APPENDIX E:

IMPACTS ASSOCIATED WITH HF AND CaF_2 CONVERSION PRODUCT SALE AND USE

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E.1 INTRODUCTION

During the conversion of the depleted uranium hexafluoride (DUF_6) inventory to depleted uranium oxide, products having some potential for sale to commercial users would be produced. These products would include aqueous hydrogen fluoride (HF) and calcium fluoride (CaF_2, commonly referred to as fluorspar). These products are routinely used as commercial materials, and an investigation into their potential reuse was done; results are included as part of this environmental impact statement (EIS). Areas examined as part of this investigation were the characteristics of these materials as produced within the conversion process, the current markets for these products, and the potential socioeconomic impacts within the United States if these products should be provided to the commercial sector. Because some low-level radioactivity would be associated with these materials, a description of the U.S. Department of Energy (DOE) process for authorizing the release of contaminated materials for unrestricted use (referred to as "free release") and an estimate of the potential human health effects of such free release were also considered in this investigation. The results and conclusions of this investigation are presented in the following sections of this appendix.

E.2 CHARACTERISTICS OF HF AND CaF_2 PRODUCED DURING CONVERSION

Conversion of DUF_6 to the solid uranium oxide form appropriate for use or disposal would be accomplished by reacting the UF_6 with steam and hydrogen, as indicated in the following reactions:

$$UF_6 + 2H_2O \rightarrow UO_2F_2 + 4HF \qquad \text{(E.1)}$$

and

$$3UO_2F_2 + H_2 + 2H_2O \rightarrow U_3O_8 + 6HF\ . \qquad \text{(E.2)}$$

The HF vapor and excess steam would be condensed, resulting in HF of approximately 55% strength. The predominant markets for HF call for 49% and 70% HF solutions; thus, the product from the conversion condensers could be further processed to yield these strengths.

A small fraction of the HF produced in the above reactions would escape capture in the condensers and remain as a vapor in the off-gas system. This uncondensed HF would be passed through a wet scrubber containing a nominal 20% potassium hydroxide (KOH) solution, where the HF would be converted into potassium fluoride (KF) via the following reaction:

$$HF + KOH \rightarrow KF + H_2O\ . \qquad \text{(E.3)}$$

The KOH would then be regenerated by adding lime to the above reaction products:

$$2KF + CaO + H_2O \rightarrow 2KOH + CaF_2 \,. \qquad \text{(E.4)}$$

The approximate quantities of HF and CaF_2 that would be produced annually via the above reactions at each site are shown in Table E-1. These quantities are based on converting the East Tennessee Technology Park (ETTP) cylinders at Portsmouth. As noted above, the 55% HF solution would be further processed into 70% and 49% solutions prior to being sold. The quantities of aqueous HF in these two concentrations are shown in Table E-2.

The quantities noted in Tables E-1 and E-2 are based on the assumption that there would be a viable economic market for the aqueous HF produced during the DUF_6 conversion process. If there were no such market, Uranium Disposition Services, LLC (UDS) proposes to convert all of the HF to CaF_2 and then either sell this product or dispose of it as a solid waste.

Under this scenario, CaF_2 would be produced by the following reactions:

$$CaO + H_2O \rightarrow Ca(OH)_2 \qquad \text{(E.5)}$$

and

$$Ca(OH)_2 + 2HF \rightarrow CaF_2 + 2H_2O. \qquad \text{(E.6)}$$

Approximate quantities of CaF_2 that would be produced annually if all the HF was converted to CaF_2 would be 8,800 t (9,700 tons) at Portsmouth and 11,800 t (13,000 tons) at Paducah. Under this scenario, the quantities of depleted triuranium octaoxide (U_3O_8) would remain the same as those shown in Table E-1.

TABLE E-1 Products from DUF_6 Conversion Assuming HF Acid Is Sold (metric tons per year)

Product	Portsmouth	Paducah	Total
Depleted U_3O_8	10,800	14,300	25,100
HF acid (55% solution)	8,300	11,000	19,300
CaF_2	18	24	42

TABLE E-2 Aqueous HF Levels for Sale (metric tons per year)

Product	Portsmouth	Paducah	Total
70% solution	2,500	3,300	5,800
49% solution	5,800	7,700	13,500

A small quantity of radioactive materials would transfer into the HF and CaF_2 products from the conversion process. As per the requirements of DOE Order 5400.5 (see Section E.4), UDS plans to apply for authorized release limits for these materials. Pending DOE's approval of authorized limits, estimates of the contaminant levels in the HF and CaF_2 have been made on the basis of the experience of Framatome Advanced Nuclear Power, Inc. (ANP) (a partner in UDS) at its Richland, Washington, facility authorized for manufacturing nuclear fuel. These values for HF are shown in Table E-3, along with the values that were assumed for estimating impacts in this EIS.

Any CaF_2 produced (either the small quantities from the off-gas treatment system or the mass conversion of all HF) would also be slightly radioactive. As it would do for HF, UDS also plans to apply for authorized release limits for CaF_2. Pending approval of authorized limits, the values shown in Table E-4 were used to estimate the impacts (UDS 2003a,b).

Certain chemical specifications must also be met for a product to be successfully marketed. Table E-5 shows likely process specifications for the production of HF. These specifications are based on vendor requirements at the Framatome ANP facility in Richland, Washington (UDS 2003a).

Similar process control specifications have been developed for CaF_2. These specifications were based on trade standards for acid-grade CaF_2 and are shown in Table E-6 (UDS 2003a).

TABLE E-3 Activity Levels for Aqueous HF

Contaminant	Expected Value	Assumed Activity
Depleted uranium	0.08 pCi/mL	3.0 pCi/mL (6.4 ppm)
Tc-99	1.6×10^{-5} pCi/mL	2.0×10^{-3} pCi/mL (15.9 ppb U)

TABLE E-4 Activity Levels for CaF_2

Contaminant	Expected Value	Assumed Activity
Uranium	0.04 pCi/g	1.5 pCi/g
Tc-99	0.8×10^{-5} pCi/g	1.0×10^{-3} pCi/g (15.9 ppb U)

TABLE E-5 Process Control Specifications for HF

Chemical Analysis or Physical Property	Specification
HF	49%
H_2SiF_6 (fluosilicic acid)	<70 ppm
H_2SO_4 (sulfuric acid)	<50 ppm
SO_2 (sulfur dioxide)	<50 ppm
Fe (iron)	<15 ppm
As (arsenic)	<14 ppm
U (uranium)	<0.5 ppm[a]
P (phosphorous)	<10 ppm
Color	Water white (clear)

[a] Based on mass concentration of uranium, regardless of radioactivity.

TABLE E-6 Process Control Specifications for Acid-Grade CaF_2

Chemical Analysis	Typical Range (%, except for As)
CaF_2	97.0 – 97.6
Total carbonate	0.8 – 1.8
SiO_2 (silica)	0.4 – 1.0
$BaSO_4$ (barium sulfate)	0.3 – 0.8
Pb (lead)	0.05 – 0.2
Fe	0.05 – 0.2
S (sulfide)	0.005 – 0.014
Moisture	<0.1 (8 – 9 as filtercake)
As (arsenic)	1 – 5 ppm

E.3 DESCRIPTION OF THE COMMERCIAL HF AND CaF_2 MARKETS AND POTENTIAL USES

Two potential markets for products made in the conversion process are considered here. The first is aqueous HF and the other is solid CaF_2. Small quantities of the CaF_2 would be produced in the preferred design. However, if no market for the HF could be found, large quantities of CaF_2 would be produced for sale to the market or for disposal as a solid waste. These products are discussed below.

E.3.1 Aqueous Hydrogen Fluoride (HF)

HF is the source of fluorine for most fluorine-containing chemicals. It is used either to directly manufacture such chemicals or to produce intermediates for their manufacture. HF is used to manufacture a wide variety of products, including refrigerants, gasoline, electronic components, aluminum, and plastics. It is used as a reactant or fluorinating source in the manufacture of fabric- and fiber-treating agents, herbicides, pharmaceutical intermediates, inert fluorinated liquids, and electronic grade etchants. Stannous fluoride, used in toothpaste, is manufactured by using HF. HF lasers have been tested for use in corneal transplants and for use in space. While the majority of HF used by industry is in the anhydrous or 100% form, aqueous HF solutions with concentrations of 70% and lower are used in stainless steel pickling, metal coatings, chemical milling, glass etching, exotic metals extraction, and quartz purification.

The commercial market in the United States for HF is in excess of 300,000 t (330,000 tons) per year (SRI Consulting 2002). However, only a small fraction (about 26,000 t [29,000 tons] or less than 9%) of that market is for aqueous HF. Uses for aqueous HF include the pickling metal and electronics industries. The U.S. capacity for producing HF consists of facilities owned by two companies. A plant near Geismar, Louisiana, has a production capacity of approximately 128,000 t (141,000 tons) per year, and a plant near La Porte, Texas, has a capacity of approximately 80,000 t (88,000 tons) per year. All of the aqueous HF produced in the United States is currently manufactured by Honeywell at the Geismar facility. Of the approximately 100,000 t (110,000 tons) of HF imported each year to the United States, Mexico provides approximately 75%, and Canada provides most of the remainder.

As the market information above shows, the HF produced during the DUF_6 conversion process would represent only about 10% and 6% of the U.S. production and demand, respectively. However, it would represent more than 70% of the total U.S. market for aqueous HF.

E.3.2 Calcium Fluoride (CaF_2)

On the basis of the assumption that a market would be found for the HF, the small quantity of CaF_2 that would be produced (approximately 42 t [46 tons] per year) would be disposed of as a solid waste. Part of this decision stems from the fact that at approximately $135/t (SRI Consulting 2002), annual revenues of only about $5,700 would be realized from the sale of this quantity of material. However, in the event that a market for the HF could not be found, approximately 20,600 t (22,700 tons) of CaF_2 would be produced annually. As shown in Table E-6, this material would be more than 97% pure. CaF_2 of this grade is commonly referred to as “acid-spar.”

The U.S. market for fluorspar is approximately 600,000 t (661,000 tons) per year. Of this, approximately 65% is used for the production of HF. Since the closing of the Rosiclare, Illinois, mine in 1995, there has been no mining of fluorspar in the United States. Instead, demand has been met by imports and by purchases of CaF_2 from the National Defense Stockpile. Since the U.S. Department of Defense was authorized to sell fluorspar from its stockpile, these sales have

represented 20% or more of the annual U.S. demand for CaF_2. In 2001, approximately 71,000 t (78,000 tons) of fluorspar were sold from the National Defense Stockpile. However, only about 9,500 t (10,500 tons) of acid-spar remain in the stockpile, with an additional 40,000 t (44,000 tons) of metallurgical grade fluorspar (a lower grade of fluorspar having a CaF_2 content of approximately 60% to 85%) (SRI Consulting 2002). Thus, it is not clear whether a significant portion of the U.S. demand for fluorspar could be met by the National Defense Stockpile.

The United States has been heavily dependent on imported fluorspar for many years. Imports have represented more than 90% of the U.S. demand in recent years, and, with the unavailability of the National Defense Stockpile to make any large-scale contributions, the percentage of CaF_2 imports is likely to get even higher. China has become the biggest supplier of fluorspar to the United States, providing 60% to 70% of the total U.S. imports. South Africa and Mexico are the other major suppliers to the United States, representing approximately 20% and 10%, respectively, of U.S. imports (SRI Consulting 2002).

E.4 OVERVIEW OF THE DOE PROCESS FOR ESTABLISHING AUTHORIZED LIMITS FOR RELEASE OF RADIOACTIVELY CONTAMINATED MATERIALS

As previously explained, two products of the DUF_6 conversion technology, HF and CaF_2, would have potential commercial use. However, because these products are expected to contain small amounts of volumetrically distributed residual radioactive material in the form of uranium and technetium-99 (Tc-99), they could not be sold for unrestricted use, unless DOE establishes authorized limits. In this context, authorized limits would be the maximum concentrations of uranium and Tc-99 allowed to remain volumetrically distributed within the HF and CaF_2 being sold.

Authorized limits are limits on the amount of residual radioactive material distributed volumetrically within property that DOE or its contractors release for unrestricted use. In cases involving volumetrically distributed residual radioactive material, such as the proposed release of HF and CaF_2, authorized limits are typically expressed as maximum allowable concentrations of specified residual radionuclides. Correspondingly, the authorized limits for HF and CaF_2 would specify maximum allowable concentrations of residual uranium and Tc-99.

In general, authorized limits for DOE property that will be released from DOE control are established and implemented on a case-specific basis according to a process defined by DOE Order 5400.5, “Radiation Protection of the Public and the Environment,” and supporting guidance documents. This process (referred to as the authorized limits process) is designed to achieve the following goals (DOE 2002):

- Property is evaluated, radiologically characterized, and, where appropriate, decontaminated before release.

- The level of residual radioactive material in the property to be released is as near to background levels as is reasonably practicable, as determined by

applying the principles of the DOE ALARA (as low as reasonably achievable) process.

- All property releases meet authorized limits and are appropriately certified, verified, documented, and reported; public involvement and notification needs are addressed; and processes are in place to appropriately maintain records.

If UDS decides to release HF and/or CaF_2 from the DUF_6 conversion facilities for unrestricted use, the authorized limits process would include the following steps:

- Identification, for both HF and CaF_2, of several sets of potential maximum allowable concentrations for residual uranium and technetium-99 to serve as alternative sets of authorized limits for the purpose of ALARA analysis;

- Verification that each alternative set of authorized limits would comply with the DOE public dose limit;

- Selection through an ALARA analysis of one set each of authorized limits to be proposed for DOE approval from among the alternatives for both HF and CaF_2;

- Coordination with the U.S. Nuclear Regulatory Commission (NRC) or the responsible Agreement State agency;

- Development of survey and/or test methods, including provisions for quality assurance, to be used for demonstrating compliance with the proposed authorized limits;

- Acquisition of DOE approval of the proposed authorized limits for release of HF and CaF_2; and

- Placement in the DOE permanent record and in the public record of documentation supporting the release for unrestricted use of HF and CaF_2.

Additional information about each step in the authorized limits process is provided below.

E.4.1 Identification of Alternative Sets of Authorized Limits

As previously mentioned, Framatome ANP (one of the partners in UDS) currently operates an NRC-licensed, nuclear fuel manufacturing facility near Richland, Washington, that has a uranium conversion system with several design features similar to those of the proposed DUF_6 conversion facilities. HF from the Richland facility is sold under the provisions of that facility's NRC license. UDS would identify alternative sets of authorized limits for the release of HF and CaF_2 from the DUF_6 conversion facilities on the basis of the Framatome ANP facility's operating experience and the release limits specified for HF in its existing NRC license. The

analyses presented in Section E.5 very conservatively estimate the impacts that would result from the use after sale of HF and CaF_2. Because these analyses are so conservative, they are expected to bound the impacts from selling HF and CaF_2, in compliance with any alternative set of authorized limits that UDS is likely to propose for DOE approval.

E.4.2 Verification of Compliance with the DOE Public Dose Limit

The DOE public dose limit for any member of the general public is 100 mrem total effective dose equivalent (TEDE) in a year. This limit applies to the sum of internal and external doses resulting from all modes of exposure to all radiation sources (i.e., both DOE and non-DOE sources) except background radiation sources and medical sources [DOE Order 5400.5, II.1.a.(3)(a)].

Because the DOE public dose limit applies to exposure from all sources and pathways, not just DOE sources, it would be very complicated and expensive to verify compliance. Therefore, for the purpose of establishing authorized limits, DOE has simplified verification of compliance with the primary dose limit by adopting a presumption of compliance if the dose from a DOE practice, such as releasing HF or CaF_2 containing residual radioactive material, to those individual members of the public most likely to receive the highest doses (referred to as the maximally exposed members of the public) can be demonstrated to comply with a dose constraint of one-quarter of the public dose limit (i.e., 25 mrem TEDE in a year) (DOE 2002). As a result, each alternative set of authorized limits identified by UDS for the release of HF and CaF_2 from the DUF_6 conversion facilities would have to be shown during the authorized limits process to result in doses to maximally exposed members of the public of no more than 25 mrem TEDE in a year.

E.4.3 ALARA Analysis

DOE Order 5400.5 requires that DOE contractors implement the ALARA process with respect to any DOE activity or practice that may cause members of the public to be exposed to radiation [DOE Order 5400.5, II.2]. For that reason, UDS is required to have an ALARA program for the DUF_6 facilities. The ALARA program must address activities on the sites that can cause members of the public or workers to be exposed to radiation. With respect to releases of property, such as the HF or CaF_2 produced by the DUF_6 conversion facilities, the ALARA program must include a procedure for an ALARA analysis to select authorized limits that would reduce radiation exposures to levels that are as low as practicable, taking into account technological, economic, safety, environmental, social, and public policy factors. There is no single best procedure for conducting an ALARA analysis. However, a key component should be a cost-benefit analysis (DOE 1997). For the purposes of this analysis, costs are assumed to accrue as a result of (1) expenditures to purchase, install, operate, and maintain the equipment and (2) expenditures to address health effects that may be induced by exposures of humans to ionizing radiation, such as cancer and genetic diseases. In evaluating expenditures to address health effects, DOE assumes that collective dose is proportional to the risk (i.e., the probability of observing radiation-induced health effects in a fixed population). Benefits accrue as a result of

(1) reduced expenditures for equipment and (2) reduced collective dose. To determine the collective dose to the exposed population for purposes of the ALARA analysis, the number of exposed persons would be multiplied by the average individual dose. The average individual dose is determined, to the extent practicable, by estimating anticipated doses to actual people (rather than doses to hypothetical maximally exposed persons), as was done for verification of compliance with the DOE public dose limit.

In addition to analysis of direct costs and benefits, consideration of technological, environmental, social, and public policy factors must also be a component of the ALARA analysis. While the particular nonradiological factors to be considered with respect to the release of HF and CaF_2 from the DUF_6 conversion facilities would be identified by UDS on the basis of case-specific issues, the following list provides examples of possible factors within each general category.

- *Technological factors:* promotion of emerging technology, technology transfer, robustness of technology, industrial safety of technology, and track record of technology;

- *Environmental factors:* effects on ecological resources, waste generation rates, ease of management of resulting wastes, probable disposition of resulting wastes, and fate of residual radioactive material released;

- *Social factors:* impacts on local/national product market, employment, public acceptance, environmental justice considerations, and transportation effects; and

- *Public policy factors:* consistency with waste minimization principles, promotion of resource conservation, adaptability to existing procedures and protocols, and environmental permitting issues.

E.4.4 Coordination with NRC and Agreement States

DOE policy prohibits the transfer of radioactive materials that require an NRC license to members of the public who are not licensed to receive them (see, e.g., Sections 3.7 and 5.6 of DOE [2002] and Section IV.5 of DOE Order 5400.5 [DOE 1990]). Accordingly, before DOE approves authorized limits for the release of HF or CaF_2, the NRC or responsible Agreement State must be consulted to ensure that releases under the proposed authorized limits do not violate any licensing requirements.

E.4.5 Development of Measurement Protocols

Radiological surveys and measurements of residual radioactive material in HF and CaF_2 must be conducted before the material is released. To accomplish this, measurement protocols, procedures, and equipment must be specified and approved by DOE as being sufficient to meet data quality objectives for characterization of the material being released and verification of

compliance with the authorized limits. To obtain DOE approval for measurement protocols and procedures, UDS will need to show that such actions comply with the quality assurance requirements contained in the *Code of Federal Regulations*, Title 10, Part 830 (10 CFR 830), "Nuclear Safety Management," Subpart A.

E.4.6 Obtaining DOE Approval of Authorized Limits

Authorized limits and survey protocols for the sale of HF and CaF_2 containing volumetrically distributed residual radioactive material must be approved by both the responsible DOE Field Element and the Assistant Secretary for Environment, Safety, and Health. The application for these DOE approvals would contain the information listed below.

- Description of the anticipated physical, chemical, and radiological attributes of the HF and CaF_2 proposed for release;
- Descriptions of the alternative sets of authorized limits evaluated in the ALARA analysis;
- For each alternative set of authorized limits, the expected doses to those individual members of the public most likely to receive the highest doses in the actual and likely use scenario and in the worst plausible use scenario;
- Results of the ALARA analysis, including collective doses and other relative costs and benefits for each alternative set of authorized limits, and discussions of any nonradiological factors that influenced the selection of the proposed authorized limits;
- Clear and concise statement of the proposed authorized limits for HF and CaF_2, including the limit for each isotope of concern;
- Discussion of the measurement protocols that would be implemented to determine compliance with the proposed authorized limits; and
- Information on activities that have been conducted to gain agreement with representatives of affected groups, including documentation that coordination has occurred with NRC personnel or Agreement State representatives.

E.4.7 Final Documentation

DOE Order 5400.5 requires that documentation of specific information related to releases of property containing residual radioactive material be made part of DOE's permanent record. In addition, DOE recognizes the importance of public participation in its program operations (DOE 2000) and instructs its contractors to make documentation supporting approval of authorized limits and subsequent releases of property containing residual radioactive material available to the public (DOE 2002). Accordingly, in addition to the information provided in this EIS, the

documentation listed below regarding DOE's approval of authorized limits and subsequent sales of HF and CaF_2 from the DUF_6 conversion facilities would be made available in the public record.

- Application submitted by UDS to DOE requesting that authorized limits be established for the sale of HF and CaF_2 from the DUF_6 conversion facilities;
- DOE's final approval of authorized limits for the sale of HF and CaF_2 from the DUF_6 conversion facilities; and
- Periodic performance reports submitted by UDS to DOE summarizing the contents of (1) certificates of conformance issued by UDS after batches of HF and CaF_2 destined for sale have been sampled and analyzed according to approved procedures and determined to meet the applicable authorized limits, (2) analytical results from the sampling and analysis, and (3) shipping manifests indicating the disposition of the HF and CaF_2.

E.5 BOUNDING ESTIMATION OF POTENTIAL HUMAN HEALTH IMPACTS FROM HF AND CaF_2 SALE AND USE

E.5.1 Radiological Impacts

E.5.1.1 Exposures to HF

Bounding radiological impacts resulting from exposure to trace amounts of uranium (U) and technetium (Tc) in HF were calculated by considering a hypothetical worker working in close proximity to an HF storage tank. The storage tank was assumed to be a 10,000-gal (37,854-L) cylindrical container, with a diameter of 3.2 m (10.5 ft) and a height of 4.7 m (15.4 ft). The worker was assumed to work 2,000 hours per year at a distance of 1 m (3 ft) from the storage tank. Concentration of U in the HF solution was assumed to be 3 pCi/mL (6.4 parts per million [ppm]), the NRC-approved limit for the Framatome ANP facility; the concentration of Tc was assumed to be 15.9 parts per billion of uranium (ppb U), or 2×10^{-3} pCi/mL.

Potential radiation exposure incurred by the hypothetical worker was considered to result from external radiation and inhalation. Because of the corrosive nature of HF, ingestion of HF was considered extremely unlikely and was excluded from consideration. According to Occupational Safety and Health Administration (OSHA) standards, the permissible exposure limit to HF vapor is 3 ppm. For concentrations of 3 to 30 ppm, a minimum of a full-face respirator equipped with an HF canister must be worn. Unlike HF, which can vaporize under room temperature, U and Tc oxides that are contained in HF solution would most likely stay in the solution. However, for the purpose of calculating a bounding exposure, the oxides were assumed to be entrained in the vaporized HF molecules. The permissible limit of 3 ppm was assumed as the air concentration for HF. The DOE-recommended air release fraction (ARF) of 0.002 for radionuclide solute in aqueous solutions (DOE 1993) was assumed for the U and Tc

oxides. The bounding inhalation dose was calculated by using an inhalation rate of 1.2 m^3/h and the maximum inhalation dose conversion factors (Class Y for U and Class W for Tc) from the U.S. Environmental Protection Agency (EPA 1988). The bounding external dose was calculated with the MicroShield computer code (Negin and Worku 1992).

On the basis of the above assumptions, it is estimated that total radiation dose for a worker in close proximity to the HF storage tank would be 0.034 mrem/yr. External radiation contributes 0.027 mrem/yr to the total dose and is the dominating pathway. Radiation doses result primarily from exposure to uranium isotopes and their decay products; the dose contribution from Tc is negligible. It should be reiterated that this bounding dose was estimated by combining several extremely conservative assumptions; for example, the close proximity to the storage tank, the exposure duration of all the work hours in a year, the entrainment of U and Tc oxides, and the bounding air release fraction for U and Tc oxides. In reality, the actual dose resulting from using or handling the HF product would be much smaller. For comparison, the radiation dose constraint set to protect the general public from a DOE practice is 25 mrem/yr (see Section E.4).

As discussed in Appendix A, Sections A.4 through A.6, transuranic (TRU) radionuclides are not expected to reach the conversion chambers in the facility and should not be present in any measurable quantities in the conversion products. Any minute concentration of such radionuclides in the products would be much less than the 10% threshold discussed in Section A.5. As a result, their contribution to doses calculated in this appendix would be negligible.

E.5.1.2 Exposures to CaF_2

Bounding radiological impacts resulting from exposure to trace amounts of U and Tc in CaF_2 were calculated by considering an exposure scenario similar to that considered for HF. A hypothetical worker was assumed to work in close proximity to a CaF_2 filling bag. The filling bag was assumed to have a 19-t (21-ton) capacity, with a diameter of 2.8 m (9.2 ft) and a height of 1.2 m (4 ft). The worker was assumed to work 2,000 hours per year at a distance of 1 m (3 ft) from the filling bag. Concentrations of U and Tc in CaF_2 were assumed to be half of those in HF solution, that is, 1.5 pCi/g for U and 15.9 ppb U or 1×10^{-3} pCi/g for Tc.

Potential radiation exposure incurred by the hypothetical worker was considered to result from external radiation, inhalation, and ingestion. The U and Tc oxides were assumed to attach to the CaF_2 particles and to become suspended in air during the filling operation. According to OSHA standards (OSHA 2002), the particulate emission limit for fluoride compounds is 2.5 mg/m^3. This limit was used to calculate the air concentration for CaF_2 and, subsequently, the air concentrations of U and Tc. The bounding inhalation dose was calculated by assuming a respirable fraction of 10% and by using an inhalation rate of 1.2 m^3/h and the maximum inhalation dose conversion factors (Class Y for U and Class W for Tc) from the EPA (EPA 1988). The hypothetical worker was also assumed to ingest CaF_2 particles incidentally. The ingestion rate was assumed to be 100 mg/d. Like inhalation, the maximum ingestion dose conversion factors for U and Tc from the EPA (EPA 1988) were used to calculate the bounding

ingestion dose. The bounding external dose was calculated with the MicroShield computer code (Negin and Worku 1992).

On the basis of the above assumptions, the estimated total radiation dose for a worker in close proximity to the CaF_2 filling station would be 0.234 mrem/yr. External radiation contributes only 0.007 mrem/yr to the total dose, which is dominated by the contribution from inhalation, 0.217 mrem/yr. The rest of the dose is contributed by ingestion, 0.01 mrem/yr. Radiation doses result primarily from exposure to uranium isotopes and their decay products; the dose contribution from Tc is negligible. It should be reiterated that this bounding dose was estimated by combining several extremely conservative assumptions, for example, the close proximity of the worker to the filling bag, the exposure duration of all the work hours in a year, and the maximum allowable particulate concentration of fluoride compounds in the air. In reality, the actual dose resulting from use or handling the CaF_2 product would be much smaller. For comparison, the radiation dose constraint set by DOE to protect the general public from a DOE practice is 25 mrem/yr (see Section E.4).

E.6 POTENTIAL SOCIOECONOMIC IMPACTS OF HF AND CaF_2 SALE AND USE

The *DUF_6 Conversion Product Management Plan* (UDS 2003a) identifies potential uses of conversion facility products, either as CaF_2 or as aqueous HF. This section assesses the impacts from the use of these products at the U.S. locations likely to be directly affected and in the U.S. economy as a whole. Since the success of CaF_2 and HF sales to chemical manufacturers depends on future market conditions, the impacts of treating CaF_2 or aqueous HF as waste are also considered.

E.6.1 Impacts from the Sale and Use of HF

The current aqueous HF producers have been identified as a potential market for the 19,200 t (21,200 tons) of aqueous HF that could be produced by the proposed conversion facility (UDS 2003a), with UDS-produced aqueous HF replacing some or all of current U.S. production. The impact of HF sales on the local economy in which the existing producer is located and on the U.S. economy as a whole is likely to be minimal.

All aqueous HF currently produced in the United States is manufactured by Honeywell at a facility in Geismar, Louisiana. Additional plants owned by Honeywell and other companies serving the U.S. market are located in Canada and Mexico. The Geismar plant as a whole employs a fairly large number of workers and manufactures a range of industrial chemicals, including both anhydrous and aqueous HF, which is marketed in various concentrations. The manufacture of aqueous HF employs a small number of production and clerical workers. A fleet of dedicated tankers employing a small number of drivers is used to transport HF to end-users in various locations in the United States (Honeywell International, Inc. 2002).

Although the actual impact of the sale of UDS HF is not known, if Honeywell were to purchase HF from UDS, production of aqueous HF at the Geismar facility might be reduced or

cease altogether, which would mean the loss of some or all aqueous HF production and transportation employment at the plant and the loss of some related clerical employment.

The loss of employment and income at the Geismar facility with the end of aqueous HF production and transportation would lead to minor additional losses in the surrounding economy, with a slight reduction in activity associated with reduced wage and salary spending. Offsetting these losses would be a slight increase in transportation employment at Paducah and Portsmouth associated with the shipment of HF from the UDS facilities. There would also be benefits to the U.S. balance of trade, with the use of UDS-produced HF reducing the need to import CaF_2, the raw material for HF production. These benefits would be minimal, however, given the small quantity of HF production likely to take place at the proposed facilities and the relatively low potential value of the HF product. There would also be some benefits to Honeywell in terms of cost savings associated with the end of blending anhydrous with aqueous HF. However, if HF concentrations were different than those preferred by end-users, some additional capital and operating expenditures might be needed to accommodate the change in acid concentration (Taylor 2003).

E.6.2 Impacts from the Sale and Use of CaF_2

No market for the 20,600 t (22,700 tons) of CaF_2 that might be produced in the proposed conversion facilities at Paducah and Portsmouth annually has been identified (UDS 2003a). If a market for CaF_2 is found, the impact of CaF_2 sales on the U.S. economy would likely be minimal.

Although CaF_2 was produced in the United States until 1995, most of the 636,000 t (701,000 tons) of CaF_2 consumed in the United States in 2001 was imported. While the use of CaF_2 produced at the UDS facilities would affect the balance of trade, this impact would be minor, given the small quantity of CaF_2 production at the proposed facilities and the relatively low potential value of the CaF_2 product. There might be benefits to U.S. users of CaF_2 if the price of CaF_2 produced in the proposed facilities provided a significant incentive to use the UDS products rather than imported material. However, a price range for UDS-produced CaF_2 has not yet been established, and since plentiful supplies of CaF_2 are available from overseas, the small amount of CaF_2 that would be produced would not likely have a significant effect on the domestic market.

E.6.3 Impacts from the Nonuse of HF and CaF_2

If no market for either HF or CaF_2 is established, it is likely that the material would be disposed of as waste. This would require shipping these wastes to an approved waste disposal facility. While disposal activities would result in a small number of transportation jobs and might lead to additional jobs at the waste disposal facility, the impact of these activities in the transportation corridors, at the waste disposal site(s), and on the U.S. economy would be minimal.

E.7 REFERENCES

DOE (U.S. Department of Energy), 1990, *Radiation Protection of the Public and the Environment*, DOE Order 5400.5, Washington, D.C., Feb. 8.

DOE, 1993, *DOE Handbook: Recommended Values and Technical Bases for Airborne Release Fraction (ARFs), Airborne Release Rates (ARRs), and Respirable Fractions (RFs) at DOE Non-Reactor Nuclear Facilities*, DOE-STD-0013-93, Washington, D.C., July.

DOE, 1997, DOE Standard, *Applying the ALARA Process for Radiation Protection of the Public and Environmental Compliance with 10 CFR Part 834 and DOE 5400.5 ALARA Program Requirements*, draft standard, Washington, D.C., April. Available at http//:tis.eh.doe.gov/oepa.

DOE, 2002, *Implementation Guide, Control and Release of Property with Residual Radioactive Material for Use with DOE 5400.5, Radiation Protection of the Public and the Environment*, DOE G 441.1-XX, draft, Washington, D.C., April 4.

DOE, 2003, *Public Participation and Community Relations*, DOE P 141.2, Washington, D.C., May 2.

EPA (U.S. Environmental Protection Agency), 1988, *Limiting Values of Radionuclide Intake and Air Concentration and Dose Conversion Factors for Inhalation, Submersion, and Ingestion*, Federal Guidance Report No. 11, EPA-520/1-88-020, Office of Radiation Programs, Washington, D.C., Sept.

Honeywell International, Inc., 2002, *Hydrofluoric Acid Properties*, Vol. 1.1, Morris Township, N.J., Jan. Available at http://www.hfacid.com.

Negin, C.A., and G. Worku, 1992, *MicroShield, Version 4, User's Manual*, Grove 92-2, Grove Engineering, Inc., Rockville, ME.

OSHA (Occupational Safety and Health Administration), 2002, "Toxic and Hazardous Substances," Subpart Z in *Code of Federal Regulations*, Title 29, Part 1910, "Occupational Safety and Health Standards," U.S. Government Printing Office, Washington, D.C., July 1.

SRI Consulting, 2002, "CEH Marketing Research Report: Fluorspar and Inorganic Fluorine Compounds," in *Chemical Economics Handbook*, Menlo Park, Calif., July.

Taylor, E., 2003, personal communication from E. Taylor (Honeywell International, Inc., Morris Township, N.J.) to T. Allison (Argonne National Laboratory, Argonne, Ill.), March 4.

UDS (Uranium Disposition Services, LLC), 2003a, *DUF_6 Conversion Product Management Plan*, DUF6-UDS-PL-004, Rev. OC, Jan. 20.

UDS, 2003b, *Initial NEPA Data*, DUF_6-UDS-NEP-001, Rev. 0, Oak Ridge, Tenn., Feb. 28.