



# COLORADO

Department of Public  
Health & Environment

Dedicated to protecting and improving the health and environment of the people of Colorado

November 7, 2017

RE: Management and Disposal of TENORM Wastes Generated by Oil and Gas  
Exploration and Production

Dear Solid Waste Landfill Owner or Operator, Oil and Gas Operator, and other  
Stakeholders:

The Colorado Department of Public Health and Environment (CDPHE), Hazardous  
Materials and Waste Management Division (Division), is providing additional  
information for the management and disposal of certain technically enhanced  
naturally occurring radioactive material (TENORM) wastes generated by the oil and  
gas exploration and production (E&P) industry.

The Colorado Solid Waste Act prohibits disposal of radioactive materials and materials  
contaminated by radioactive substances at landfills unless a landfill is specifically  
designated for that purpose (Section 30-20-110(1)(c), C.R.S.). In addition, the  
Colorado Radiation Control Act prohibits a) the possession, ownership, and use of  
radioactive materials without having been granted a license from the department,  
and b) the transfer or disposal of radioactive material without prior approval by the  
department (Section 25-11-107(1), C.R.S.).

After the Division sent out an initial letter on TENORM wastes in May 2017 (since  
rescinded), many stakeholders asked that the Department develop TENORM  
regulations through a stakeholder process. However, since the U.S. Environmental  
Protection Agency has never developed TENORM regulations, the Division is  
specifically prohibited from promulgating TENORM disposal regulations per statutory  
requirements found at Section 25-11-104, C.R.S. Therefore, the Division will pursue  
changes to the Radiation Control Act allowing the development of TENORM  
regulations. If that effort is successful, we will then convene a stakeholder process to  
develop TENORM regulations, including regulations for TENORM management and  
disposal.

Changing the Radiation Control Act and developing TENORM regulations will take  
time. In the interim, the Division will continue to implement the “Interim Policy and  
Guidance Pending Rulemaking for the Control and Disposition of Technologically  
Enhanced Naturally Occurring Radioactive Materials in Colorado” (February 2007) (the  
Interim Policy) with the following modifications:



1. Effective immediately and until further notice, E&P waste streams with the potential for high concentrations of TENORM are prohibited from disposal in all landfills in Colorado not specifically approved and designated to take them unless and until each waste is sampled and tested on a per shipment basis or in a representative and statistically-valid manner consistent with the guidelines provided in Attachment B and found to contain TENORM at levels less than the administrative release levels found in the Interim Policy: combined Ra226+228 < 3 pCi/g, natural uranium < 30 pCi/g and natural thorium < 3 pCi/g, each above background. This includes the following wastes: tank bottoms (solids and liquids), filter socks, filter press cake or sludge, discarded pipe and flow line sections, and residual materials dislodged during cleaning and maintenance activities on pipelines, flow lines, connector pipes, tanks and vessels. The Division will be evaluating the Engineering Design and Operations Plans (EDOPs) for all Colorado landfills not approved and designated to take these wastes and will be modifying the EDOPs as needed to implement this requirement. Attachment A to this letter presents language the Division will be using as a basis for EDOP modifications.
2. Potentially high TENORM E&P wastes (those wastes listed in the previous paragraph) must be managed as having high levels of TENORM until adequate characterization demonstrates they do not. Attachment B to this letter provides information from the Division on acceptable waste characterization for TENORM constituents. Once characterized, if the administrative release levels are exceeded, these high TENORM E&P wastes can be disposed at appropriately approved out-of-state facilities<sup>1</sup> and the following approved and designated disposal sites within the state at the corresponding radionuclide limits:

Colorado Facility Name	Radionuclide Limits
Clean Harbors Deer Trail	Total activity less than or equal to 2000 pCi/g, Ra-226 less than or equal to 222 pCi/g
Pawnee Waste	Combined Radium 226+228 less than or equal to 50 pCi/g, natural Uranium less than or equal to 10 pCi/g, natural Thorium less than or equal to 10 pCi/g, Lead-210 less than or equal to 10 pCi/g, and Po-210 less than or equal to 10 pCi/g
Waste Connections Southside Landfill	Uranium Only less than 339 pCi/g

3. Additional disposal facilities may become approved and designated to take high TENORM E&P wastes in the future. For landfills that intend to seek approval to accept high TENORM E&P wastes, please refer to Attachment C which contains the minimum design and operational requirements that landfills need to have in place

<sup>1</sup> As with import of TENORM waste for disposal in Colorado from states other than Nevada or New Mexico, the export of TENORM waste from Colorado to states other than Nevada or New Mexico must be authorized by the Rocky Mountain Low-Level Radioactive Waste Board ([www.rmlwb.us](http://www.rmlwb.us)).



to receive department approval and designation for these wastes up to the radionuclide levels listed in the attachment without the need to perform a site-specific dose assessment. Alternatively, disposal facilities can seek approval and designation by performing a site-specific radiological dose assessment. All prerequisite information required, and acceptable methods, for performing a site-specific radiological dose assessment are listed in Attachment D to this letter. Once a facility is approved and designated by CDPHE, it may need local government approval and a modification to the facility's Certificate of Designation.

CDPHE will continue to collect radiologic analytical results on potentially high TENORM E&P wastes as well as other E&P wastes generated in Colorado. As we collect sufficient information on one or more waste streams such that the requirements of this letter can be changed, we will send that information out to all interested stakeholders. In addition, as additional solid waste disposal facilities become approved and designated for TENORM wastes, we will inform stakeholders.

If you have any questions regarding the solid waste-related aspects of this letter, please contact Jerry Henderson of the Solid Waste Permitting Unit at 303-692-3455 or [jerry.henderson@state.co.us](mailto:jerry.henderson@state.co.us). If you have any questions regarding the radiological characteristics of these waste streams, or the application of the department's "Interim Policy and Guidance Pending Rulemaking for the Control and Disposition of Technologically Enhanced Naturally Occurring Radioactive Materials in Colorado," please contact Jim Grice of the Radioactive Materials Unit at 303-692-3371 or [james.grice@state.co.us](mailto:james.grice@state.co.us).

Sincerely,



Joe Schieffelin, Manager  
Solid Waste and Materials Management Program  
Hazardous Materials and Waste Management Division

Attachments



## Attachment A

### **Revision to Engineering Design and Operations Plans (EDOPs) for Landfills that either 1) do not meet the Design Requirements in Attachment C, or 2) meet the Design Requirements in Attachment C, but are not yet designated to receive TENORM**

The following language will be used as a guide to develop specific language to be inserted into each Facility's EDOP or stand-alone Waste Characterization Plan, as appropriate. Some landfills may already be prohibited from taking oil and gas wastes generally or the wastes listed here specifically.

According to the Colorado Revised Statute Title 30, Article 20, Part 1 (C.R.S 30-20-110), the Facility cannot dispose of radioactive materials or materials contaminated by radioactive substances unless specifically designated for that purpose.

This Facility has not been designated to receive radioactive materials. Therefore, unless the generator has adequately determined that the waste does not include Technologically Enhanced Naturally Occurring Radioactive Materials (TENORM) above the following levels:

- 3 pCi/g above background for Ra-226/228 combined
- 30pCi/g above background for natural uranium, and
- 3 pCi/g above background for natural thorium,

this Facility must reject (i.e. not accept for disposal) oil and gas exploration and production wastes in the following categories:

- Tank bottoms (solids and liquids),
- Filter socks,
- Filter press cake or sludge,
- Discarded pipe and flow line sections, and
- Residual materials dislodged during cleaning and maintenance activities on pipelines, flow lines, connector pipes, tanks and vessels



## Attachment B

### TENORM Waste: Sampling, Sample Laboratory Analysis Recommendations, and Conversions for Comparison to the Administrative Release Levels

In making decisions on how to characterize different waste streams for TENORM, there are essentially two different categories of waste streams, static and dynamic.

A static waste stream is one that is a result of an essentially constant and consistent process where the input materials are of a consistent character and the output residuals are also expected to have little variability. These static waste streams are eligible for an initial characterization effort followed by periodic verification. In other words, a statistically significant number of samples (as per SW-846) are used to characterize the waste prior to the first waste acceptance and periodic samples are used to verify that the newly collected waste data is not statistically different from the initial data.

A dynamic waste stream is one that is the result of a process that is inherently variable in terms of the inputs into and/or outputs out of the process. These waste streams will require an individual characterization for each load and/or batch of waste. The variability may be the result of variations in raw materials, process time, throughput, geographic area, or other factors that could affect the type or concentrations of constituents within the residual.

#### Analytical Methods:

##### I. Uranium and Thorium:

ICP-MS analysis (Inductively Coupled Plasma-Mass Spectroscopy) (Method 6020)

- Solids (less than ~90% moisture):
  - digested using a SW-846 3050 simple acid leach method
- Liquids (greater than ~90% moisture):
  - digested using a SW-846 3005 simple acid leach method to obtain mg/l
  - Then assay for Total Suspended Solids and Total Dissolved Solids to obtain Mass per volume (i.e. g/l)
  - Finally calculate mg/kg by using the Uranium mass per volume result and the Total Solids mass result

##### II. Radium:

- Solids (less than ~90% moisture)
  - Dried down completely and counted by Gamma Spectroscopy
    - This should provide for a quicker turnaround time.
    - No need for chemical yield testing/correction (the whole sample is present)
  - Dried down completely and counted via EPA drinking water methods (903/904)
    - needs to be reported in pCi/g by taking into account the total mass of the solids that are digested
    - Likely take at least 30 days
    - Depending on the materials there can be significant radium loss using a simple digestion method such as acid leach.
    - Should use a fusion digestion (sodium carbonate for most, pyrosulfate for barite scale like materials that are less likely to yield radium during the digestion)
    - May need to employ chemical yield testing to ensure all of the radium from the sample is captured in the analyzed portion
- Liquids (greater than ~90% moisture)
  - First assayed via EPA drinking water methods (903/904) to obtain pCi/l
  - Then assay for Total Suspended Solids and Total Dissolved Solids to obtain Mass per volume (i.e. g/l)
  - Finally determine pCi/g by dividing the pCi/l result by the g/l result

##### III. Conversions to pCi/g and final numbers for comparison to Administrative Release Levels

- Uranium:
  - Total Uranium in mg/kg
    - Multiply the result by 0.678
  - Uranium as U3O8 in mg/kg
    - Multiply by 0.848 which results in mg/kg Uranium only then,

- Multiply the result by 0.678
  - Once you have pCi/g subtract the background of 2.4 pCi/g
  - The administrative release level value is 30 pCi/g
- Thorium:
  - Multiply the result by 0.678 to obtain pCi/g
  - Once you have pCi/g subtract the background of 1.3 pCi/g
  - The administrative release level value is 3 pCi/g
- Combined Radium 226+228
  - Calculate Ra-226:
    - Subtract the background of 1.4 pCi/g
  - Calculate Ra-228:
    - Subtract the background of 1.3 pCi/g
  - Add the Ra-226 result to the Ra-228 result (negative numbers must be treated as zeros)
  - The administrative release level value is 3 pCi/g



## Attachment C

### **Minimum Design and Operational Requirements to Accept TENORM Wastes Without a Site Specific Dose Assessment**

No TENORM above the administrative release levels (combined Ra226+228 < 3 pCi/g, natural uranium < 30 pCi/g and natural thorium < 3 pCi/g, each above background) can be received by any Colorado solid waste facility until the facility receives specific approval and designation by CDPHE.

The following Design and Operational attributes must be in place, and included in the approved facility EDOP, in order to receive CDPHE approval and designation for the receipt of solid waste containing the following TENORM materials:

- Combined Radium 226+228 less than or equal to 50 pCi/g above background<sup>1</sup>
- Natural Uranium less than or equal to 339 pCi/g above background<sup>1</sup>
- Natural Thorium less than or equal to 55 pCi/g above background<sup>1</sup>
- Lead-210 less than or equal to 50 pCi/g above background<sup>1</sup>

#### Design Requirements:

- Engineered Liner/Barrier must meet 6 CCR 1007-2, Part 1, Section 3.2.5(c)(2) and (3) (1X10<sup>-7</sup> cm/sec hydraulic conductivity);
- Minimum of 3 meters of Non-TENORM materials prior to closure of any area (including Cover);
- Minimum of 4 meters of materials, in addition to the engineered barrier/liner, between the lowest placement of TENORM and groundwater (combination of clean layer at bottom of cell and distance from engineered barrier/liner to groundwater);
- Leachate collection and monitoring system must meet 6 CCR 1007-2, Part 1, Section 3.2.5(d); and
- Groundwater monitoring system must meet 6 CCR 1007-2, Part 1, Sections 2.1.15 and 2.2

#### Operational Requirements:

- No more than 10% of the total volume of wastes containing TENORM materials may be received by the facility;
- A minimum of 12 inches of clean Non-TENORM cover shall be placed on all TENORM wastes on the same day as it is received;
- Leachate must be sampled and characterized for each TENORM isotope received by the facility:
  - If concentrations of TENORM isotopes are detected in the leachate in excess of the groundwater standards, these isotopes must be included in the groundwater monitoring plan;
  - Leachate containing concentrations of TENORM isotopes in excess of the groundwater standards may not be recirculated within the facility without prior written approval from the department;
- Any drill cuttings from methane gas collection system installation shall be placed within the facility on the working face and treated as TENORM waste;
- TENORM received for disposal at the facility shall be characterized in a representative and statistically-valid manner consistent with the guidelines found in SW-846:
  - Characterization data must demonstrate with adequate confidence that the wastes being disposed of at the facility remain below the activity concentrations described above;
  - Samples must be analyzed for their dry weight concentrations and no liquids contained within may contribute to the total mass of the sample;
- TENORM received for disposal shall contain no free liquids as demonstrated by use of the paint filter test (US EPA Method 9095); and
- Following closure of the landfill, an environmental covenant must be placed on the facility property and shall include a specific provision which requires that any future buildings, residential or commercial, constructed on the permitted site post closure, 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;

- Alternatively, the environmental covenant may be more restrictive, i.e. no buildings, residential or commercial, are permitted to be constructed on the site.

*Note 1: Background values for these isotopes have been established by the department as follows: Ra-226 1.4 pCi/g; Ra-228 1.3 pCi/g; Natural Uranium 2.4 pCi/g; Natural Thorium 1.3 pCi/g; Pb-210 1.4 pCi/g*

## Attachment D

### Radiological Dose Assessments for Solid Waste Landfills

A dose assessment for the receipt of solid waste containing TENORM consists of gathering information on the design and operational attributes of a facility, environmental conditions at the facility, the radiological characteristics of the TENORM that is desired to be received, the operational aspects of the facility, and using this information to run models and ultimately assess the potential radiological dose to a member of the public. The standard for acceptance is that no member of the public exceed 25 millirem annually.

#### Models:

- RESRAD-ONSITE
  - This is a computer code designed at Argonne National Laboratory for estimating radiation doses and cancer risks to an individual located on top of radioactively contaminated soils and to derive radionuclide soil guideline levels corresponding to a specific dose criterion.
- MILDOS-AREA
  - The MILDOS-AREA computer code (MILDOS 4) is used to estimate the radiological impacts from airborne emissions from uranium milling facilities. It provides the capability to consider both conventional uranium ore operations and operations associated with in-situ recovery (ISR) facilities. The code is used by license applicants and U.S. Nuclear Regulatory Commission staff to perform routine radiological impact and compliance evaluations for various uranium recovery operations. This code may be used to estimate the Radiological dose from radon (Rn-222) to individuals who may be offsite but in the vicinity of the facility.
- CAP-88 PC
  - The U.S. Environmental Protection Agency's CAP-88 (Clean Air Act Assessment Package - 1988) computer model is a set of computer programs, databases and associated utility programs for estimating dose and risk from radionuclide emissions to air. CAP-88 is a regulatory compliance tool under the National Emissions Standard for Hazardous Air Pollutants (NESHAP). This code may be used to estimate the Radiological dose from radon (Rn-222) to individuals who may be offsite but in the vicinity of the facility.

#### Facility Information:

##### Design:

- Total airspace (total area and depth) of the facility/cell
- Cover design
  - Thickness, density, erosion rate
- Engineered Liner/Barrier
  - Thickness, density, hydraulic conductivity
- Distance to groundwater
  - Unsaturated layer
    - Thickness, density, hydraulic conductivity
- Methane gas collection system:
  - Total gas production
  - Flowrate of exhaust
  - Dimensions of stack (height, diameter)

##### Operations:

- Radiologic data:
  - Isotopes and concentrations
- Percent volume of TENORM waste

- Daily Cover thickness
- Identify Non-TENORM layers potentially at the bottom of the cell or the top of the cell prior to closure
- Leachate collection and monitoring system
  - Recirculation activities
- Groundwater monitoring

**Environmental Conditions:**

- Climate/Weather Data
  - STAR data files
  - Wind and precipitation data

**Modeling Phases/Scenarios:**

Models must be run for the following scenarios:

- Operational Phase
  - Dose to worker during placement of TENORM materials (RESRAD-ONSITE)
  - Dose to worker during placement of Non-TENORM materials (RESRAD-ONSITE)
- Closure Phase
  - Dose to offsite individuals from radon emissions through gas collection and evacuation system (MILDOS-AREA or CAP-88 PC)
- Post Closure Phase
  - Dose to a resident farmer out to 1000 years (RESRAD-ONSITE)