that includes watersheds located in the northern third of Illinois. It is possible that land application sites utilized in these areas are enrolled in conservation programs funded and administered by USDA-NRCS. Land applicators and generators are encouraged to familiarize themselves with any applicable requirements. The Practice Standard Code 633: Waste Utilization, references the application of wastewater treatment residuals in accordance with State and Federal regulations. Although no provisions of this code have been interpreted to be more restrictive than Part 503 or 35 Illinois Administrative Code 391, the setback standards and nutrient loading limits should be noted before developing a land management program. Among other provisions, wastes are not to be applied to fields with slopes greater than 15%. No application shall occur within 200 ft of wells, sinkholes, or surface waters. Any receiving field must have at least 10" of permeable soil before bedrock and 12" of soil before the water table. The single application and lifetime limits on metals shall not be exceeded.

Setback and slope requirements under Code 633 are also specified in 35 Illinois Administrative Code 391. In general, compliance with 35 Illinois Administrative Code 391 obtains compliance with provisions in Code 633 provided land application is not performed on fields with greater than 15% slope. Questions concerning USDA-NRCS watershed protection initiatives or Practice Standard Code 633: Waste Utilization in Illinois should be directed to the Illinois state agronomist at (217) 353-6644.

9. Local Ordinances, Statutes, and Policies

WWTPs may limit the amount of influent radium to their treatment works by virtue of pretreatment standards. This may limit the amount of brine, backwash, or reject water a CWS may discharge to the sanitary sewer. Operational changes may be necessary; or capture-and-disposal of process water to achieve compliance with local requirements. Additionally, IEPA permitted landfills may choose to implement policies that restrict the quantity or concentration of treatment

residuals containing radium they accept. IEMA has, on a case by case basis, worked with landfill owners to facilitate landfill disposal of material that would have otherwise been rejected. Persons possessing or producing treatment residuals containing radium are encouraged to research local disposal requirements that may be stricter and significantly more complex than those presented in this guide.

Appendix B.

Identifying Aquifers that Contribute Radium to Source Water

Concentrations of naturally occurring radium-226 and radium-228 in excess of the US EPA standard for drinking water of 5 pCi/L have been detected in water from deep aquifers used for public supply that underlie parts of northern Illinois (fig. 1)¹¹. This graphic is from the US Geological Survey (USGS) Fact Sheet 137-99, Sept. 1999 and, consequently, shows the predominate areas in Illinois where radium treatment is necessary for municipalities drawing water from a deep well. In general, the same aquifer below the southern boundary, as shown in Figure 1, is too saline for potable use due to increasing depth within the Illinois Basin as you move south.

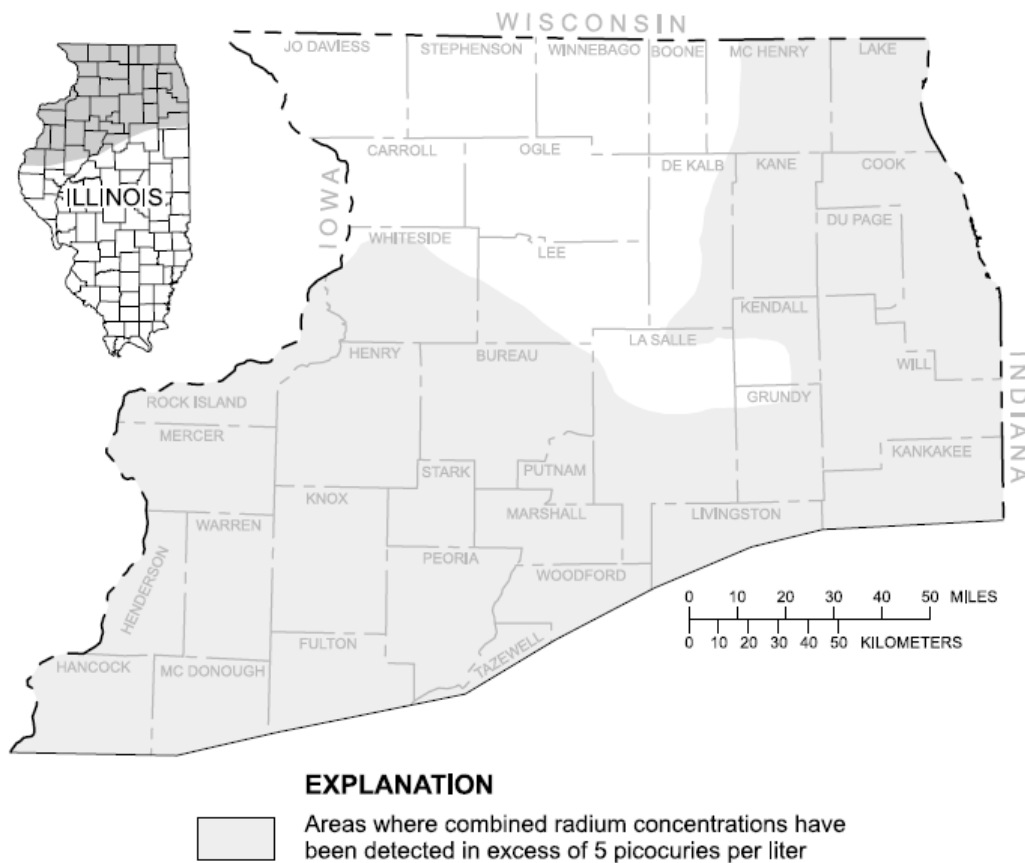
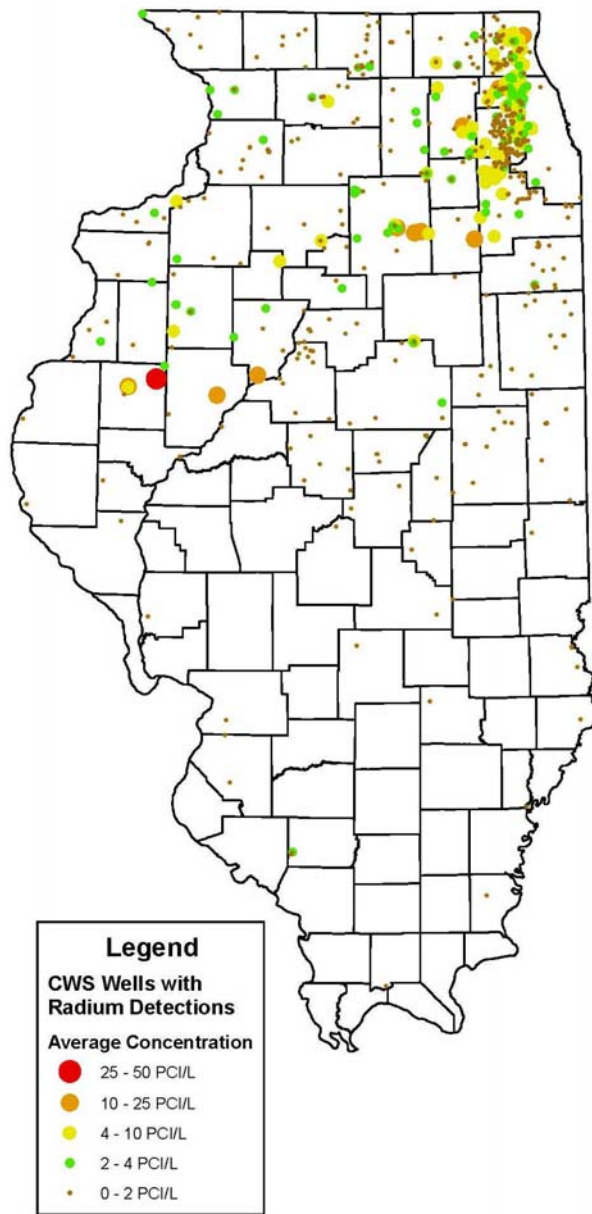


Figure 1. Areas where radium concentrations in excess of 5 picocuries per liter have been detected in aquifers used for public-water supply in northern Illinois.

The area where elevated radium concentrations may be present in northern Illinois extends from Kankakee, Livingston, Woodford, Tazewell, Fulton, McDonough, and Hancock Counties north to the Wisconsin State line. The primary aquifers that contribute to these elevated concentrations of radium are the Mt. Simon and Cambrian-Ordovician.



IEMA has worked with the Illinois Environmental Protection Agency (IEPA) to further analyze available raw water data from municipal wells around the state. Approximately 644 wells distributed across the State were sampled to determine untreated source water radium concentrations. This information included well depth, aquifer confinement and aquifer type or time stratigraphic description. Summarized in the graphic below, the data depicts the distribution of radium concentrations in aquifers across the State. Radium is present in southern Illinois aquifers as well and at times, can accumulate to levels that present disposal problems. This is especially true when a treatment technology is employed that is capable of concentrating the radium over time (see Appendix C). IEMA utilizes municipal well information (utilization of the Cambrian-Ordovician and Mt Simon aquifer, depth of the well, and aquifer confinement) to determine the likelihood radium will be present in the source water. One of the two primary factors IEMA uses to determine if a municipality must comply with the provisions of Section 330.40(d) is the aquifer from which they draw. Aquifers that contribute raw water above the US EPA drinking water standard of 5 pCi/L often require treatment installation. By virtue of treatment installation, the radium is further concentrated and accumulates in treatment residuals. This, consequently, results in most of the regulated community lying in the USGS graphic shown above. Albeit lower levels, other aquifers (such as the Pennsylvanian and Southern Illinois aquifers, due to their

location and depth within the Illinois Basin) can contain radium as well. While not generally requiring treatment for radium, installation of a treatment technology capable of concentrating radium may result in accumulation of radium in the treatment residuals. *IEMA has witnessed southern Illinois communities with raw water radium as low as 1.1 pCi/L concentrate radium in their treatment residuals to well over 200 pCi/g.*

Aquifers Contributing Radium to Source Water

IEMA utilizes studies performed by USGS¹² as well as information maintained and produced by IEPA on the aquifer each CWS draws from (if any) to determine “aquifers contributing elevated concentrations of radium to the source water”. These are primarily the Mt. Simon and Cambrian-Ordovician deep sandstone aquifers. However, the sand and gravel deposits in the glacial drift as well as fractures and crevices in the shallow Silurian or Maquoketa dolomite bedrock have shown elevated concentrations of radium¹². Of the 644 IEPA wells tested, (69) exhibited average

concentrations above 5 pCi/L. The contributing aquifers for these wells were the Devonian and Silurian systems in only two cases. Every other well obtained their source water from the Ordovician and Cambrian systems.

IEMA and IEPA analyzed aquifers contributing source water beneath 5 pCi/L to determine areas where, despite lower concentrations of radium, treatment technologies could concentrate the radium over time. For average radium concentrations beneath 5 pCi/L, the Cambrian and Ordovician (Canadian series) systems comprise only 3.10% of the test population. The Ordovician (Cincinnatian and Champlainian series) comprise 18.3% and average approximately 3.0 pCi/L. The Devonian and Silurian systems comprise 32.5% of the aquifers supplying raw water with concentrations less than 5.0 pCi/L and average approximately 1.6 pCi/L. The remainder of the production wells draw from aquifers throughout the quaternary system. The low probability of the Cambrian and Ordovician systems to contribute water beneath 5 pCi/L in the dataset agrees with the studies and evaluations of the USGS studies. Therefore, IEMA has designated the Ordovician (Cincinnatian, Champlainian, and Canadian Series) and Cambrian systems as aquifers that contribute elevated concentrations of radium to the source water. This classification may change as site specific aquifer characteristics may vary.

The municipal wells in use by Illinois communities have been compared to the depth, aquifer confinement, and aquifer type of those shown to contribute significant amounts of radium (> 5pCi/L). 5 pCi/L is utilized due to the fact that above this concentration, treatment is required by US EPA which will further concentrate the radium onto a treatment residual. There are instances of detectable levels (1 to 3 pCi/L) of radium in other aquifers (Pennsylvanian and quaternary systems); however, the levels detected, at this time, typically do not warrant treatment installation. (Incidentally, if no treatment is installed, there is not a media on which to accumulate radium). IEMA will continue to monitor the radium content of aquifers throughout the state, by virtue of maximum contaminant level violations, to assess the likelihood of treatment residual accumulation.

Appendix C

Treatment Technologies Capable of Concentrating Radium

As the groundwater is removed from an aquifer, the CWS may treat the water for compliance with US EPA maximum contaminant levels as well as aesthetic quality. If treating for radium, the reject water, backwash, brine, and process water are often discharged to a wastewater treatment plant for ultimate disposition in a sludge. The radium from the aquifer, aside from what is distributed in the finished drinking water, resides in the drinking water treatment plant media and wastewater treatment residuals. Depending on the time the media spends in service, the backwash frequency, the operational procedures employed, and the amount of water treated; combined radium may accumulate to levels that warrant not only the restrictions stipulated in Section 330.40(d) but licensure and low level radioactive waste disposal (> 200 pCi/g).

Table 1: Residual Type by Treatment Technology

Treatment	Types of Residuals							
	Solid			Liquid				
	Spent Resins & Media	Spent Membranes	Sludge	Brine	Backwash Water	Rinse Water	Acid Neutralization Water	Concentrate
Ion Exchange	X			X	X	X		
Reverse Osmosis		X						X
Lime Softening	X		X		X			
Green Sand Filtration	X		X		X			
Co-precipitation with Barium Sulfate	X		X		X			
Electrodialysis/ Electrodialysis Reversal		X						X
Hydrous Manganese Oxide Filtration	X		X		X			
Activated Alumina	X			X	X	X	X	
Coagulation/Filtration	X		X		X			
Granular Activated Carbon	X			X	X	X		
Adsorbitive Media	X			X	X	X		
Pressure and Sand Filtration	X		X		X			

It should be noted, that by installing a treatment technology capable of concentrating radium, *any* aquifer with detectable concentrations of radium in the raw water may give rise to treatment residuals with elevated radium. An example would be a system that utilizes anthracite for water quality and draws from the Pennsylvanian system. Test well data (from Appendix B) indicates radium concentrations in this aquifer can average as high as 2.8 pCi/L. If left in service for extended periods of time, the radium will accumulate on the treatment media to levels warranting

disposal in accordance with Section 330.40(d). Therefore, although the Cambrian and Ordovician aquifers are the primary aquifers designated by IEMA and IEPA to contribute elevated amounts of radium to the source water, systems employing treatment technologies capable of concentrating radium are required to register under Section 330.40(d).

Proximity to an aquifer identified in Appendix B as 'contributing radium to the source water' does not necessarily mandate a CWS to comply with Section 330.40(d). Furthermore, a CWS in southern Illinois drawing from an aquifer with less than 5 pCi/L may be required to comply with provisions of Section 330.40(d). When a treatment technology is utilized that preferentially removes radium, any aquifer may give rise to treatment residuals with technologically enhanced levels of radium if left in service for a long enough period of time. Higher levels of radium in the source water require less time in contact with treatment media to accumulate to levels warranting disposal in accordance with Section 330.40(d).

The treatment technologies listed in Table 1 are identified by USEPA as capable of producing solid residuals (including spent resins, spent filter media, spent membranes, and sludges) and liquid residuals (including brines, backwash water, rinse water, acid neutralization streams, and concentrates). Approximately 28 percent of water treatment processes remove radionuclides from water. Those of most concern are lime softening, ion exchange, and activated charcoal. IEMA has initially used this information as indicators of technologies that may create treatment residuals necessary of regulation under Section 330.40(d). Table 1 is not a comprehensive or exhaustive listing as anthracite and gravel have been shown to accumulate combined radium when left in service for extended periods of time. Additionally, initial testing indicates reverse osmosis filters may not require disposal in accordance with Section 330.40(d) – although the reject water will. Facilities are encouraged to test their media as often as facility operations allow. Table 1 will be modified as data becomes available to IEMA and treatment technologies evolve.

All treatment residuals will have some radium as a result of the radionuclide's natural abundance. However, when the supply of radium is elevated (by virtue of the aquifer) and technologically enhanced (by virtue of treatment technology), the residuals are under the regulatory scope of Section 330.40(d). Absence of a treatment technology that is capable of concentrating radium is only currently foreseeable avenue in which treatment residuals remain at environmentally encountered levels (i.e., not technologically enhanced). However, should the concentrations of produced treatment residuals remain beneath 3.0 pCi/g, the residuals could be disposed/utilized without the regulatory requirements of Section 330.40(d). This is due to the fact that, at a concentration of 3.0 pCi/g, the receiving fields would never accumulate radium to an average above 3.0 pCi/g. Review Section IV.D for further discussion.

APPENDIX D

Explanation of IEMA Facility Monitoring Criteria

Appendix B and C detail the impact aquifer and treatment technology, respectively, play in radium concentration of treatment residuals. IEMA utilizes the Safe Drinking Water Information System (SDWIS), as maintained by IEPA, to monitor changes in drinking water facilities.

Radium concentrations in treatment residuals increase when the source water is drawn from an aquifer contributing radium and a treatment technology is employed that concentrates radium. If any aspect of this scenario changes for a facility, the facility may fall under the scope of Section 330.40(d). The following changes do not necessarily cause a facility to produce treatment residuals nor do they dictate a system will be under the regulatory scope of Section 330.40(d). However, the following examples are indicators of facility changes that IEMA monitors to evaluate if a facility should dispose of their treatment residuals in accordance with Section 330.40(d).

- A new maximum contaminant level violation (MCL) for combined radium. This indicates the aquifer used is contributing water with elevated levels of combined radium. Often treatment will be required to mitigate the MCL, resulting in treatment residuals containing radium.
- Well changes. New deep wells drilled into the aquifers designated by IEMA to contribute radium to source water, blending of well sources, switching wells to 'inactive', and increasing demand on a well all effect the potential regulation of a CWS under Section 330.40(d).
- Installation or removal of a treatment technology. Due to the fact even low amounts of radium in a source water may be concentrated over time, the installation of a treatment technology capable of concentrating radium may initiate a system to dispose of treatment residuals in accordance with Section 330.40(d). The likelihood of treatment residuals being regulated under Section 330.40(d) increases if the CWS also draws from an aquifer designated by IEMA to contribute radium to the source water.

Appendix E

Approved Sample Methods

Approved Analytical Methods

There is no federal requirement to test waste residuals specifically for radionuclides, and no specific federal regulation governing landfill disposal of water treatment plant solids or sludges containing radium. The responsibility to determine the most appropriate analytical method for testing water treatment plant waste containing radium (and possibly source material) and any requirements or guidelines for disposal is currently designated to the individual states.¹ As such, IEMA has completed a review of applicable guidance and regulations to compile a list of appropriate analytical methods.

USEPA published a list of analytical methods for radionuclides in 40 CFR 141.25(a) that were approved for determining compliance with the maximum contaminant levels in drinking water. Of the approved methods, two (method 4, EPA 1979; and method 10, RA-02) are also applicable to soils or 'dry basis' treatment residuals. Tables 2 and 3 provide summary information on all approved methods from 40 CFR 141.25 for radium-226 and 228, respectively. The method descriptions are intended to serve as an easy reference guide. If users require additional information, they should consult with the laboratory or refer to "COMPENDIUM OF EPA-APPROVED ANALYTICAL METHODS FOR MEASURING RADIONUCLIDES IN DRINKING WATER" Oak Ridge Associated Universities, Prepared by the Office of Environmental Policy and Assistance Air, Water and Radiation Division (EH-412), June 1998.

Method	Reference	Methodology	Minimum Detectable Level^a (pCi/L)	Sample Size (mL)	Counting Time (min)	Noteworthy Features
1- Method 903.1	EPA 1980	Radon emanation; count alpha by scintillation counter.	0.5	1,000	100	There are no radioactive interferences in this method. The calibration constant of each scintillation cell must be determined using a standardized radium-226 solution.
2	EPA 1976	Radon emanation; count alpha by scintillation counter.	0.01-0.04	1,000	1,000-60	The calibration constant is determined using radium-226 standard solution.
3 - Method Ra-04	EPA 1984	Radon emanation; count alpha by scintillation counter.	na ^b	na	na	The calibration constant is determined by sealing a known quantity of radium-226 in a de-emanation tube.
4	EPA 1979	Radon emanation (for radium-226); for radium-226, count alpha by scintillation counter and for radium-228, count beta by low-level proportional counter.	0.3	1,500	na	This method is applicable for the determination of radium-226 and radium-228 in water, soil, air, biological tissues, and biological fluids.
5 - Method 7500-Ra C	APHA 1995	Radon emanation; count alpha by scintillation counter.	0.03-0.05	1,000	na	This method is suitable for the determination of soluble, suspended, and combined radium-226.
6 - Method 305	APHA 1971	Radon emanation; count alpha by scintillation counter.	0.03-0.05	1,000	na	This method requires a moderate amount of chemistry coupled with a sensitive alpha scintillation count of radon-222 plus progeny in a small chamber.
7 - Method D 3454-91	ASTM 1994	Radon emanation; count alpha by scintillation counter.	0.1	na	na	This method covers the measurement of soluble, suspended, and combined radium-226 in water.
8- Method R-1141-76	GSI 1977	Radon emanation; count alpha by scintillation counter.	0.1	1,000	1,000	This method is applicable to any water sample.

Table 2: 40 CFR 141.25 Analytical Methods for Radium-226

Method	Reference	Methodology	Minimum Detectable Level^a (pCi/L)	Sample Size (mL)	Counting Time (min)	Noteworthy Features
9- Method Ra-05	DOE 1990	Radon emanation; count alpha by ionization chamber or scintillation cell.	na	na	na	Only radium-226 yields radon-222 progeny that has suitable characteristics for detection by an emanation technique; therefore, the procedure is specific.
10- Method Ra-02	RSI 1982	Radon emanation (for radium-226); count alpha by scintillation cell for radium-226 and by beta/gamma coincidence counter for radium-228.	na	na	na	This method is applicable to water, soil, and air particulate samples and can be used to measure radium-226 alone or radium-226 in conjunction with radium-228.
11- Method 903.0	EPA 1980	Radiochemical/precipitation; counted by alpha scintillation or gas-flow proportional alpha particle counting.	0.5	1,000	100	The method does not always give an accurate measurement of the radium-226 content of the sample (when other radium alpha emitters are present); it can be used to screen samples. Absolute measurement can be made by calibrating the alpha detector with standard radium-226 in the geometry obtained with the final precipitate
12	EPA 1976	Radiochemical/precipitation; count alpha by internal proportional counter.	0.4-0.15	2,000	1,000-60	None.
13- Method Ra-03	EPA 1984	Radiochemical/precipitation; alpha counting by scintillator counter.	na	na	na	Radium-226 in solution is determined by coprecipitation from the sample with barium sulphate. The sample is then analyzed using the de-emanation procedure
14- Method 7500-Ra B	APHA 1995	Radiochemical/precipitation; alpha counting by gas-flow proportional counter, scintillation counter, or thin end-window gas-flow proportional counter.	na	na	na	This method is suitable for determination of the alpha-emitting isotopes of radium.
15- Method 304	APHA 1971	Radiochemical/precipitation; alpha counting by gas-flow internal proportional counter, scintillation counter, or thin end-window gas-flow proportional counter.	na	na	na	This method is designed to measure radium in clear water. It is applicable to sewage and industrial wastes, provided steps are taken to destroy organic matter and eliminate other interfering ions.

Table 3 40 CFR 141.25 Analytical Methods for Radium-228

Method	Reference	Methodology	Minimum Detectable Level^a (pCi/L)	Sample Size (mL)	Counting Time (min)	Noteworthy Features
7- Method Ra-02	RSI 1982	Radon emanation (for radium-226) followed by radiochemical/precipitation (for radium-228); count alpha by scintillation cell for radium-226 and by beta/gamma coincidence counter for radium-228.	na	na	na	This method is applicable to water, soil, and air particulate samples and can be used to measure radium-226 alone or radium-226 in conjunction with radium-228.
8	DEP 1980	Radiochemical/precipitation; count by low-background beta counter.	0.4	1,000	100	Each laboratory that uses this method is required to operate a formal quality control program.

^{a,b} Minimum detectable level is defined as the minimum detectable concentration reported for the method at the 99% confidence level (EPA 1980) or at the 95% confidence level (EPA 1976).
na - information not available.

Other Analytical Methods

WWTPs and CWSs have expressed a concern with the turnaround time and cost of radium analyses. Specifically, analyzing a dewatered 'cake' prior to land application may not be practical due to the fact a radiochemical test result typically requires six weeks for receipt and facilities are required to remove stockpiles of treatment residuals within 60 days. Other methods are available, such as gamma spectroscopy that may expedite sample turnaround and lower analytical cost. However, these may not *always* be viable alternatives based on the amount of solids available in samples, sample size required, or the concentrations of radionuclides present.

IEMA may, upon written application, approve the use of an alternative analytical technique (such as gamma spectroscopy for soils and dry weight basis sludges). An alternative analytical technique shall not be approved unless IEMA determines that the technique is substantially equivalent to the prescribed test both in precision and accuracy. Such approval shall be in writing and performed utilizing the validation procedures in (*EPA 2006, Validation and Peer Review of US EPA Radiochemical Methods of Analysis*). This document covers the method validation parameters for radioanalytical methods and provides guidance to satisfy US EPA requirements for general method validation for measurement uncertainty, method bias and trueness, precision, detection capability, analyte concentration range, specificity, and ruggedness.”²⁹

Because these parameters vary by regulatory program, it is necessary to specify method performance criteria as applicable to Section 330.40(d). The most common measure of detection capability in the field of radiochemistry is the minimum detectable concentration (MDC)²⁹. In general, the MDC is most useful when one does not expect to detect the analyte but wants to know at what level one could reasonably expect to have a positive detection. It is defined and utilized in this guide as:

“For radiochemical methods, the *a priori* minimum detectable concentration (MDC) is used to express detection capability. ... the MDC is “an estimate of the true concentration of analyte [radionuclide] required to give a specified high probability that the measured response will be greater than the critical value.”

'Method uncertainty' is most useful when one expects to positively detect the analyte and wants to quantify it to a certain level of confidence. Given the predisposition of radium to be present in the soil (by means of background) and the treatment residuals (by means of drawing from an aquifer contributing radium and concentrating via treatment), IEMA has elected to set a *method uncertainty* (defined below) for the appropriate sample matrix (field soil or treatment residual). This is based on the typical analyte concentration ranges observed for each sample matrix, the recommendations of (*EPA 2006, Validation and Peer Review of US EPA Radiochemical Methods of Analysis*), and the need to adequately quantify concentrations for compliance with the regulatory limits established in Section 330.40(d). This method validation parameter is a guideline and may be reviewed by IEMA on an as-needed basis.

“Method uncertainty* is defined as the 'predicted uncertainty of a result that would be measured if a method were applied to a hypothetical laboratory sample with a specified radionuclide activity or concentration'....For most radiological projects having regulatory limits for radioactive materials, a required method uncertainty at an action level (i.e., regulatory limit for the radionuclide) is considered essential to assure the quality of data used in statistical analyses and hypothesis testing” .²⁹

In proposing alternative analytical methods for approval:

Field Soil Samples:

- The method uncertainty specified for field soil samples, at a typical combined radium environmental concentration of 2.0 pCi/g, is 0.2 pCi/g for radium-226, at the 95% confidence level.
- The method uncertainty specified for field soil samples, at a typical combined radium environmental concentration of 2.0 pCi/g, is 0.2 pCi/g for radium-228, at the 95% confidence level

Treatment Residuals:

- For sludges or treatment residual samples, the relative required method uncertainty for each radionuclide (radium-226 and radium-228) is specified at 0.10 (10%), at the 95% confidence level.

****Method uncertainty should not be confused with measurement uncertainty, which MARLAP and the International Organization for Standardization (ISO) (1993a) define as: “[the] Parameter associated with the result of a measurement that characterizes the dispersion of the values that could reasonably be attributed to the measurand.”²⁸ (I.e., the “+/- .2” in 2.7 +/- .2 pCi/g)***

If licensable concentrations of source material are found at systems, the IEMA LLRW Section should be consulted.

Sources of information on alternative methods are available from US EPA. In the process of completing the ISCORS Assessment³, NRC and US EPA selected 313 WWTPs to be sampled. The selection emphasized WWTPs with the greatest potential to receive waste from licensees and in areas with higher levels of naturally occurring radioactive material (NORM). Approximately half of the samples were analyzed by the U.S. Department of Energy's Oak Ridge Institute for Science and Education (ORISE) in Oak Ridge, Tennessee, under contract to NRC, and the remainder were analyzed by the EPA's National Air and Radiation Environmental Laboratory (NAREL) in Montgomery, Alabama.² The published methods used in the report are demonstrated to be acceptable analytical procedures by both the U.S. Department of Energy's Oak Ridge Institute for Science and Education (ORISE) in Oak Ridge, Tennessee, and EPA's National Air and Radiation Environmental Laboratory (NAREL) in Montgomery, Alabama. Individual SOP references for each laboratory are referenced in Appendix B of the source document. Further information on additional analytical methods applicable to radium-226 and radium-228 in both water and soils is available in “Inventory of Radiological Methodologies For Sites Contaminated With Radioactive Materials. EPA 402-R-06-007”.