TENORM Policy and Guidance, Revision 2014

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Appendices (Proposed and in development)

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Policy Statement

It is the mission of the Colorado Department of Public Health and Environment to protect and improve the health of Colorado's people and the quality of its environment and as a result it is the policy of the Department to limit the potential annual exposures resulting from the radiations associated with TENORM and unimportant quantities of source material to a maximum of 25 mrem above background for any individual member of the public.

Overview

In February 2007, the Department issued the Final Draft Interim Policy and Guidance Pending Rulemaking for Control and Disposition of Technologically-Enhanced Naturally Occurring Radioactive Materials in Colorado, Rev 2.1 (2007 Policy). Subsequent rulemaking did not address technologically-enhanced naturally occurring radioactive material (TENORM) issues and the anticipated expansion and revision to include guidance for oil and gas-related TENORM was not developed. However, in the intervening time, significant experience has occurred in applying the TENORM policy to water treatment residuals, contaminated soils, and other materials. As a result of this experience, regulatory changes, and the progression of certain industries, resulting in production of additional TENORM materials, the policy document requires updating and revision.

One significant regulatory change was the alignment of the Colorado regulatory definition for source material with that used by the Nuclear Regulatory Commission. The previous Colorado definition excluded materials that contain by weight one-twentieth of 1 percent (0.05 percent) or less of uranium, thorium or any combination. However, to be compatible with the NRC, the broader NRC definition was accepted that specifies uranium or thorium, or any combination thereof, in any physical or chemical form. The TENORM definition excludes source material, thus low levels of uranium or thorium could not be included. The NRC addresses the low level uranium and thorium through their definition as "unimportant quantities" of source material (UQ). This policy intends to include unimportant quantities of source material and NORM along with TENORM to allow the department to consider alternative mechanisms for management of the material without invoking radioactive materials licensing and still providing for the protection of public health and safety.

Another change is the shifting of the focus of the policy from a industry or material-specific (for example, drinking water residuals) approach to a general approach to any media that contains TENORM (diffusely contaminated soil-like materials, liquids, surface-contaminated objects). Individual guidance volumes will be developed specific to an industry or situation, such as drinking water residuals, oil and gas (O&G) produced water, wastewater biosolids, etc. It is expected that the guidance may expand over time as more information is gleaned from experience and from the identification of additional TENORM or UQ sources.

The basic concept of the policy document and associated guidance has not changed: provide a protective standard to protect public health and develop mechanisms to address radiation protection requirements while minimizing additional regulatory structure or burden.

The policy continues to utilize a process that is simple, equitable, consistent and predictable. It provides generic steps for TENORM and UQ management and disposal. The previous policy identified a stepwise approach for the evaluation of the potential dose posed by the residuals and materials. This approach is retained in the revised policy and guidance with modifications to also define default management options for a wider range of materials. In addition, the current case-by-case approach will be retained as an option for those entities with the resources to pursue a more detailed and facility or site specific evaluation of the potential dose.

Basis and Purpose

This policy and its associated guidance material is intended to provide a tool to be used by both private sector facilities and industries and regulatory agencies to make decisions on the handling and disposition of technologically-enhanced naturally occurring radioactive material (TENORM) and unimportant quantities of source material (UQ).

It has become apparent that naturally occurring radioactive materials are becoming more and more prevalent in our world as technology progresses and we continue to recover and refine or process our natural resources in more efficient ways. The geology of our state dictates that Uranium, Thorium, Radium and their radioactive progeny are common materials that are typically contained in the waste streams of these natural resource recovery operations. Activities such as drinking and waste water treatment, oil and gas exploration and production, metal mining and refining, and various others remove these naturally occurring materials as part of their process and the resultant waste stream or residual material needs to be managed. As time progresses there are technological developments that allow for the introduction of more of these materials and the ability to further concentrate them as a result of increased production and efficiency. Additionally, over time the understanding of and concern regarding the potential hazards associated with these materials increases as well.

A national and international effort to identify sources of these materials has resulted in a better, but still incomplete, understanding of the scope of the situation. As a result it is no longer practical to address these issues only in terms of a specific industry or process or event. This type of approach leads to inequity and confusion for private sector facilities and industries as well as regulatory agencies.

Unfortunately, at this time there is no federal regulatory structure for the handling and disposition of many of these materials. In order to address this issue in a way that provides consistency and equity, the policy sets a basic standard that the department has determined to be protective of public health and consistent with regulatory standards regarding unrestricted, unregulated, and unlicensed radioactive materials and the potential impact to individual members of the public.

This policy is not a regulation nor is it intended to be a document from which regulatory enforcement originates. However, the document is intended to provide the department's position on a threshold which provides reasonable protection to members of the public from the hazards associated with the handling and disposition of these materials as well as a guide for the department to make decisions on whether or not a chosen course of action, such as an industrial operation or a disposal method, is appropriate and protective in terms of the basic standard as described by the policy. Additionally, it is the intention for the policy and guidance to provide that same level of guidance in terms of decision making for private sector entities to make informed decisions in order to best manage these materials and the potential liabilities associated with improper handling or disposal.

Applicable Regulations

The U.S. Environmental Protection Agency (EPA) has federal jurisdiction over TENORM, but has chosen to not promulgate specific regulations yet for these materials. The U.S. Nuclear Regulatory Commission does not regulate NORM or TENORM materials except in narrowly defined cases. Under the Radiation Control Act , Colorado has authority over all forms of radioactivity, including NORM and TENORM. Colorado exercises discretion on regulating materials that do not pose a health or environmental risk and may rely upon other existing regulatory authorities to address radiation, if those programs meet the protectiveness required.

Other Regulations that apply to materials that potentially contain TENORM or UQ materials include:

- Regulations Pertaining To Solid Waste Sites and Facilities (6 CCR 1007-2)
- The Colorado Primary Drinking Water Regulations (5 CCR 1003-1).
- Surface Water Quality Classification and Standards (5 CCR 1002-31) (Regulation 31)
- Basic Standards for Ground Water (3.11.0) 5 CCR 1002-41 (Regulation 41)
- Beneficial Use of Water Treatment Sludge and Fees Applicable to the Beneficial Use of Sludges
- Pretreatment Regulations (Regulation 63) (5 CCR 1002-63)
- Biosolids Regulations (Regulation 64) (5 CCR 1002-64)
- Omnibus Low-Level Radioactive Waste Interstate Compact Consent Act, P.L. 99-240
- Rules of The Rocky Mountain Low-Level Radioactive Waste Board

Regulation vs. Policy

The Suggested State Regulations for Control of Radiation

The Conference of Radiation Control Program Directors, Inc. (CRCPD) is a professional organization made up primarily of radiation professionals in State and local government that regulate the use of radiation sources. The CRCPD publishes **The Suggested State Regulations for Control of Radiation (**SSRCR**),** a dynamic document that's revised and updated on an ongoing basis. The SSRCRs consist of a number of Parts that relate to various aspects of radiation regulation.

The Colorado Radiation Control Act requires that when rules for radiation control are promulgated that they shall be consistent with **The Suggested State Regulations for Control of Radiation** proposed by the CRCPD, unless the Board of Health concludes that a substantial deviation is warranted .

The SSRCRs contain a volume, PART N - Regulation & Licensing of Technologically Enhanced Naturally Occurring Radioactive Material (TENORM), which lays out a regulatory scheme for TENORM.

The contents of this Colorado policy are not, and are not intended to be, a regulatory scheme based on the SSRCR Part N, and as a result there are some variations between the policy's approach and that of Part N.

Specifically, there are some different approaches to the thresholds for licensing, certain exemptions, doses to the public, disposal criteria, and beneficial reuse, among others. It is difficult to make a direct comparison of the policy to Part N because one is a regulatory scheme that depends on radioactive materials licensing and oversight by a radiation control agency and the other is a policy that would allow for flexibility in licensing and for materials to be regulated by their current regulatory agencies.

The Part N SSRCR is currently open for revision by CRCPD and it appears that there could be significant changes made to that document as a result of the same issues that prompted the revision of this policy and guidance. Early discussions on Part N revisions and work done by another CRCPD working group investigating current issues and policies regarding TENORM indicate that Colorado is working toward a policy that would be consistent with their approach to TENORM regulation.

Application of the policy

This policy applies to those materials that are less than the concentrations which would require a radioactive materials license to possess. Radioactive materials that would require licensing would be subject to all of the requirements and provisions of the Colorado Rules and Regulations Pertaining to Radiation Control 6CCR 1007-1 (the Regulations.)

TENORM and UQ Materials

Radioactive materials can be present in a wide variety of media due to contamination, inadvertent concentration or through natural processes. In some cases, these media can contain radioactivity at a level that creates a potential for worker or public exposure. The more common media potentially containing TENORM or UQ materials include diffusely contaminated soil-like materials, liquids, and surface-contaminated objects.

Diffusely contaminated soil-like materials are generally solids with TENORM or UQ materials spread throughout the material. As solids, these materials can be handled and packaged using common techniques and equipment, and may be generated from treatment of liquids containing radioactive materials, unintentional concentration through refining or combustion, and other processes. Risk pathways associated with these materials include direct exposure, dispersal through handling, wind or water erosion, and leaching into surface or ground waters. These soil-like materials may be managed for beneficial reuse in compost, inert fill or agriculture, and are often disposed in solid waste landfills. Each of these activities may be subject to solid waste regulation, and agricultural beneficial reuse may be subject to solid waste or water quality regulation.

Liquid materials are generated through groundwater extraction and water treatment. Drinking water regulations have driven greater removal of contaminants from domestic and industrial water supplies, and some treatment options generate liquid wastes that contain concentrated TENORM or UQ. Often the efficiency of the process results in materials that exceed TENORM or UQ specifications and require a radioactive materials license for management and disposal. Other materials may have levels of TENORM and UQ that allow for discharge or beneficial reuse. Risk pathways associated with the materials include direct exposure, dispersal through discharge to surface or ground waters, and contamination of solid materials subject to disturbance or wind dispersal. These materials may be discharged to surface water, ground water or sanitary sewers, or beneficially reused for dust control, irrigation, or other applications. Discharges are regulated through water quality regulations, and radiation regulations in some cases. Beneficial reuse may be regulated through water quality, solid waste or radiation regulations.

Surface-contaminated objects are generally equipment or piping where TENORM or UQ has been deposited due to pressure, temperature, or chemical changes. The materials are typically found at oil and gas operations, water treatment systems, mining facilities, and power plants where the naturally occurring radioactive materials can concentrate on interior surfaces of processing equipment. The materials are in solid form and often strongly fixed to the contact surface, therefore risks are largely due to direct exposure or possibly disturbance and inhalation. These materials are often detected in scrap piping and equipment by gate or portal alarms at landfills and metal recycling facilities. Depending on the degree of concentration, the objects may require disposal at a radioactive materials facility. In other cases, disposal at a landfill or use as scrap may be allowed. Surface-contaminated objects may be regulated through either solid waste or radiation regulations.

Source Material

The Part 3 Section 3.2 of the Regulations, exempts materials that are by weight less than 0.05% source material (uranium and thorium) from licensing. This equates to approximately less than 339 pCi/g of natural uranium and 55 pCi/g natural thorium.

Radium

The Regulations do not have a similar exemption from licensing for radium. As a result the department has determined that in order to provide some regulatory relief an exemption to the licensing requirements for radium-226 and 228 and its progeny may be granted for TENORM materials. The potential exemption from licensing is granted as a provision of this policy and is set at equal to or less than 50 pCi/g for combined radium (Ra-226 + Ra-228). (Materials with slightly higher concentrations of radium may also be eligible for licensing exemption depending on the nature of the situation.)

For those instances when progeny of radium exist by themselves the department would likely apply the same value to those materials individually, i.e. equal to or less than 50 pCi/g of each daughter radioisotope of radium.

The following basic criteria as described above, has been retained from the previous policy:

Materials that do not exceed the following limits may be managed **without consideration of the radioactive constituents**:

Combined Ra-226/Ra-228	3 pCi/g above background
Natural Uranium	30 pCi/g above background
Natural Thorium	3 pCi/g above background

Materials that exceed the following limits **will require a radioactive materials license** and will be directly regulated by the Radioactive Materials Unit:

Combined Ra-226/Ra-228	50 pCi/g above background
Source materials greater than 0.05% by mass:	
Natural Uranium	339 pCi/g above background, or
Natural Thorium	55 pCi/g above background

If both U Nat and Th Nat are present unity applies. (i.e. the sum of the fractions of the limits for U Nat and Th Nat may not exceed 1.)

Operational exposures above 25mrem

In addition to the above mentioned requirements for a radioactive materials license, it is likely that the department would require a radioactive materials license for the possession and handling of TENORM and UQ materials if it is likely that the operations involving the handling of the materials would cause a member of the public, including non-radiation workers, to receive an exposure in excess of 25 mrem in any year.

Technical issues

Radon

Radon gas, specifically radon-222, is generated as a result of the decay of radium-226. This gas tends to migrate through different media into areas that may be occupied by individuals. Radon has a short half life of 3.82 days and quickly decays producing a number of different daughter radionuclides. These daughter radioisotopes then are available for inhalation and deposition within the lungs of humans who breath in areas that have radon in the air. The radioactive decay of these radioisotopes within the lungs can cause biological damage and result in detrimental health effects.

Because TENORM and UQ quite frequently involve radium-226 the department has determined that risk from radon should be included in assessments regarding the handling and disposition of these materials. This exposure pathway has been frequently excluded from these types of risk assessments in the past but models demonstrate that there are many possible scenarios that would result in the dose from radon comprising a very significant portion of the potential dose to an individual member of the public and cannot be ignored as a potential hazard resulting from the handling and disposition of TENORM and UQ materials.

When developing a risk assessment for a particular scenario there are many variables that are difficult to predict. In most instances it is common to take a conservative approach to each possibility but in the case of radon the hazard is really only a concern in the cases in which there is a closed in space such as a residential or industrial structure and an individual spends time in that closed space. Due to the variability in construction, size, ventilation rates, and other factors that are specific to a structure it is difficult to reasonably represent the likely dose that an individual would receive. Depending on the assumptions that are made a model can produce results that are either significant or insignificant in terms of risk or dose for a structure with small differences in the attributes listed above.

As a result the department has chosen to include the potential dose from radon in assessments but to allow for the dose from radon to be subtracted for the purposes of meeting the 25 mrem standard as long as other measures are taken to ensure that the hazards from radon are mitigated in the future. The department considers it appropriate to use institutional controls, such as environmental covenants on property, that would, for any future buildings, require radon resistant construction, post construction assessment and testing, and radon mitigation in order to meet any federal, local, or Colorado standards or guidance on indoor radon concentrations.

25 mrem per year

The department has determined that selecting 25 mrem annually as the policy standard is consistent with the current regulatory structure that applies to licensed radioactive materials and provides protection to public health that is equivalent to the protection provided for any specifically regulated facility containing radioactive materials once they are released for unrestricted use.

Within Section 4.14 and Section 4.61 of the Regulations there are two basic standards that would apply to dose limits to members of the public.

The first is applicable to doses to individuals as a result of licensed operations and those under the control of a radioactive materials licensee, and limits exposures to 100 mrem per year.

The second standard is applicable to sites or facilities that contain radioactive materials and are being considered for release from the control of a radioactive materials licensee. This standard dictates that sites that have radioactive materials present as a result of licensed activities may only be released from the control of a licensee if certain radiological criteria are met. Whether a site that contains any residual radioactive materials is to be released for restricted or unrestricted use the Regulations require that those materials be reduced to levels that are as low as reasonably achievable (ALARA) and that no individual should receive a dose in excess of 25mrem in a year.

As a result of the exemptions from radioactive materials licensing that apply to the materials addressed within this policy, the materials and sites that contain these radioactive materials are not controlled by a radioactive materials licensee. The department has concluded that TENORM and UQ radioactive materials, the sites that contain these materials, and the scenarios in which these materials are handled

and dispositioned are more equivalent to the condition of an unlicensed site containing radioactive materials which is released for restricted or unrestricted use and therefore selected the 25mrem/year standard for the policy.

Background

As stated in the policy statement the standard of 25 mrem per year is that dose which is in addition to any background dose. Based on that premise, when performing risk or dose assessments, background concentrations may be subtracted from the radionuclide concentrations that are contained within the materials that are subject to the assessment.

The policy contains some generic background concentrations for Radium, Uranium and Thorium. If it is desired to establish a background specific to the site that is being assessed that is appropriate. The department would recommend that the background be established as per the following characterization protocols:

- EPA's Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM), or
- EPA's Guidance for QA Project Plans (EPA QA/G-5) and Guidance for Choosing a Sampling Design for Environmental Data Collection (EPA QA/G-5S), or
- EPA's SW-846, Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, Chapter nine: Sampling Plan

The department has concluded that for the purposes of this policy when assessing handling or disposal scenarios that the background values be those published within the policy or those established by characterizing the site for which the assessment is being performed. The spirit of the policy is to limit the dose from radioactive materials to any individual, to no more than 25 mrem/year in excess of that which would have been received in that same place and scenario, had the activities and operations that resulted in the presence of TENORM or UQ not taken place. It would not be appropriate to try and make comparisons of a background concentration at a remote site, such as a different geographical area of the state or the subsurface environment, to the conditions at the site in which an evaluation is being made. This is the state of practice and routine method used for any risk/dose assessment that would be prepared for licensed materials and the department recognizes no compelling reason to divert from this normal course.

Speciation-isotope specific analysis

As a result of a reference to 40 pCi/g gross alpha concentrations in both the water quality control commission and solid waste regulations regarding the disposal or beneficial use of water treatment plant sludges, there has been some confusion in regard to the need for materials to be analyzed to determine the isotope specific concentrations.

This policy and associated guidance are based on the potential dose to a member of the public. Although many of the naturally occurring radioactive isotopes emit alpha particles with similar energies,

each element (such as Uranium, Thorium, or Radium) will behave differently in the human body. Human biochemistry and biological processes accumulate different elements within different portions of the body, with differing efficiencies as well as differing retention times. As a result one amount of an alpha emitter may deliver a greater dose than the same amount of a different alpha emitter when they are introduced in to a human body. While a gross alpha determination may provide information on radioactivity of a sample it does not provide information on what elements are present in a material and as a result does not provide adequate information to determine a potential dose from exposure to the materials. Because the potential exists for different radioactive elements to be present in materials of concern and dose contribution to an individual is not directly relatable to a gross alpha determination it is important to identify which radioactive isotopes are present. Therefore, the analysis of the materials of concern must be an isotope specific analysis to accurately predict the potential dose that may be delivered to an individual. Additionally, many of the radioisotopes associated with TENORM and UQ materials do emit alpha particles when they decay and these radioisotopes may also contribute to a dose to an individual.

Finally, because of the differing geochemistry or elemental chemistry there also exists differing potentials for the elements to be mobile in certain environments and materials, and to be concentrated in others. This makes it very difficult to predict what elements and or isotopes may be present in an unknown sample.

Without knowing the specific isotopes present in a material it is unlikely that a reasonable assessment of potential dose could be performed. For example, there are materials such as iron precipitate that will selectively adsorb and concentrate radium but not uranium, there are cation exchange resins that will selectively remove uranium but not capture radium, radium is likely to be found in barite scales where uranium is not, polonium is likely to be found in natural gas transport lines and tanks but radium and uranium would not, and all of these elements and their isotopes would have differing potential effects on an individual in terms of dose.

Because of the differing potential contributions from different elements and isotopes, risk or dose assessments should only be based on specific isotopic data in order to accurately predict the potential dose to a member of the public.

In regard to the regulatory citations that reference the 40 pCi/g value they read as follows:

- Colorado Solid Waste Regulations 6 CCR 1007-2: Part 1 - Regulations Pertaining to Solid Waste Disposal Sites and Facilities: Section 12 Water Treatment Plant Sludge
    - Section 12.2.1: "If the total alpha activity of the sludge exceeds 40 picocuries per gram of dry sludge, the sludge generator shall contact the Department's Radiation Control Division for further disposal guidance."
- Water Quality Control Commission 5 CCR 1003-7: Beneficial Use Of Water Treatment Sludge And Fees Applicable To The Beneficial Use Of Sludges
    - Section 3.C: "No person shall undertake the beneficial use of water treatment plant sludges which exceed 40 picocuries total alpha activity per gram of dry sludge."

Both of these provisions were developed to avoid the beneficial use of or the disposal as solid waste of water treatment plant sludge that had radioactivity at levels above background. The threshold was developed based on an estimate of gross alpha activity in soils in Colorado at the time of regulatory promulgation. As it has become clearer that the likelihood of TENORM and UQ materials having an isotopic distribution equivalent to that which occurs naturally in soils in Colorado is very unlikely the gross alpha value becomes less useful as an indicator of the presence of isotopes in concentrations above background. For example, materials that are the result of the selective removal of radium and that have 35 pCi/g radium-226 would not exceed the 40 pCi/g gross alpha standard but would clearly exceed the 1.4 pCi/g radium-226 background and would, in many disposal scenarios, exceed the 25 mrem per year dose standard.

Definitions

From *Colorado Rules and Regulations Pertaining to Radiation Control*:

Naturally occurring radioactive material (NORM) means any radioactive material that is not byproduct, source, or special nuclear material, produced in an accelerator, or by-products of fossil-fuel combustion, including bottom ash, fly ash, and flue-gas emission by-products.

Technologically enhanced naturally occurring radioactive material (TENORM) means naturally occurring radioactive material whose radionuclide concentrations are increased by or as a result of past or present human practices. "TENORM" does not include:

(1) Background radiation or the natural radioactivity of rocks or soils;
(2) "Byproduct material" or "source material", as defined by Colorado statute or rule; or
(3) Enriched or depleted uranium as defined by Colorado or federal statute or rule.

Byproduct material means:

(1) Any radioactive material, except special nuclear material, yielded in or made radioactive by exposure to the radiation incident to the process of producing or utilizing special nuclear material;
(2) The tailings or wastes produced by the extraction or concentration of uranium or thorium from ore processed primarily for its source material content, including discrete surface wastes resulting from uranium or thorium solution extraction processes (underground ore bodies depleted by these solution extraction operations do not constitute “byproduct material” within this definition);
(3) Any material produced, extracted, or converted after extraction, for use for a commercial, medical, or research activity, that:
    (a) Is a discrete source of radium-226; or
    (b) Has been made radioactive by use of a particle accelerator; or
(4) Any discrete source of naturally occurring radioactive material, other than source material, that:
    (a) Is extracted, or converted after extraction, for use for a commercial, medical, or research activity; and

(b) Is determined by NRC to pose a threat to the public health and safety or the common defense and security similar to the threat posed by a discrete source of radium-226.

Source material means uranium or thorium, or any combination thereof, in any physical or chemical form, including ore that contains by weight one-twentieth of 1 percent (0.05 percent) or more of uranium, thorium or any combination thereof. Source material does not include special nuclear material.

"Natural thorium" means thorium with the naturally occurring distribution of thorium isotopes (essentially 100 weight per cent thorium-232).

"Natural uranium" means uranium containing a mixture of the uranium isotopes 234, 235 and 238 (approximately 0.7 weight percent uranium-235 and the remainder by weight essentially uranium-238) that is neither enriched nor depleted in the isotope uranium 235.

From U.S. Nuclear Regulatory Commission Regulations (10 CFR 40.13):
Unimportant quantities of source material (UQ) means source material in any chemical mixture, compound, solution, or alloy in which the source material is by weight less than one-twentieth of one percent (0.05 %) of the mixture, compound, solution or alloy.

TENORM/UQ Approval Process

Situations involving TENORM/UQ determinations can arise in various ways, and result from different circumstances. The need for a determination can result from permitting activities, remedial actions, incidents or routine operations. Application of the TENORM/UQ policy can be initiated in several ways:

- Direct request to the Radioactive Materials Unit
- Referral to the Radioactive Materials Unit from another department entity (solid waste, drinking water, wastewater)
- Identification by department staff from inspection, incident report or other means

In all cases, the initial contact should include, to the extent available:

- the current state, condition and location of the material
- any chemical or radiological characterization information
- the origination of the material through process knowledge or documentation
- contact information for the possessor and/or owner of the material
- The planned disposition of the materials (Disposal, beneficial reuse, storage, transfer, etc.)

The driving force for an action related to the materials is also needed. For example, the material is waste and requires disposal; the material requires handling to accommodate other activities; or the material has been discovered and inadvertently possessed.

If insufficient information is available to characterize the material, additional characterization is necessary. Existing regulatory requirements in solid waste and water quality may specify characterization details; however, associated guidance documents will seek to provide both the existing requirements as well as some generic sampling and analysis approaches.

The characterization information will be compared to the generic criteria discussed below for appropriate actions related to the material, and staff will determine or approve acceptable options. Recommendation will be made by staff, and consultation with other potentially-affected department staff will follow. The determination will be relayed to the owner/possessor of the material with direction for subsequent actions. Documentation may vary for different programs, but will be shared among affected staff. Staff will be available to discuss the evaluation and results with the owner/possessor, as appropriate.

It should also be made clear that any acceptable concentrations or levels established within this policy should not be construed as provisions for the disposal or disposition of higher-activity materials by mixing and dilution with clean material. This would be considered radioactive waste dilution and is inconsistent with federal and state radioactive waste handling policy and regulation. There may exist options for blending higher concentration materials with lower concentrations materials under certain controlled conditions, if approved by the Department.

Potential Exposure Pathways

In order to evaluate acceptable management options for various materials, an understanding of exposure pathways and levels is necessary. Consideration of exposure pathways utilizes a conceptual model where material presence and movement through the environment is mapped. Once pathways are determined, exposure levels can be defined. This approach and results are discussed below for each media.

Diffusely Contaminated Soil-Like Materials may exist in the form of soil, water treatment residuals (alum sludge, raw sludge, resins), cuttings from well drilling, ash or slag from incineration or smelting processes, tailings from (non-uranium or thorium) milling and wastewater treatment residuals (grit, biosolids). As solids, each of these materials has differing characteristics that affect the potential pathways of exposure. Potential pathways for solids are discussed below:

- External exposure is essentially when one comes into contact or is in close proximity to the material allowing for the radiations to interact with tissues of an individual. While external exposure is time dependent, in some cases the materials may contain enough activity that external exposure presents a health impact.
- Direct contact: an additional concern is that if one comes in direct contact with materials, transfer of the material may occur resulting in inhalation or ingestion of the material. Some materials are more susceptible to degradation with contact, such as soil, raw sludge, ash, cuttings, grit and biosolids.

- Wind erosion can disperse materials making them more likely to be contacted, inhaled or ingested, or disseminated further, leading to movement in the environment and increased chances of exposure.
- Water erosion can also disperse materials making them more likely to be contacted, or disseminated further, leading to movement in the environment and increased chances of exposure.
- Contaminants in the solids in contact with moisture can leach out and move into surface water making them more likely to be contacted, or disseminated further, leading to movement in the environment and increased chances of exposure.
- Contaminants in the solids in contact with moisture can leach out and move into ground water making them more likely to be contacted, or disseminated further, leading to movement in the environment and increased chances of exposure.
- Handling or spills of the material can change the degree of movement of the material and introduce it into other pathways of exposure. Spills of solid materials can be readily addressed; however, if ignored dissemination can be accelerated.
- Some solids may be applied to land surfaces, which can create additional pathways as described above. In addition, vegetation may absorb contaminants from the soil that are incorporated into the vegetative matter, making it available for human or animal consumption.

Liquid materials such as water treatment backwash, water treatment brines, oil & gas produced water and other produced water can move more quickly in the environment if inadequately contained. Pathways for liquids are similar to that for solid materials; however, intermediate steps may be abbreviated. Pathways of concern include:

- External exposure may occur; however, high levels of contaminants are necessary for this to result in significant exposure.
- Direct contact: Ingestion and inhalation can result from direct contact to liquids.
- Liquids can move directly into surface water, enhancing the dispersion and potential for exposure.
- Liquids can move directly into ground water, enhancing the dispersion and potential for exposure.
- Liquids may be applied to land surfaces for dust control or irrigation, or as soil amendment. As the water component of the liquid evaporates, contaminants may be collected on or concentrated in the soil, which leads to the pathways described above. In addition, vegetation may absorb contaminants from the soil that are incorporated into the vegetative matter, making it available for human or animal consumption.

Surface contaminated objects include piping, equipment and other items where TENORM or UQ material has been deposited. Normally, changes in pressure, temperature, or chemistry cause metals to plate out on the interior of these devices, much like calcium deposits in a shower stall. These metals may include both TENORM and UQ, but also decay progeny of these materials such as lead or polonium. Exposure pathways include external exposure and direct contact causing a disturbance of the material

that could result in inhalation or ingestion. Other pathways described above are unlikely exposure routes for this material.

Generic dose assessments to determine activities and dispositions acceptable to the Department will be developed over time, and included in the guidance, for some of the scenarios described below to determine what activity level of the material would limit an exposure to less than 25 mrem per year. Conservative estimates consistent with ALARA will be used in models used for dose assessment. The details of generic assessment parameters for each will be included.

Activities likely to be evaluated for each matrix or medium include:

Liquids:

- Storage and evaporation
- Discharge to Sewer
- Discharge to Surface water
- Discharge to ground water
- Deep Well Injection
- Beneficial reuse: Land application: road dust suppression
- Beneficial reuse: Land application: agricultural irrigation

Solids:

- Beneficial reuse: Land application: agricultural application
- Disposal in RCRA D solid waste landfill
- Disposal in RCRA C hazardous waste landfill
- Disposal by land burial on site
- Beneficial reuse: Compost feed

Surface contaminated objects:

- Disposal in RCRA D solid waste landfill
- Disposal in RCRA C hazardous waste landfill
- Descaling activities and management of solids

Generic Evaluation Criteria

The 2007 Policy relied on exposure assessments and process knowledge to develop a tiering system suitable for a generic determination of disposal options for TENORM.

As a function of the new policy, generic disposition criteria and the associated values for the radionuclides of interest will be developed over time using new and existing exposure assessments, process knowledge, input from industry and stakeholders, and the most current information to be included in the guidance appendices. The values Used in the departments assessments will be based on conservative assumptions and described within the details of each assessment. Generic values may be used to make determinations on disposition of materials without further analysis, however, a more detailed review and assessment with site specific information may be presented to the Department for review and approval.

Site Specific Assessments

In some occasions there may be conditions or parameters that exist for a certain disposition that do not align with the generic assessment performed by the department and would therefore not be automatically approved. In those cases the department would accept alternate assessments performed using site specific and activity specific information that demonstrate that the activity meets the 25 mrem per year policy threshold.

Because we live in a diverse state with many differing climates and geologic characteristics it is likely that there may be sites that are more protective in terms of potential dose and would therefore potentially warrant a higher value for the radionuclides to be dispositioned. Examples of this would be; an incomplete path to groundwater, little to no annual precipitation, cover thickness and material density, etc. Please note that in these cases consultation with the department before completing the assessment is recommended to ensure that the approach and scope would satisfy department expectations.

Appendices:

Specific Guidance for TENORM and UQ materials

*These items will likely incorporate information from the previous policy and guidance with little or no revision.

Appendix A
Regulatory Basis for TENORM Policy and Guidance [in development]

Radiation Control Act

The U.S. Environmental Protection Agency (EPA) has federal jurisdiction over TENORM, but has chosen to not promulgate specific regulations yet for these wastes. Colorado has authority over all forms of radioactivity, including NORM and TENORM. Colorado exercises discretion on regulating materials that do not pose a health or environmental risk.

The authority is found in the *Radiation Control Act* (RCA) (CRS 25-11-101 et seq), which states:

> "The department shall develop and conduct programs for evaluation and control of hazards associated with the use of any and all radioactive materials and other sources of ionizing radiation, including criteria for disposal of radioactive wastes and materials to be considered in approving facilities and sites pursuant to part 2 of this article."

TENORM is regulated under Part 1 of the RCA.

The regulatory scheme is not discrete, but is rather distributed throughout the RCA and the implementing regulations. The RCA requires that the Department issue licenses pertaining to radioactive materials, and all radioactive material be disposed of in a licensed facility. However, the implementing regulations provide for relief from the regulations when public health can be protected using other methods.

There was a previous effort to promulgate specific state regulations for disposal of NORM; however, the rulemaking died, and a provision was inserted into the RCA that remains:

> §25-11-104 (1)(b): "The state board of health may adopt regulations concerning the disposal of naturally occurring radioactive materials at any time after the promulgation by the federal Environmental Protection Agency or its successor of rules for the disposal of naturally occurring radioactive materials."

US Nuclear Regulatory Commission

[being developed]

Colorado Rules and Regulations Pertaining to Radiation Control (6 CCR 1007-1)

The RCA is implemented by the Radiation Program of the CDPHE Hazardous Materials and Waste Management Division through the *Colorado Rules and Regulations Pertaining to Radiation Control* (radiation regulations), specifically Parts 1, 3, 4, 10 and 17. The radiation regulations address licensing, protection of the public and workers from radiation, disposal, worker education, and transportation requirements.

Of particular importance is an exemption found in § 1.5 Exemptions:

> Section 1.5.1 General Provision. "The Department may, upon application or upon its own initiative, grant such exemptions or exceptions from the requirements of these regulations as it determines are authorized by law and will not result in undue hazard to public health and safety or property."

This provision provides the Department with the discretion to manage TENORM, if alternative approaches are protective of public health and the environment. Conversely, the Department has the authority to impose requirements to protect health.

> Section 1.9 Additional Requirements. "The Department may, by rule, regulation, or order, impose upon any licensee or registrant such requirements in addition to those established in these regulations, as it deems appropriate or necessary to minimize danger to public health and safety or property."

Unimportant Quantities of Source Material

This means uranium that is less than about 350 pCi/g or natural thorium that is less than about 50 pCi/g does not require a license to possess or transfer. It is not a health-based exemption, and the Department evaluates each waste stream for protection of workers and public health and the environment.

Part 4 of the regulations addresses dose limits to members of the public and to occupationally exposed radiation workers. The majority of workers who encounter TENORM are considered members of the public and are limited to an annual exposure of 25 mrem per year. In addition,

> Section 4.5.2 "The licensee or registrant shall use, to the extent practical, procedures and engineering controls based upon sound radiation protection principles to achieve occupational doses and doses to members of the public that are as low as is reasonably achievable (ALARA)."

Dose must be reduced as low as is practical below the regulatory limits.

Part 4 also has requirements for disposal of radioactive material (§4.35), with respect to disposal into sewers and for the limits used in determining if material is radioactive with respect to NPDES permitting requirements. In addition, the discharge must be allowed and approved by the local sewerage agency.

Regulations Pertaining To Solid Waste Sites and Facilities (6 CCR 1007-2)

Solid waste management is regulated by the Solid Waste and Materials Management Program in the CDPHE Hazardous Materials and Waste Management Division through the *Solid Wastes Disposal Sites and Facilities Act* (C.R.S. 30-20 Part 1 et. seq., the Act) and the *Regulations Pertaining To Solid Waste Sites And Facilities* (solid waste regulations), specifically Sections 1, 2, 3, 9, 12, 13, 14 and 17.

The Act specifies in Section 30-20-101(6)(b) that:

> "Solid waste" does not include…..(V) Materials handled at facilities licensed pursuant to the provisions on radiation control in article 11 of title 25 C.R.S

This provisions that the facilities managing radioactive materials are appropriately regulated, but not required to comply with overlapping regulations for the same activites. Further Section 30-20-110(1)(c) states:

> "No radioactive materials or materials contaminated with by radioactive substances shall be disposed of in sites or facilities specifically designated for that purpose."

These statutory requirements ensure appropriate management and care of radioactive solid wastes or solid wastes contaminated with radioactive substance such that they do not present an unacceptable risk to human health or the environment.

Section C.R.S. 30-20-119 et. seq. prevents the disposal of low level radioactive wastes at a solid wastes disposal sites and facility without "the express written permission of the appropriate governmental entity which has the authority to grant a certificate of designation…" This section of the statute further states " the appropriate governmental entity "shall require a technical review by the department of the low-level radioactive waste proposed to be disposed… and the department shall make a written recommendation to the governmental entity as to whether such waste shall be accepted." These statutory requirements preserver the dual solid waste regulatory authorities consistent with other section of the Act.

The regulations address administrative requirements, minimum standards, solid waste landfills, waste impoundments, water treatment plant sludge, composting, and commercial exploration and production waste impoundments.

Section 2 and other sections require waste characterization:

> §2.1.2(C) "All sites and facilities, requiring a certificate of designation, shall have a waste characterization and disposal plan approved by the Department and in use for such site and facility. The plan shall outline waste screening methodologies, appropriate waste handling procedures, and waste exclusion procedures which shall be implemented at each facility."

There are numerous provisions of this requirement. The more heterogeneous the facility's waste stream, the more rigorous the facility's waste screening methodologies will need to be in order to have an appropriate statistical power and confidence in waste characterization.

Section 9 includes procedures for classifying impoundments based on their potential hazard. This process uses site features and waste characterization for comparison to groundwater standards. An Engineering Design and Operation Plan, Closure Plan and financial assurance will be required in most cases that include TENORM.

Section 12 provides the requirements for disposal of drinking water treatment plant sludge. Surface and groundwater monitoring may be required, and alum sludge from drinking water treatment plants in excess of 40 pCi/g gross alpha requires notification of the Radiation Program.

Section 14 of the Solid Waste Regulations regulates composting facilities. Composting facilities that accept Type 3 feedstocks (which include sludges) are required to maintain a CD, a Design and Operation

(D&O) Plan and financial assurance. There are also provisions for surface and groundwater protection, windblown and other operational parameters.

Section 17 addresses commercial oil and gas exploration and production waste impoundments. All such impoundments are subject to the stricter requirements of Section 9.

CDPHE Water Quality Control Division

The Colorado Primary Drinking Water Regulations (5 CCR 1003-1).

- Monitoring for rads in produced water
- Residual management plans in design process for new facilities or significant modification to existing facilties

Surface Water Quality Classification and Standards (5 CCR 1002-31) (Regulation 31)

The Basic Standards and Methodologies for Surface Water

- Sets requirements for discharges to surface water
- Includes radionuclides

Basic Standards for Ground Water (3.11.0) 5 CCR 1002-41 (Regulation 41)

- Sets limits applied by Implementing Agency decisions
- Includes radionuclides

Beneficial Use of Water Treatment Sludge and Fees Applicable to the Beneficial Use of Sludges

- Beneficial Use Plan
- Monitoring to include total alpha activity, (and others as directed by the Department)

Pretreatment Regulations (Regulation 63) (5 CCR 1002-63)

- Sets requirements for industrial process water discharges to sanitary sewer collection systems including prohibitions, effluent limits, monitoring, etc.
- Incorporates parts of 40 CFR 403 by reference.
- May require notice of discharge requirements from the WQCD (similar to a permit).
- May require periodic discharge monitoring reports.

Biosolids Regulations (Regulation 64) (5 CCR 1002-64)

- Notice of Authorization for the Use and Distribution of Biosolids
- Biosolids Management Plan
- Monitoring to include sludge and soils at application site
- Radionuclides not specified, but additional monitoring may be directed by the Division
- Annual Self-Monitoring Report

Colorado Oil and Gas Conservation Commission

Statewide Water Sampling and Monitoring (new Rule 609 and amended Rule 318A.e.(4)) (2 CCR 404-1)

Requires baseline and post activity monitoring of ground water

Radionuclides not specified