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U.S. NUCLEAR REGULATORY COMMISSION

DOCKET 70-7005

WASTE CONTROL SPECIALISTS, LLC

SAFETY EVALUATION REPORT REGARDING THE PROPOSED EXEMPTION FROM REQUIREMENTS OF 10 CFR PART 70

January 2009

1. INTRODUCTION

By letter dated December 10, 2007, Waste Control Specialists, LLC (WCS) requested an amendment to its November 2004 U.S. Nuclear Regulatory Commission (NRC) Order that grants an exemption from certain NRC regulations in Title 10, Code of Federal Regulations (10 CFR), Part 70, "Domestic Licensing of Special Nuclear Material." The exemption was first granted by Order in November 2001, and later revised in November 2004. The Order exempts WCS from certain NRC regulations and permitted WCS, under specified conditions, to possess waste containing special nuclear material (SNM) in greater quantities than specified in 10 CFR Part 150, "Exemptions and Continued Regulatory Authority in Agreement States and in Offshore Waters Under Section 274," at WCS's storage and treatment facility in Andrews County, Texas, without obtaining an NRC license pursuant to 10 CFR Part 70. WCS is authorized to treat and store LLW pursuant to Radioactive Materials License R04971, which was issued by the Texas Commission on Environmental Quality (TCEQ). In its December 2007 request, WCS seeks NRC approval to further modify the conditions of the Order to: Discontinue confirmation sampling upon receipt of waste that WCS verifies is adequately characterized by a waste generator to be uniform and which contains less than one-thousandth of the SNM concentration limits presented in Condition 1; and to meet the confirmatory sampling requirements of Condition 7 of the Order for sealed sources using surface smear surveys. By letter dated January 22, 2008, NRC informed WCS that it would also clarify Condition 2, which states that waste must not contain "pure forms" of chemicals containing carbon, fluorine, magnesium, or bismuth in bulk quantities.

Section 274 of the Atomic Energy Act of 1954, as amended, permits Agreement States to license SNM in quantities not sufficient to form a critical mass. The quantities are set forth in NRC regulations at 10 CFR 150.11. For SNM quantities greater than the 10 CFR 150.11 limits, a 10 CFR Part 70 license issued by NRC is required. By the initial NRC Order issued November 21, 2001, WCS was exempt from licensing under Part 70 for possession of greater than the Part 150 SNM limits (66 FR 57489; November 15, 2001).

The conditions of the 2001 Order were:

- SNM isotope concentration limits (Condition 1);
- bulk chemical limits (Condition 2);
- unusual moderator limits (Condition 3);
- soluble uranium limits (Condition 4);
- mixed waste processing limits (Condition 5);

- waste characterization and certification requirements (Condition 6);
- waste receipt sampling condition (Condition 7); and
- notification requirements (Conditions 8 and 9).

Conditions 1 through 4 specified four sets of technical criticality safety limits. Condition 6, waste characterization and certification requirements, assured that these limits will not be exceeded. The waste sampling plan required by Condition 7 provided for detection of erroneous shipments of waste not complying with the concentration limits. Condition 5 limited the chemical reagents WCS may use in stabilizing any mixed waste that contains SNM.

By letters dated August 6, 2003, and March 14, 2004, WCS requested a modification to its November 2001 Order to include additional reagents that may be used for chemical stabilization of mixed waste containing SNM. NRC granted a modified exemption by Order dated November 4, 2004. The conditions of the November 2004 Order are the same as the November 2001 Order, except that the names of specific reagents were removed from Condition 5, and replaced with a requirement that each container of mixed waste containing SNM that is received for treatment (i.e., stabilization) meet a mass limit.

2. FACILITY AND SITE DESCRIPTION

WCS operates a 5.4 km^2 (1,338-acre) hazardous waste disposal facility and a hazardous waste, low-level radioactive waste (LLW), and mixed waste (MW) processing and storage facility in western Andrews County, TX and eastern Lea County, NM. The WCS facility is located near the southwestern edge of the Southern High Plains where surface elevations range from about 1,040 to 1,070 m (3,415 to 3,500 ft) above mean sea level. The site lies on a broad topographic ridge that forms surface water drainage divide between the Pecos and Colorado Rivers. The region receives approximately nine inches of rain annually and is atop a solid base of Triassic red bed clay (Hydraulic Conductivity: 10^{-8} cm/s [3 x 10^{-5} ft/day]) with the first groundwater, which is not potable and too salty for irrigation use, found 240-300 m (800-1000 ft) below.

The primary land use within a five-mile radius of the WCS facility is grazing and ranching. Future water uses in the area will include, industrial, domestic, livestock, and agricultural purposes. Oil and gas exploration and production activities have also been conducted in the vicinity of the WCS facility. Other businesses in proximity to the site include the Wallach Quarry (crushed stone, sand and gravel) and Sundance, Inc. (oil recovery and solids disposal), both located about one mile west of the facility. The Lea County Landfill is located approximately one mile southwest of the facility. In addition, construction of the Louisiana Enrichment Services (LES) uranium enrichment facility is currently underway in Lea County, NM and is located approximately one mile west of the WCS facility.

Major structures at the WCS facility include:
- On-site rail spur and rail-unloading facility for hazardous waste only
- Maintenance building
- Administration building with analytical and radiological laboratories
- Container Storage Building
- Stabilization and Mixed Waste Treatment (Combined) Building
- Bulk/Bin Storage Units
- RCRA subtitle C landfill

- Ten-acre storage area for low-specific-activity (LSA) waste
- 11e (2) byproduct material landfill Facility (*Authorized May 2008 – under construction*)
- Federal LLW/MW landfill Facility (license issuance pending)
- Texas Compact LLW landfill Facility (license issuance pending)
- Chemical oxidation (*Proposed*)

Other WCS permits and authorizations are summarized below:

<u>By-Product Material Disposal Facility License</u>

- Issued: May 29, 2008, by the TCEQ
- Authorization: Receipt and disposal of by-product material as defined in Title 25 of the Texas Administrative Code, Section 289.260(c)(4)
- Authorization covers dry, discrete solid objects and containerized bulk (i.e., soil or soil-like) by-product material received by road
- Containers shall be sealed, flexible or rigid drums, pails, boxes, sacks, or similar containers that do not tear, split, or rupture upon handling, placement, and compaction in the disposal unit, or lose their structural strength and integrity when contacting water. Acceptable containers include (but are not limited to) U.S. DOT containers. Containers shall not contain free liquids or more than 15% void space.

<u>Low Level Radioactive Waste Treatment, Processing & Storage License</u>

- Issued: December 19, 2007 by the Department of State Health Services
  This license is now under the authority of the Texas Department of Environmental Quality.
- Authorization: Treatment, processing, and storage of low-level radioactive wastes (including Greater Than Class C (GTCC), sealed sources, solids, and liquids)
- Amendment: October 15, 1998 - Storage of Transuranic (TRU) wastes
- January 17, 2002 - Exemption from Part 70 (Special Nuclear Material (SNM) concentration-based limitations)

<u>Industrial Solid Waste and Hazardous Waste Storage, Processing, and Disposal Resource Conservation and Recovery Act Wastes (RCRA) Permit</u>

- Issued: August 5, 1994, by the Texas National Resource Conservation Commission (TNRCC)
- Renewed: October 5, 2005 by the TCEQ
- Authorization: Treatment, storage, and land disposal of over 2,000 RCRA waste codes
- WCS holds a RCRA part B equivalent permit to receive ignitable, corrosive, toxic, and select reactive hazardous waste
- Liquids, sludge's, solids, lab packs in approved containers, and liquid in bulk tankers

<u>Texas Pollutant Discharge Elimination System Permit</u>

- Issued: December 2, 1999
- Renewed: May 31, 2005

<u>Toxic Substances Control Act Land Disposal Authorization</u>

- Issued: November 22, 1999
- Renewed: September 19, 2005 by the EPA

- Authorization: Treatment, storage, and land disposal of TSCA wastes including Polychlorinated Biphenyl (PCB) and PCB contaminated materials such as debris, spill solids, transformers (drained and flushed), and transformer carcasses
- PCB liquids are acceptable for bulking and off-site treatment

<u>Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)</u>

- Issued: March 21, 1997, by the EPA, Region 6
- Authorization: Receipt of hazardous substances, pollutants or contaminants from CERCLA

<u>Pursuant to the State and Federal permits and authorizations described above, WCS is authorized to use the following waste treatment technologies:</u>

- Chemical oxidation
- Chemical reduction
- Deactivation
- Micro- and macro-encapsulation (debris only)
- Neutralization
- Stabilization
- Controlled reaction

Waste shipments are received in a variety of sealed packages such as standard 208 liter (55-gallon) steel drums, rectangular steel boxes, intermodal, roll-offs, waste generator-designed canisters, or from a list of 400 radioactive material packages certified by the DOE for transport by road only. The facility is accessible by a nearby interstate highway and has truck off-loading capabilities.

3. PROPOSED ACTION

By letter dated December 10, 2007, WCS requested that NRC modify its November 2004 Order to allow it to discontinue confirmation sampling upon receipt of waste that WCS verifies is adequately characterized by a generator to be uniform and which contains less than one-thousandth of the SNM concentration limits presented in Condition 1; and to meet the confirmatory sampling requirements of Condition 7 of the Order for sealed sources using surface smear surveys. By letter dated January 22, 2008, NRC informed WCS that it would also clarify Condition 2, which states that waste must no contain “pure forms” of chemicals containing carbon, fluorine, magnesium, or bismuth in bulk quantities.

Based on its review of WCS’s requests, and after consultation with WCS and the Texas Commission on Environmental Quality (see discussion in the “Evaluation” section), the NRC staff will: (1) modify the requirements for sampling in Conditions 6 and 7 to remove requirements to sample waste for which a generator’s written certification provides assurance that the concentration of SNM is below one tenth of the limits in Condition 1; (2) clarify that the requirements for waste sampling by the generator in Condition 6 and for confirmatory sampling by WCS in Condition 7 do not apply to sealed sources for which sufficient documentation exists to demonstrate that the requirements of Conditions 1-4 are met; (3) modify Condition 2 by removing the prohibition on “pure forms” of chemicals containing carbon, fluorine, magnesium, or bismuth in bulk quantities, and replace it with a table of mass concentration limits for the elements carbon, fluorine, and bismuth; (4) clarify and consistently apply a requirement for spatial uniformity of SNM in the waste in Conditions 1, 6 and 7 by stating that the SNM must be uniformly distributed throughout the waste, such that the limiting concentrations of Condition 1 must not be exceeded on average in any contiguous mass of 600 kilograms; and (5) revise Condition 4 of the Order, which currently limits the amount of highly water soluble SNM in each package, to address security concerns raised by the NRC staff during its review.

Other conditions of the Order would remain unchanged. With the exception of highly water soluble forms of SNM, SNM concentration limits are applied, in lieu of mass limits, such that accumulations of SNM at or below the concentration limits would not pose a criticality safety concern. The concentration limits are specified in Condition 1 of the Order.

4. EVALUATION

In evaluating the safety of the proposed action, the NRC staff is relying on the State of Texas Department of Health safety evaluations relative to SNM for radiation safety other than criticality safety. These evaluations are documented in a Technical Evaluation Report prepared by the Texas Department of Health, Bureau of Radiation Control, dated May 1997. Moreover, WCS's exemption is limited to the concentration of SNM in the MW and LLW and does not address any solely hazardous waste issues.

By letter dated December 10, 2007, WCS requested that NRC modify its Order to allow it to discontinue confirmation sampling upon receipt of waste that WCS verifies is adequately characterized by a generator to be uniform and which contains less than one-thousandth of the SNM concentration limits presented in Condition 1; and to meet the confirmatory sampling requirements of Condition 7 of the Order for sealed sources using surface smear surveys. By letter dated January 22, 2008, NRC informed WCS that it would also clarify Condition 2, which states that waste must no contain "pure forms" of chemicals containing carbon, fluorine, magnesium, or bismuth in bulk quantities

GENERATOR AND WCS SAMPLING REQUIREMENTS

In its December 10, 2007, request, WCS stated, with regard to the requirement for confirmatory sampling in Condition 7 of the Order as applied to high dose rate waste and debris waste, that "Confirmatory sampling of these very low SNM activity waste streams results in unnecessary radiation exposure during sampling for a corresponding insignificant reduction in assurance of safety." The essence of this rationale is that the small benefit to criticality safety provided by sampling wastes with very low SNM concentrations does not justify the radiation exposure that workers may incur when they are exposed to high dose rate wastes and debris wastes during confirmatory sampling activities at WCS. Underlying this rationale is the radiation protection principle that radiation doses should be "as low as reasonably achievable," or ALARA.

In the November 2001 Order, which remained unchanged in the November 2004 Order, NRC adopted a graded approach to sample frequency requirements for both generators and WCS. In the graded approach described in Condition 6 of the Order for waste generators, if SNM concentrations were expected to be greater than 10% of the Condition 1 limits, the required waste sampling frequency was once per 600 kg of waste. The basis for the 600 kg value was described in the SER for the November 2001 Order. The frequency was reduced stepwise to once per 6,000 kg for SNM concentrations expected to fall between 1% and 10% of the Condition 1 limits, and once per 60,000 kg for SNM concentrations below 1% of the Condition 1 limits. Similarly, WCS was required to take confirmatory samples at once per 1,500 kg for the first shipment, and every 6,000 kg thereafter when expected SNM concentrations were above

10% of the limits. Sampling frequencies fell to once per 20,000 kg for the first shipment and every 60,000 kg thereafter for SNM concentrations between 1% and 10% of the limits. The WCS confirmatory sampling interval was once per 600,000 kg for SNM concentrations expected to fall below 1% of the limits.

In its December 2007 request, WCS proposed that if it can verify that high dose rate and debris waste streams are adequately characterized by the generator, and that SNM concentrations are homogeneous, and less than one-thousandth of the SNM concentration limit, then they would perform no confirmatory sampling. This proposed new requirement would modify the current WCS confirmatory sampling requirement that applies when SNM concentrations are expected to fall below 1% of the Condition 1 limits. Namely, in lieu of confirmatory samples at a rate of once per 600,000 kg of waste when SNM concentrations are expected to fall below 1% of the Condition 1 limits, for debris waste between 0.1% and 1% of the SNM concentration limits in Condition 1, WCS proposed to perform smear surveys from which they would estimate the SNM concentration in wastes. When SNM concentrations are expected to fall below 0.1% of the SNM concentrations, WCS proposes that no confirmatory sampling would be performed.

NRC evaluated WCS' request and the requirements of the Order in light of conservatism in the staff's criticality safety evaluation and the ALARA principle. As a result, the NRC staff believes that generator waste sampling and WCS confirmatory sampling provides the greatest benefit to assuring criticality safety when the expected concentrations of SNM in the waste fall within the range of 10% to 100% of the limits of Condition 1 of the Order.

NRC staff took several factors into account in developing the range of expected SNM concentrations for which generator waste sampling and WCS confirmatory sampling should be performed. For example, certain assumptions that are relied upon to calculate the limits of Condition 1 of the Order are very conservative. These include assumptions that: (1) the SNM-bearing waste is infinite in both lateral and vertical dimensions; (2) the SNM concentration in waste is uniform and at the maximum allowable value cited in Condition 1, and; (3) the SNM-bearing waste contains an optimum concentration of water. Given this level of conservatism, and other information which may be relied upon to ensure that the limits of Condition 1 are met (such as process knowledge), the staff's professional judgement is that sampling by both the waste generator and WCS is only necessary when SNM concentrations are expected to fall between 10% and 100% of the Condition 1 limits.

In addition to considering the conservatism in the analysis used to calculate the limits in Condition 1, the NRC staff also considered the ALARA principle. The NRC staff believes that when SNM concentrations in waste are expected to be below 10% of the limits in Condition 1, as determined by a waste generator in support of a written certification required by Condition 6, the radiation hazard to workers involved in both generator sampling and WCS confirmatory waste sampling activities will, in many cases, outweigh the benefit to criticality safety. For example, as the concentration of SNM in waste decreases below 10% of the concentrations cited in Condition 1 of the Order, the relative proportion of source and/or byproduct materials (e.g., Cs-137 and Co-60) that are routinely present in Class A, B, and C wastes will necessarily increase. At some point, the benefit of additional sampling to ensure criticality safety is outweighed by the need to ensure worker doses remain ALARA. As a result, NRC, in consultation with WCS and the Texas Commission on Environmental Quality, has removed the graded-approach sampling requirements from the Order, in favor of a simpler threshold for sampling requirements, which applies to both the generator and WCS, at 10% of the Condition 1 limits.

Further, the use of a graded sampling approach in the November 2001 Order, which was not changed in the November 2004 Order, wherein the frequency for waste generator and WCS confirmatory sampling is reduced approximately ten-fold for each ten-fold decrease in expected SNM concentration in the waste, has no identified technical basis and, thus, provides little to no additional assurance of protection from inadvertent criticality. This type of graded approach to sampling frequencies is not uncommon in waste management and environmental protection. However, it is generally applied when sample results are required to test a statistical hypothesis that, for example, the average concentration of an analyte in a population (e.g., contaminant concentration in a lake) is below a regulatory limit. In such cases, there are statistical methods available which allow one to estimate the number of samples of a population required to decide, with some statistical level of confidence (say, 95%) that the regulatory limit is met. One is usually required, as part of hypothesis testing of this type, to have some prior information on the expected mean value and standard deviation of the mean value for the population. The practical outcome of the hypothesis testing approach is that fewer samples are usually determined to be necessary as the expected mean value of the population moves further from the regulatory limits. This outcome is reflected in the current graded approach to the Order. However, in this case, NRC is not concerned with an average SNM concentration over an entire population (i.e., waste stream). Rather, the NRC is concerned with whether SNM concentration limits are met over a mass of waste no larger than 600 kilograms.

Therefore, sampling a "stream" of LLW entering into a facility for the purpose of finding an unacceptable mass of SNM poses a very different sort of problem than hypothesis testing of the sort described above. The statistical problem may be referred to as “hot spot search sampling.” In search sampling, one calculates the optimum spacing between sampling points to find a hot spot of a known size. In this case, the hot spot size is 600 kilograms of waste, as described in the SER for the November 2001 Order. Therefore, the frequency of sampling should be determined only by the size of the potential hot spot of concern, and doesn't vary at all with the expected average concentration of SNM in the overall waste stream within which a potential hotspot could occur.

Therefore, NRC is removing the graded approach from the Order, in favor of a simpler approach based on a single threshold (described above), and a single sample frequency.

This revision to the Order is also consistent with the current requirements for a similar exemption Order issued to Energy Solutions in June 2006 (71 FR 34165). In Condition 7 of that Order, there are no specific sampling frequencies required of waste generators and the confirmatory sampling and radiological testing of debris waste by Energy Solutions containing SNM (that is exempted from sampling by the State of Utah) can be eliminated if the SNM concentration is lower than 10% of the limits in Condition 1.

SEALED SOURCES

In its December 10, 2007, request, WCS stated that direct sampling of sealed sources is not practical. In lieu of direct sampling, WCS proposes to perform surface smear surveys to meet the confirmatory sampling requirements of the Order. NRC evaluated this requested and, in consultation with WCS and the Texas Commission on Environmental Quality, has determined that, given the documentation that is generally available for sealed sources, and ALARA considerations, it is sufficient for both generators and WCS to rely on a written certification for the purposes of ensuring Conditions 1-4 of the Order are met.

PROHIBITION ON PURE FORMS OF CARBON, FLUORINE, MAGNESIUM AND BISMUTH

In its December 10, 2007, request, WCS stated that it plans to accept bulk quantities of waste containing very low concentrations of SNM that have been homogeneously commingled by the generator with inert compounds so that the final waste no longer contains just SNM and the "pure forms" of the identified chemicals carbon, fluorine, magnesium, and bismuth. The prohibition on "pure forms" of carbon, fluorine, magnesium, and bismuth is Condition 2 of the November 2004 Order. WCS further stated in its December 10, 2007, letter that the process employed by the generator will ensure that the final waste forms can be properly characterized for SNM concentration by WCS in compliance with the requirements specified in the SNM exemption. As NRC noted in a letter to WCS dated January 22, 2008, WCS has explained to NRC by phone call on December 18, 2007, that the waste is magnesium fluoride mixed with sand. NRC subsequently informed WCS on January 10, 2008, that there would be no criticality concerns with such waste, provided the waste is less than 40% MgF_2 by volume, and less than 50% MgF_2 by weight. In the January 22, 2008, letter, NRC committed to clarify Condition 2 limits in this revision of the Order.

NRC evaluated the technical basis for Condition 2 of the November 2004 Order, and performed sensitivity studies to derive mass concentration limits for the impurities carbon, fluorine, magnesium, and bismuth in wastes containing SNM. The first step in the staff's evaluation was a study using the XSDRNPM discrete ordinates code of the general case of a spatially infinite emplacement of low-level waste. For this study, the bulk waste matrix is assumed to be silicon dioxide (i.e., sand) at a mass density of 1.6 grams per cubic centimeter, with varying mass densities of the impurities carbon, fluorine, magnesium, or bismuth, and SNM mass concentrations equal to the concentration limits in Condition 1 of the Order. For the initial study, only dry waste was considered (no water), no special moderators specified in Condition 3 of the Order were assumed to be present, and the concentration of SNM in the waste was assumed to be spatially uniform.

Staff calculated k_∞ curves for each isotope in Condition 1, as a function of the weight percent (wt%) of each impurity: Carbon, fluorine, magnesium, and bismuth.

The results are shown below in Figures 1-4

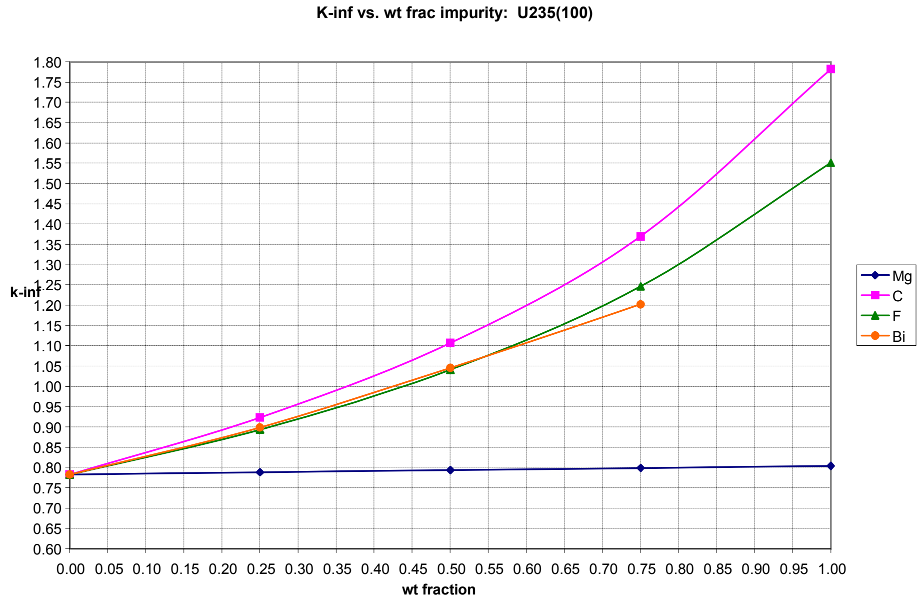

Figure 1. k_∞ as a function of Mg, C, F, and Bi impurity mass concentrations in an infinite SiO_2 waste matrix containing uranium enriched to 100% ^{235}U at the Condition 1 concentration limit

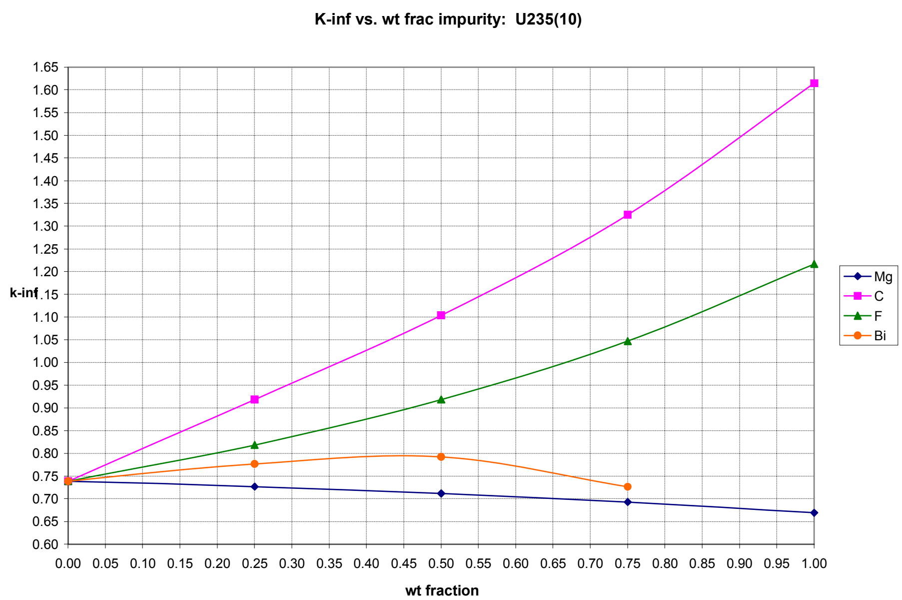

Figure 2. k_∞ as a function of Mg, C, F, and Bi impurity mass concentrations in an infinite SiO_2 waste matrix containing uranium enriched to 10% ^{235}U at the Condition 1 concentration limit

Figure 3. k_∞ as a function of Mg, C, F, and Bi impurity mass concentrations in an infinite SiO_2 waste matrix containing uranium-233 at the Condition 1 concentration limit

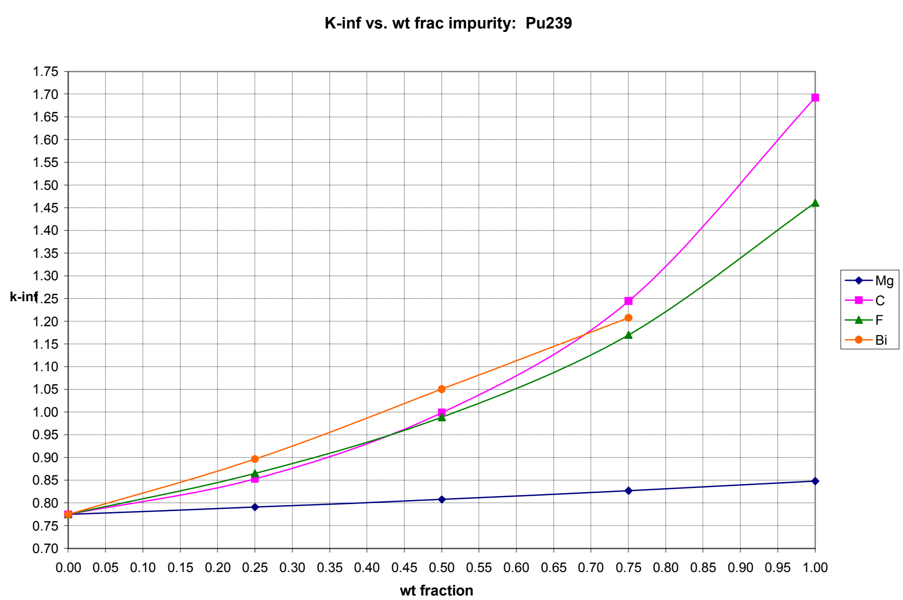

Figure 4. k_∞ as a function of Mg, C, F, and Bi impurity mass concentrations in an infinite SiO_2 waste matrix containing plutonium-239 at the Condition 1 concentration limit

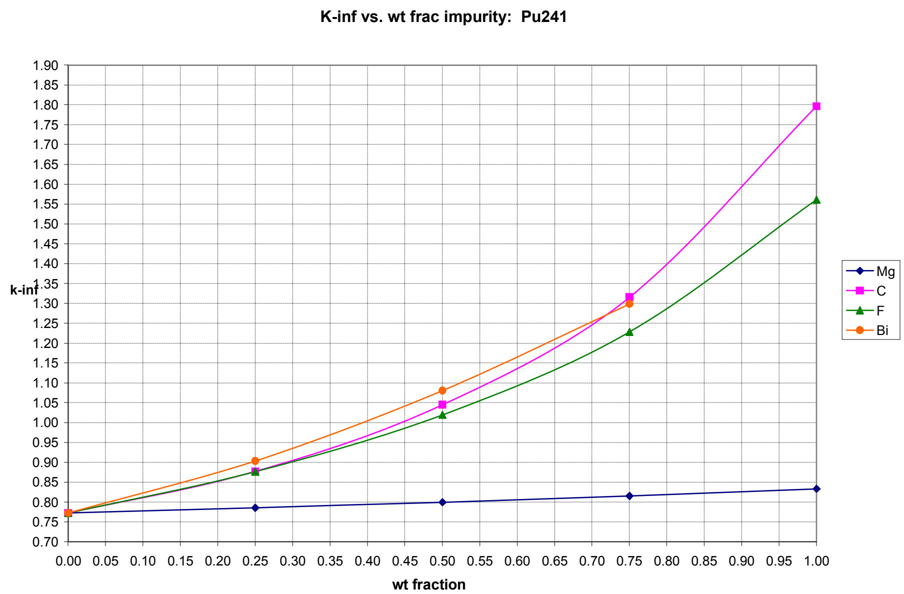

Figure 5. k_∞ as a function of Mg, C, F, and Bi impurity mass concentrations in an infinite SiO_2 waste matrix containing plutonium-241 at the Condition 1 concentration limit

Based on this study, the Table 1 summarizes the maximum mass concentration allowable for each impurity (in terms of wt %), at the maximum allowed concentration of each SNM radionuclide listed in Condition 1. The impurity mass concentration limits are calculated for $k_\infty = 0.95$.

Table 1. Maximum allowable mass concentrations of Mg, C, F, and Bi for each SNM radionuclide listed in Condition 1 of the Order.

SNM Radionuclide	**SNM Concentration Limit (Condition 1)**	**wt% Mg**	**wt% C**	**wt% F**	**wt% Bi**
^{235}U(100%)	6.2E-4	any	28%	34%	34%
^{235}U(10%)	9.9E-4	any	28%	56%	any
^{233}U	4.7E-4	any	41%	42%	33%
^{239}Pu	2.8E-4	any	43%	43%	34%
^{241}Pu	2.2E-4	any	37%	39%	32%

This initial study indicates that the SNM concentration limits of Condition 1 are safe, so long as the mass concentrations of carbon, fluorine, and bismuth shown in Table 1 are met. However, this initial study did not account for the presence of water in the waste. Therefore, staff conducted a follow-on study which focused on the effect of water on the mass limits expressed in Table 1.

For the follow-on water study, staff assumed a certain mass concentration of water in the matrix material; for this study, staff assumed that the total density of waste was 1.6 gram per cubic centimeter (g/cc), even though there probably would be some porosity to the waste so it could absorb a limited amount of water without a change in volume. Review of the results indicated that, for uranium enriched to 100% ^{235}U(or ^{235}U(100%)), ^{233}U, ^{239}Pu, and ^{241}Pu, adding even a small amount of water reduced k_∞. Therefore, the dry case bounds all moderation levels for these radionuclides. This was not true for the case of uranium enriched to 10% ^{235}U (or ^{235}U(10%)), where a small amount of water actually increased k_∞. Therefore, staff completed a study wherein a series of calculations was performed with 1, 2, and 3 wt% water, to determine the optimal moderation level. The optimum moderation occurred between 1-1.5 wt% water. Since the waste system was modeled as a spatially infinite system, adding more hydrogen than is present in waste containing 1-1.5 wt% water resulted in excess neutron absorption, which caused k_∞ to rapidly decrease.

The results of this study are shown in Figures 6-9 below:

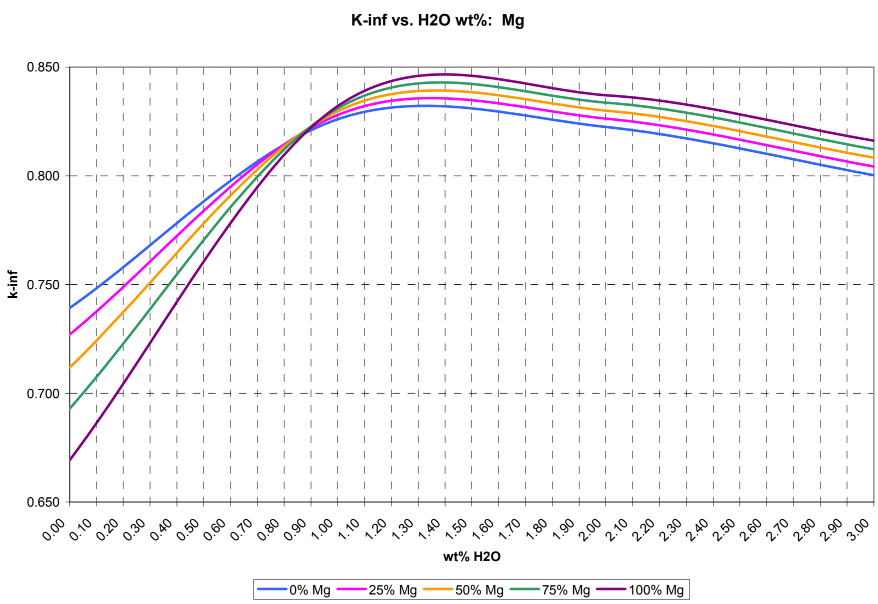

Figure 6. k_∞ as a function of water mass concentration (wt%) in an infinite SiO_2 waste matrix containing uranium enriched to 10% ^{235}U at the Condition 1 concentration limit, for various magnesium impurity mass concentrations.

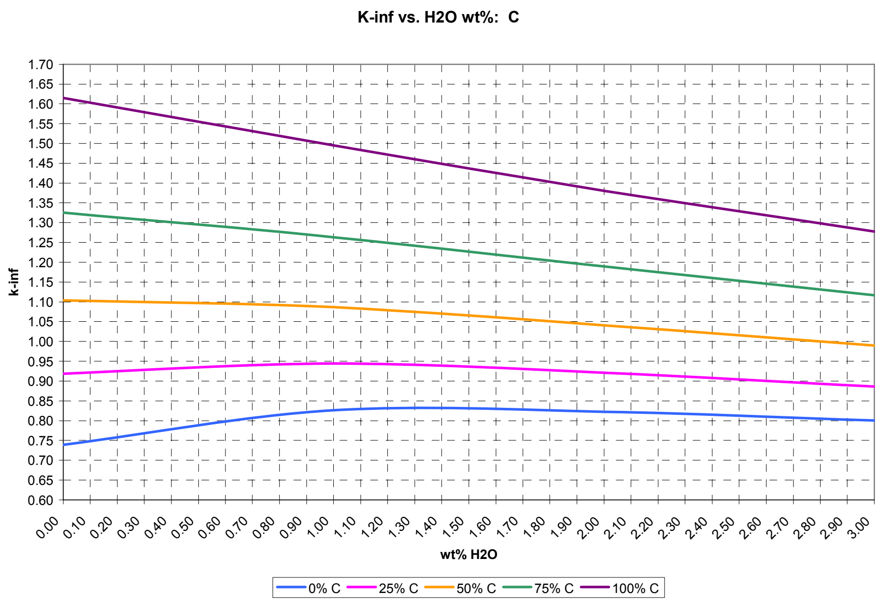

Figure 7. k_∞ as a function of water mass concentration (wt%) in an infinite SiO_2 waste matrix containing uranium enriched to 10% ^{235}U at the Condition 1 concentration limit, for various carbon impurity mass concentrations.

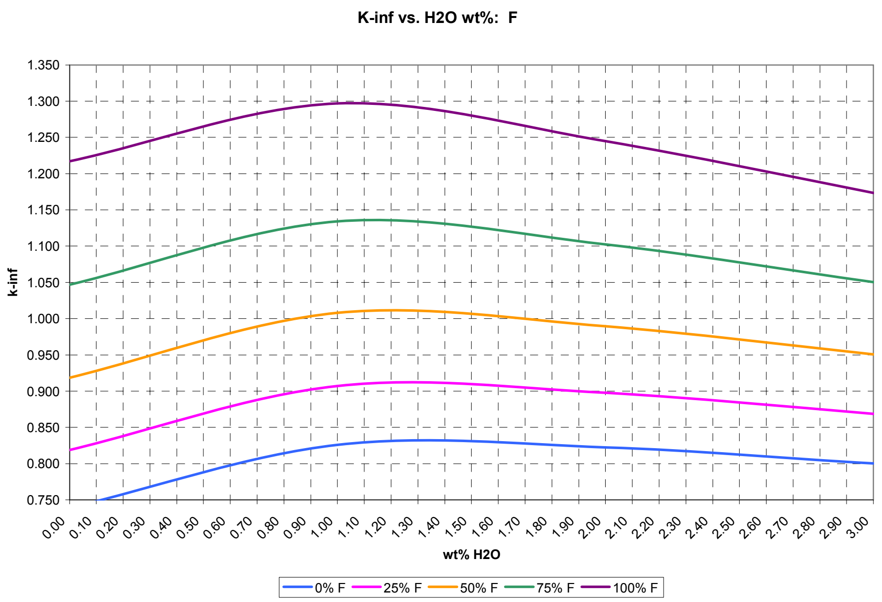

Figure 8. k_∞ as a function of water mass concentration (wt%) in an infinite SiO_2 waste matrix containing uranium enriched to 10% ^{235}U at the Condition 1 concentration limit, for various fluorine impurity mass concentrations.

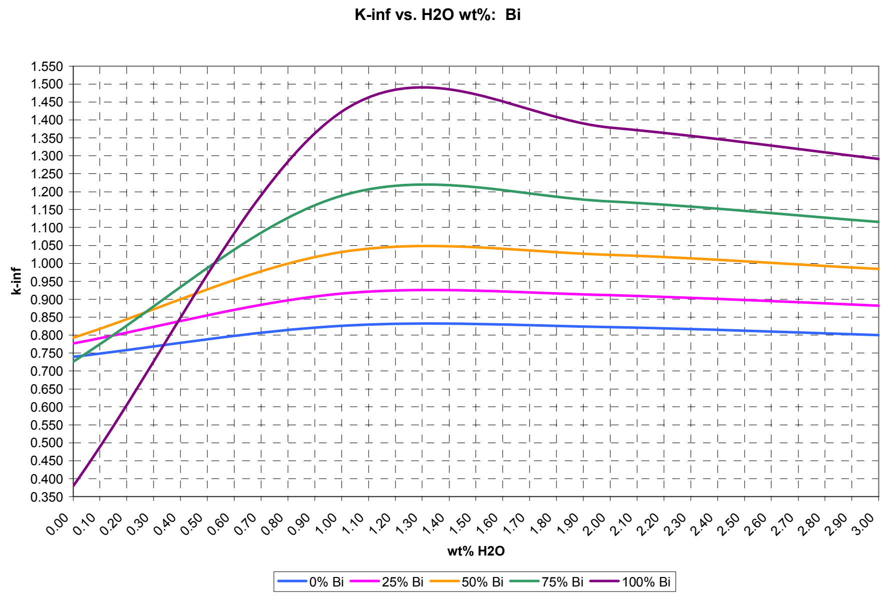

Figure 9. k_∞ as a function of water mass concentration (wt%) in an infinite SiO_2 waste matrix containing uranium enriched to 10% ^{235}U at the Condition 1 concentration limit, for various bismuth impurity mass concentrations.

To account for possible water moderation, the optimum value of the mass concentration of water was taken off each of the graphs. Based on this, the graph of k_∞ as a function of wt% impurities was recalculated, for ^{235}U(10%), as shown below in Figure 10:

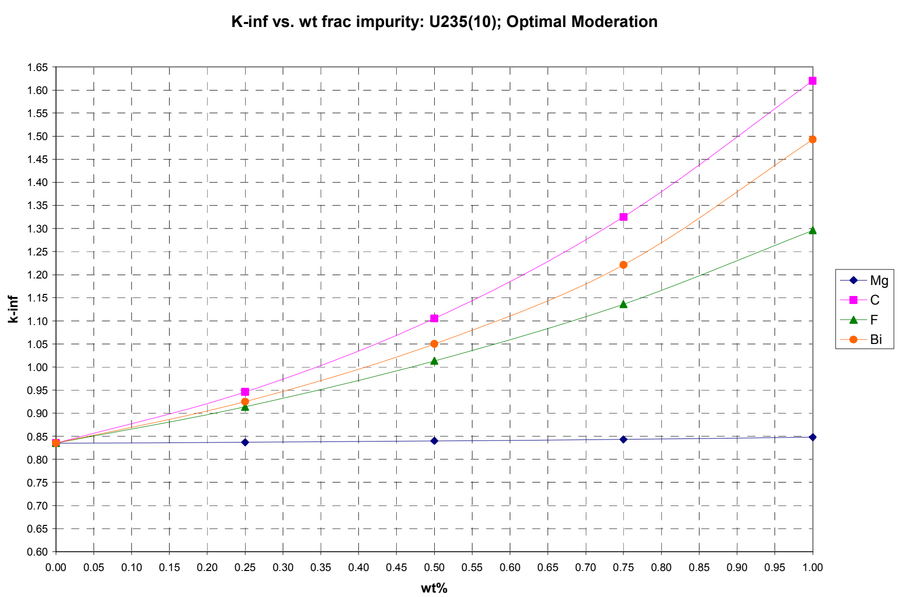

Figure 10. k_∞ as a function of impurity mass concentrations at the optimal water mass concentration in an infinite SiO_2 waste matrix containing uranium enriched to 10% ^{235}U at the Condition 1 concentration limit.

The new results are summarized in Table 2 below, and are subject to the following limitations:

- Assumes no “special moderators” are present as in Condition 3
- Assumes total density of waste material does not exceed 1.6 g/cc

Based on this study, the following table shows the maximum allowable mass concentration of the impurities carbon, fluorine, and bismuth for each SNM radionuclide at the maximum allowed SNM concentration. The results of the second study on water moderation results in updated values for ^{235}U(10%).

Table 2. Maximum allowable mass concentrations of Mg, C, F, and Bi for each SNM radionuclide listed in Condition 1 of the Order, with consideration for optimal water moderation.

Isotope	**Concentration Limit**	**wt% Mg**	**wt% C**	**wt% F**	**wt% Bi**
^{235}U(100%)	6.2E-4	any	28%	34%	34%
^{235}U(10%)	9.9E-4	any	25%	35%	31%
^{233}U	4.7E-4	any	41%	42%	33%
^{239}Pu	2.8E-4	any	43%	43%	34%
^{241}Pu	2.2E-4	any	37%	39%	32%

The values in Table 2 are Condition 2 of the revised Order.

For waste containing mixtures of C, F, and Bi, the sum of the weight fractions of C, F, and Bi shall be compared to the most restrictive maximum allowable weight fractions for any one of those elements. For example, if waste contains uranium enriched to 3.5% in the uranium-235 isotope (^{235}U(3.5%)), and 15 wt% C, 5 wt% F, and 1 wt% F, then the calculated weight fraction of C, F, and Bi shall be assumed to be 21 wt% C, which is less than the allowable weight fraction for C in ^{235}U(10%) of 25%. Similarly, where mixtures of radionuclides are present in the waste, then the limiting maximum allowable weight fraction of C, F, and Bi shall be applied. For example, for waste containing a mixture of ^{239}Pu and ^{235}U(10%), the maximum allowable weight fractions of C, F, and Bi for ^{235}U(10%) shall apply.

Staff also evaluated the limitations of the water moderation study, which are described above:

Effect of Unusual Moderators

Condition 3 in the Order states that there must be no special moderators such as deuterium oxide (D_2O), beryllium (Be), or carbon (graphite) present in excess of 0.1%. The above calculations do not take these impurities into account. Staff evaluated the results of a previous sensitivity study performed by Oak Ridge National Laboratory for both Be and D_2O. The results of this evaluation are discussed shown below.

K_∞ appears to vary roughly linearly with the mass concentration of the special moderators. Examination of the lower end of this curve shows that an addition of 0.1 wt% of either Be or D_2O only results in a change in k_∞ of ~0.1%. This is relatively insignificant, so NRC staff concludes that a small proportion of these materials will only have a very small effect on the overall results.

Assumption that waste mass density is 1.6 g/cc

Because this is an infinite system, k_∞ is invariant to the total bulk density, as long as the relative mass concentration of the fissile material, waste matrix (SiO_2), additional fluorine, carbon, and bismuth impurities, and "special moderators" remains unchanged.

CLARIFICATION OF THE SPATIAL UNIFORMITY (HOMOGENEITY) REQUIREMENT

During its review of the December 10, 2007, request by WCS, NRC staff noted that the requirements in the Order that SNM concentration in waste be uniform or homogeneous are neither clear nor consistent throughout the Order. Notably, Condition 1 of the Order requires that the "SNM must be homogeneously distributed throughout the waste. If the SNM is not homogeneously distributed, then the limiting concentrations must not be exceeded on average in any contiguous mass of 600 kilograms." NRC staff believes the requirement, as stated, should be clarified. The intent of this requirement is that SNM concentrations in the waste must be spatially uniform, such that the limiting concentrations must not be exceeded on average in any contiguous mass of 600 kilograms.

In Condition 6 of the Order, generators are required to certify wastes, and include in the certification, among other things, "a description of the process by which waste was generated showing that the spatial distribution of SNM must be uniform, or other information supporting spatial distribution." Given the different terminology used in Conditions 1 and 6 (i.e., "SNM must be homogeneously distributed" vs. "spatial distribution of SNM must be uniform"), it is not clear whether the generator's certification of spatial uniformity should be judged by the homogeneity standard implied in Condition 1, or by a second standard suggested later in Condition 6.

The penultimate paragraph of Condition 6 states, "If the waste is determined to be not homogeneous (i.e., maximum, which cannot exceed the limits of Condition 1, and minimum testing values performed by the generator are greater than five times the average value), the generator shall sample and determine the SNM concentration once per 600 kg thereafter, regardless of SNM concentration. In this case, samples shall be a composite consisting of four uniformly sampled aliquots." The statistical test for homogeneity (or spatial uniformity) expressed parenthetically in this paragraph of the November 2004 Order does not comport with the definition stated in Condition 1 of the Order. Also, the outcome of the statistical test in this part of Condition 6, as stated, is always the null set. That is, the minimum value in a data set is never 5 times the average value. Therefore, if this test were applied literally, one would necessarily (and incorrectly) conclude that <u>all</u> waste streams are homogeneous. The Condition 6 statistical test for homogeneity is repeated in the second paragraph of Condition 7, which addresses the WCS confirmatory sampling requirements.

The single requirement for spatial uniformity of SNM concentration in waste that NRC intended is the requirement stated in Condition 1 of the Order. This requirement states: "The SNM must be uniformly distributed throughout the waste, such that the limiting concentrations must not be exceeded on average in any contiguous mass of 600 kilograms." The basis for 600 kilograms is described in the November 2001 Order. NRC has made certain clarifying changes to Condition 1, and conforming changes to other Conditions of the Order.

RESTRICTION ON POSSESSION OF HIGHLY WATER SOLUBLE FORMS

As part of its review of the Order, NRC staff evaluated whether the requirement that applies to highly water soluble forms of SNM should be revised. The current requirement (Condition 4) is as follows:

> “Waste packages must not contain highly water soluble forms of SNM greater than 350 grams of U-235 or 200 grams of U-233 or 200 grams of Pu. The sum of the fractions rule will apply for mixtures of U-233, U-235, and Pu. When multiple containers are processed in a larger container, the total quantity of soluble SNM shall not exceed these mass limits. Highly soluble forms of SNM include, but are not limited to: uranium sulfate, uranyl acetate, uranyl chloride, uranyl formate, uranyl fluoride, uranyl nitrate, uranyl potassium carbonate, uranyl sulfate, plutonium chloride, plutonium fluoride, and plutonium nitrate. The presence of the above materials will be determined and documented by the generator, based on process knowledge or testing.”

This requirement addresses the risk to worker and public safety posed by the potential that highly water soluble SNM might redistribute into a critical configuration within a package, should water intrude into a waste package. The basis for the highly water soluble SNM mass limits in the Order, as cited in the November 2001 SER, is 10 CFR 150.10, “Persons exempt.” Staff also noted in the November 2001 SER that “the mass of SNM will be limited by the consignment mass limits in 10 CFR Part 71.”

The staff believes that the current regulations in 10 CFR Part 71, “Packaging and Transportation of Radioactive Material,” and 49 CFR, “Transportation,” are adequate to ensure packaging and transportation safety of SNM-bearing waste. These regulations include provisions for exemption of waste from classification as fissile materials (i.e., 10 CFR 71.15), which is likely to apply to many SNM-bearing wastes. Therefore, staff will delete Condition 4 from the Order, insofar as this Condition specifies SNM mass limits for individual packages.

Recent history of Part 71 rulemakings

The following provides a brief chronology of Part 71 rulemaking in the area of fissile material exemptions since 1997, in support of the staff’s recommendation to delete SNM mass limits for individual packages from Condition 4. Staff reviewed the recent history of Part 71 rulemakings pertaining to fissile-exempt packages, beginning with the NRC’s February 1997 emergency final rule entitled “Fissile Material Shipments and Exemptions” (62 FR 5907). In response to public comments on this emergency final rule, NRC contracted with Oak Ridge National Laboratory to prepare an assessment of the rule. A July 1998 Oak Ridge report, “Assessment and Recommendations for Fissile-Material Packaging Exemptions and General Licenses Within 10 CFR Part 71,” NUREG/CR-5342, recommended a range of fissile-exempt mass ratios to replace exemption criteria of section 71.53(a). Table 5-4 of NUREG/CR-5342 is reproduced below:

Proposed fissile-exempt mass ratios to replace criteria of §71.53(a)

Package fissile material limit	Ratio: Fissile-to-nonfissile
15 g	1:200
350 g	1:2000
350 g	1:200[a]

[a]Packaging required to satisfy standards for Normal Conditions of Transport

In April 2002 (67 FR 21390), the NRC issued a proposed revision to Part 71 to make the regulations on packaging and transporting radioactive material compatible with International Atomic Energy Agency standards, and to codify other applicable requirements, including revisions to the exemption criteria included in the 1997 emergency final rule. Section 71.15 of the proposed rule addressed fissile materials which are exempt from classification as fissile material and from the fissile material package standards. Specifically, section 71.15(b) of the proposed rule described one requirement, which is similar to the requirement in Condition 4 of the WCS exemption Order, which is based on the recommendations in NUREG/CR-5342:

> "(b) The mass ratio of noncombustible, insoluble-in-water, material (including both the contents and packaging) to fissile material is greater than 2000:1 and the package contents contain less than 350 g of fissile material. Lead, beryllium, graphite, and hydrogenous material enriched in deuterium may be present in the package, but must not be included in determinining the mass ratio for the package. The fissile material may be contained in individual or bulk packaging."

However, as noted in the discussion published with the final rule, section 73.15(b) in the final rule:

> ". . . was modified by referring to fissile and non-fissile materials as solid materials instead of using 'noncombustible' and 'insoluble-in-water.' The modification was a pragmatic consideration and was made to avoid reference to the undefined/ specified word, "noncombustible," and the phrase, 'insoluble-in-water,' while addressing the need to avoid fissile and nonfissile liquids/gases that easily could be consolidated or lost (thereby decreasing nuclear criticality safety) in normal and hypothetical accident transportation circumstances. An additional modification, §71.15(c)(2) in the final rule, also removes the limit of 350 g in a package and instead specifies criteria for commingling of the material such that, within any selected 360 kg of nonfissile solid material, there can be no more than 180 g of fissile material. Thus a large rail car with a homogenized distribution of fissile material within a nonfissile waste matrix might exceed the 180 g limit but would be effectively mixed at low enough concentration to enable safe shipment."
>
> (69 FR 3749, January 26, 2004)

As a result, the January 2004 final rule (69 FR 3698) replaced a proposed mass limit in the fissile material exemption that would most likely apply to large waste shipments (i.e., 350 g), and replaced it with a mass-concentration limit of 180 g fissile material distributed within 360 kg of contiguous nonfissile material.

Limits on possession of highly water soluble SNM

Notwithstanding the removal of individual package mass limits for highly water soluble SNM, the staff believes that one or more packages of SNM-bearing waste containing highly water soluble forms of SNM up to the SNM concentration limits in Condition 1 of the Order could pose a security concern, since highly water soluble forms of SNM are readily separable from common waste matrices (e.g., soil, metal debris, etc.). To ensure the security of highly water soluble (and thus readily separable) forms of SNM, the staff has modified Condition 4, consistent with 10 CFR 150.14, such that possession of readily separable forms of SNM in waste is limited to amounts below the amount of SNM of low strategic significance defined in 10 CFR 73.2.

The staff does not believe that this requirement need apply to waste bearing insoluble forms of SNM possessed under RML R04971. Water insoluble SNM contained in waste that meets the concentration and homogeneity requirements of Condition 1 is sufficiently inseparable, and requires no more protection than is already afforded to other radioactive waste stored at this facility.

SNM possessed under multiple radioactive material licenses at the facility

The NRC staff also evaluated whether the total amount of highly water soluble SNM that might be possessed by WCS both under its treatment, processing, and storage license (R04971), and its pending LLW disposal facility license, raises a concern regarding security of the totality of all highly water soluble SNM that might be contained in waste above ground at the WCS site.

Above ground possession of SNM under the pending disposal facility license is limited to quantities not sufficient to form a critical mass, as specified in 10 CFR Part 150.11, namely 350 grams of uranium-235, or 200 grams of uranium-233, or 200 grams of plutonium-239, or mixtures of these radionuclides subject to the unity rule. The totality of waste emplaced for disposal (i.e., not above ground) could contain more than a critical mass of SNM dispersed in large amounts of waste. Emplaced waste may remain uncovered until the disposal cells are prepared for closure. However, the staff concludes that highly water soluble SNM contained in emplaced waste is generally much less readily identified and retrieved from disposal cells than waste in above ground temporary storage. Therefore, given the small amount of additional SNM that may be possessed above ground under the disposal facility license, and the relative inaccessibility of emplaced waste, staff finds that it would be highly unlikely that highly water soluble SNM contained in waste under both the treatment, processing, and storage license (R04971) and the disposal license (R04100) could be identified, retrieved, processed, and recovered by a potential adversary in quantities in excess of SNM of low strategic significance, as defined in 10 CFR Part 73.

5. SUMMARY AND CONCLUSION OF SAFETY EVALUATION

Based on its analysis of the operations and waste forms at the WCS's facility, the NRC staff concludes that waste processing and storage operations can be conducted with an acceptably low risk of nuclear criticality, theft or diversion, subject to the Conditions of this Order. The NRC staff developed maximum concentration limits to ensure criticality safety and a set of additional conditions that ensure criticality safety and special nuclear material safeguards. These conditions are included in this Order to WCS. The Order would become effective when the conditions are incorporated by the State of Texas into WCS's RML.

6. EXEMPTION CONDITIONS

Conditions 1, 2, 4, 6, and 7 of the Order are amended to read:

1. Concentrations of SNM in individual waste containers and/or during processing must not exceed the following values:

SNM Isotope	Operational Limit (gram SNM/gram waste)	Measurement Uncertainty (gram SNM/gram waste)
U-233	4.7E-04	7.1E-05
U-235 (10 percent enriched)	9.9E-04	1.5E-04
U-235 (100 percent enriched)	6.2E-04	9.3E-05
Pu-239	2.8E-04	4.2E-05
Pu-241	2.2E-04	3.2E-05

When mixtures of these SNM isotopes are present in the waste, the sum-of-the-fractions rule, as illustrated below, should be used.

$$\frac{\text{U - 233 conc}}{\text{U - 233 limit}}+\frac{\text{100wt\%U - 235 conc}}{\text{100wt\%U - 235 limit}}+\frac{\text{10wt\%U - 235 conc}}{\text{10wt\%U - 235 limit}}+\frac{\text{Pu - 239 conc}}{\text{Pu - 239 limit}}+\frac{\text{Pu - 241 conc}}{\text{Pu - 241 limit}}\leq 1$$

The measurement uncertainty values in column 3 above represent the maximum one-sigma uncertainty associated with the measurement of the concentration of the particular radionuclide.

The SNM must be uniformly distributed throughout the waste, such that the limiting concentrations must not be exceeded on average in any contiguous mass of 600 kilograms.

2. The mass concentration of carbon, fluorine, and bismuth in the waste must be limited as follows:

SNM Isotope	Carbon	Fluorine	Bismuth
U-233	28 wt%	34 wt%	34 wt%
U-235(10)	25 wt%	35 wt%	31 wt%
U-235(100)	41 wt%	42 wt%	33 wt%
Pu-239	43 wt%	43 wt%	34 wt%
Pu-241	37 wt%	39 wt%	32 wt%

For waste containing mixtures of C, F, and Bi, the sum of the weight fractions of C, F, and Bi shall be compared to the most restrictive maximum allowable weight fractions for any one of those elements. Similarly, where mixtures of radionuclides are present in the waste, the limiting maximum allowable weight fraction of C, F, and Bi shall be applied.

The presence of the above materials will be determined and documented by the generator, based on process knowledge or testing.

4. Possession of highly water soluble forms of SNM shall not exceed the amount of SNM of low strategic significance defined in 10 CFR 73.2. Highly water soluble forms of SNM include, but are not limited to: uranium sulfate, uranyl acetate, uranyl chloride, uranyl formate, uranyl fluoride, uranyl nitrate, uranyl potassium carbonate, uranyl sulfate, plutonium chloride, plutonium fluoride, and plutonium nitrate. The presence of the above materials will be determined and documented by the generator, based on process knowledge or testing.

6. Prior to shipment of waste, WCS shall require generators to provide a written certification containing the following information for each waste stream:

    a. Waste Description. The description must detail how the waste was generated, list the physical forms in the waste, and identify uranium chemical composition.
    b. Waste Characterization Summary. The data must include a general description of how the waste was characterized (including the volumetric extent of the waste, and the number, location, type, and results of any analytical testing), the range of SNM concentrations, and the analytical results with error values used to develop the concentration ranges.
    c. Uniformity Description. A description of the process by which the waste was generated showing that the spatial distribution of SNM is homogeneous or other information supporting spatial homogeneity.
    d. Manifest Concentration. The generator must describe the methods to be used to determine the concentrations on the manifests. These methods could include direct measurement and the use of scaling factors. The generator must describe the uncertainty associated with sampling and testing used to obtain the manifest concentrations.

WCS shall review the above information and, if adequate, approve in writing this pre-shipment waste characterization and assurance plan before permitting the shipment of a waste stream. This will include statements that WCS has a written copy of all the information required above, that the characterization information is adequate and consistent with the waste description, and that the information is sufficient to demonstrate compliance with Conditions 1 through 4. Where generator process knowledge is used to demonstrate compliance with Conditions 1, 2, 3, or 4, WCS shall review this information and determine when testing is required to provide additional information in assuring compliance with the Conditions. WCS shall retain this information as required by the State of Texas to permit independent review.

At the time waste is received, WCS shall require generators of SNM waste to provide a written certification with each waste manifest that states that the SNM concentrations reported on the manifest do not exceed the limits in Condition 1, and that the waste meets Conditions 2 through 4.

WCS shall require generators to sample and determine the SNM concentration for each waste stream, not to include sealed sources, at a frequency of once per 600 kg if the concentrations are above one tenth the SNM limits of Condition 1. The measurement uncertainty shall not exceed the uncertainty value in Condition 1 and shall be provided on the written certification.

7. WCS shall sample and determine the SNM concentration for each waste stream, not to include sealed sources, at a frequency of once per 600 kg if the concentrations are above one tenth the SNM limits of Condition 1. This confirmatory testing is not required for waste to be disposed of at DOE's WIPP facility.

7. REFERENCES

The ADAMS accession numbers for the documents related to this SER are:

Document Description	Accession Number
December 10, 2007, WCS request for modification to Order	ML073550638
January 22, 2008, NRC acknowledgement of WCS request	ML080150622