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OFFICE OF SAFETY REGULATION POSITION ON CONFORMANCE WITH RISK GOALS IN DOE/RL-96-0006

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Office of Safety Regulation

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PREFACE

As directed by Congress in Section 3139 of the *Strom Thurmond National Defense Authorization Act for Fiscal Year 1999,* the U.S. Department of Energy (DOE) established the Office of River Protection (ORP) at the Hanford Site to manage the River Protection Project (RPP), formerly known as the Tank Waste Remediation System. ORP is responsible for the safe storage, retrieval, treatment, and disposal of the high level nuclear waste stored in the 177 underground tanks at Hanford.

The initial concept for treatment and disposal of the high level wastes at Hanford was to use private industry to design, construct, and operate a Waste Treatment Plant (WTP) to process the waste. The concept was for DOE to enter into a fixed-price contract for the Contractor to build and operate a facility to treat the waste according to DOE specifications. In 1996, DOE selected two contractors to begin design of a WTP to accomplish this mission. In 1998, one of the contractors was eliminated, and design of the WTP was continued. However, in May 2000, DOE chose to terminate the privatization contract and seek new bidders under a different contract strategy. In December 2000, a team led by Bechtel National, Inc. was selected to continue design of the WTP and to subsequently build and commission the WTP.

On January 10,2001, the U.S. Department of Energy published the revised Nuclear Safety Management rule, 10 CFR 830. This rule, in Subpart B, "Safety Basis Requirements," established specific requirements for the establishment and maintenance of the safety basis of DOE nuclear facilities, including the River Protection Project Waste Treatment Plant (RPP-WTP) project.

A key element of the River Protection Project Waste Treatment Plant (RPP-WTP) is DOE regulation of safety through a specifically chartered, dedicated Office of Safety Regulation (OSR). The OSR reports directly to the ORP Manager. The regulation by the OSR is authorized by the document entitled *Policy for Radiological, Nuclear, and Process Safety Regulation of the River Protection Project Waste Treatment Plant Contractor* (DOE/RL-96-25) (referred to as the Policy) and implemented through the document entitled *Memorandum of Agreement for the Execution of Radiological, Nuclear, Process Safety Regulation of the RPP-WTP Contractor* (DOE/RL-96-26) (referred to as the MOA). These two documents provide the basis for the safety regulation of the RPP-WTP at Hanford, including the implementation of regulatory requirements such as 10 CFR 830.

The foundation of both the Policy and the MOA is that the mission of removal and immobilization of the existing large quantities of tank waste by the RPP-WTP Contractor must be accomplished safely, effectively, and efficiently.

The Policy maintains the essential elements of the regulatory program established by DOE in 1996 for the privatization contracts. The MOA clarifies the DOE organizational relationships and responsibilities for safety regulation of the RPP-WTP. The MOA provides a basis for key DOE officials to commit to teamwork in implementing the policy and achieve adequate safety of RPP-WTP activities.

The Policy, the MOA, the RPP-WTP Contract, and the four documents incorporated in the Contract define the essential elements of the regulatory program being executed by the OSR. The four documents incorporated into the Contract (and also in the MOA) are as follows:

> *Concept of the DOE Process for Radiological, Nuclear, and Process Safety Regulation of the RPP Waste Treatment Plant Contractor,* DOE-96-0005,
>
> *DOE Process for Radiological, Nuclear, and Process Safety Regulation of the RPP Waste Treatment Plant Contractor,* DOE/RL-96-0003,
>
> *Top-Level Radiological, Nuclear, and Process Safety Standards and Principles for the RPP Waste Treatment Plant Contractor,* DOE/RL-96-0006, and
>
> *Process for Establishing a Set of Radiological, Nuclear, and Process Safety Standards and Requirements for the RPP Waste Treatment Plant Contractor,* DOE/RL-96-0004.

DOE patterned its safety regulation of the RPP-WTP Contractor to be consistent with the concepts and principles of good regulation (reliability, clarity, openness, efficiency, and independence) used by the Nuclear Regulatory Commission (NRC). In addition, the DOE principles of integrated safety management were built into the regulatory program for design, construction, operation, and deactivation of the facility. The regulatory program for nuclear safety permits waste treatment services to occur on a timely, predictable, and stable basis, with attention to safety consistent with that which would occur from safety regulation by an external agency. DOE established OSR as a dedicated regulatory organization to be a single point of DOE contact for nuclear safety oversight and approvals for the WTP Contractor. The OSR performs nuclear safety review, approval, inspection, and verification activities for ORP using the NRC principles of good regulation while defining how the Contractor shall implement the principles of standards-based integrated safety management.

A key feature of this regulatory process is its definition of how the standards-based integrated safety management principles are implemented to develop a necessary and sufficient set of standards and requirements for the design, construction, operation, and deactivation of the RPP-WTP facility. This process meets the expectations of the DOE necessary and sufficient closure process (subsequently renamed Work Smart Standards process) in DOE Policy 450.3, *Authorizing Use of the Necessary and Sufficient Process for Standards-based Environment, Safety and Health Management*, and is intended to be a DOE approved process under DOE Acquisition Regulations, DEAR 970.5204-2, *Laws, Regulations and DOE Directives,* Section (c). DOE approval of the contractor-derived standards is assigned to the OSR.

The RPP-WTP Contractor has direct responsibility for WTP safety. DOE requires the Contractor to integrate safety into work planning and execution. This integrated safety management process emphasizes that the Contractor's direct responsibility for ensuring that safety is an integral part of mission accomplishment. DOE, through its safety regulation and management program, verifies that the Contractor achieves adequate safety by complying with approved safety requirements.

All documents issued by the Office of Safety Regulation of the RPP-WTP Contractor are available to the public through the DOE/RL Public Reading Room at the Consolidated Information Center, Room 101L, Richland, Washington. Copies may be purchased for a duplication fee.

RECORD OF REVISION

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10/06/00	1	Updated, corrected errors, added Appendix B, added discussion on site boundary, added discussion of chemical process risks.
04/03/02	2	Updated, added discussion to ensure consistency with ORP/OSR-2001-17.

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OFFICE OF SAFETY REGULATION (OSR) POSITION ON CONFORMANCE WITH RISK GOALS IN DOE/RL-96-0006

1.0 PURPOSE

This position paper describes a method, acceptable to the Office of Safety Regulation (OSR), for demonstrating conformance with the radiological risk goals found in Section 3.0 of DOE/RL-96-0006, *Top-Level Radiological, Nuclear, and Process Safety Standards and Principles for TWRS Privatization Contractor*. This paper also discusses non-radiological risks for completeness, but does not address goals for such risks. Alternative approaches to those described in this position paper, may be used if they are adequately justified.

2.0 BACKGROUND

One component of the River Protection Project Waste Treatment Plant (RPP-WTP) integrated safety management (ISM) process is to ensure that the risks from facility operations, including the risks from potential accidents, are limited. The Contractor has committed to an overall approach to safety that integrates the radiation dose standards for normal operations, accidents and effluents, as low as is reasonably achievable (ALARA) design objectives, and risk goals for operating the facility with mandatory defense-in-depth principles.

The RPP-WTP regulatory program refers to "risk" in a variety of locations.[1] For example, Top-Level Safety Principle 4.2.1.2, Risk Assessment, states: "Acceptable risk analyses should be applied during the design to delineate provisions for the prevention and mitigation, including emergency preparedness and response, of otherwise risk-dominant events." The definition of "important to safety" in the contract also requires that the Top-Level Safety Standards and Principles be applied to structures, systems, and components (SSCs) "commensurate with their contribution to risk." Under "General Safety Objectives," three "risk goals" are provided to limit the risk of fatality to a selected population.

The following are the three risk goals that are presented as radiological and nuclear safety objectives in DOE/RL-96-0006:

- Operations risk goal
- Accident risk goal
- Worker accident risk goal.

Regarding process safety, DOE/RL-96-0006 contains a set of "overall principles" which includes a requirement to reduce the incidence or mitigate the consequences of accidental hazardous chemical releases. However, quantitative risk goals similar to those for radiological and nuclear safety are not provided. In lieu of quantitative goals, Section 5.2.2 of DOE/RL-96-0006 requires the Contractor to "document the results of the hazards analysis including process hazards and possible safety and health effects" and to "submit the results of the hazards analysis to the

[1] See also a treatment of this subject in RL/REG-2000-15, *Regulatory Unit Position on the Achievement of Adequate Safety*, Section 3.3.1.2, Rev. 0.

Safety Regulation Official (SRO) for evaluation and in support of authorization decisions and regulatory oversight."

3.0 POSITION

The following sections describe each of the risk goals and the OSR's position concerning acceptable methods for demonstrating conformance.

3.1 Limitations Concerning Calculation of Risk

3.1.1 Due to the differences between the previous Contractor's facility risk calculation methodology and traditional reactor probabilistic risk assessment (PRA) methodology, the OSR position concerning the risk analysis requirements in the RPP-WTP regulatory program is that facility risk assessment results for the construction authorization submittal should be limited to the following:

- Relative risk comparisons when evaluating design options during the design process.
- Identification of risk-dominant events to influence the design so as to reduce risk or uncertainty of risk.
- Order-of-magnitude comparison to risk goals as a qualitative measure of the acceptability of the overall facility risk. If the results of this comparison are found to be unacceptable (i.e., estimated risk is significantly higher than the risk goals), then an engineering judgement should be made whether a more detailed PRA of selected portions of the design is appropriate to better estimate the risk, and to identify design changes that appear to more closely meet the risk goals.

3.1.2 If the risk estimates for the facility based on the design confirmation stage do not conform to the risk goals, the Contractor should resolve the non-conformance. The OSR position is that there are several acceptable alternatives, as follows:

- Modification of the design to reduce the estimated risk of the facility below the risk goals, and revision of the construction authorization submittal accordingly.
- Refinement of the risk estimate based on more elaborate calculation or better data, and revision of the construction authorization submittal accordingly.
- No revision of the construction authorization submittal, pending development of the final design and accident analysis for the operating authorization submittal. However, the accident analysis for the operating authorization submittal must demonstrate that the final design of the facility will achieve the risk goals, based on reasonable analyses using available data and standardized approaches, and making appropriate allowance for the uncertainty of the analysis. This approach

may later require design modifications during construction at a point where the modifications are more costly to incorporate, so it should be used with care.

- Some combination of the above.

The alternative(s) selected should be appropriately justified in the construction authorization submittal. Other approaches may also be acceptable, if appropriately justified.

3.2 Operations Risk Goal

The operations risk goal is prescribed in DOE/RL-96-0006, Section 3.1.1:

> "The risk, to the population (public and workers) in the area of the Contractor's facility, of cancer fatalities that might result from facility operation should not exceed one-tenth of one percent (0.1%) of the sum of cancer fatality risks to which members of the U.S. population generally are exposed." (For evaluation purposes, individuals are assumed to be located within 10 miles of the controlled area.)

The OSR position concerning this goal is:

1. This risk goal may be considered numerically equivalent to a latent cancer fatality risk of 2×10^{-6} per year.[2]

2. To determine conformance with the operations risk goal, best estimates of the risk to the most limiting hypothetical location of a person at the Hanford Site boundary are acceptable (as described in the SRD, Vol. II, Appendix D, Section 3.5.3).

3. The risks shall include those resulting from both normal operations and postulated accidents that credibly could result in releases of radioactive material from the RPP-WTP facility.

3.3 Accident Risk Goal

The accident risk goal is prescribed in DOE/RL-96-0006, Section 3.1.2:

> "The risk, to an average individual in the vicinity of the Contractor's facility, of prompt fatalities that might result from an accident should not exceed one-tenth of one percent (0.1%) of the sum of prompt fatality risks resulting from other accidents to which members of the U.S. population are generally exposed." (For evaluation purposes, individuals are assumed to be located within one mile of the controlled area.)

[2] The numerical equivalence of 2×10^{-6} per year was established in RL/REG-98-01, *DOE Regulatory Unit Evaluation Report of the BNFL Inc. Safety Requirements Document*. Additional discussion on the relationship between risk goals and average annual doses is provided in Appendix B.

The OSR's position on this goal is as follows:

1. This risk goal may be considered to be numerically equivalent to a prompt fatality risk of 4×10^{-7} per year.[3]

2. Prompt[4] fatalities to individuals outside the controlled area of the RPP-WTP facility as a result of accidental releases would require very large doses over a short time to such individuals. Accordingly, to reduce the analytical burden of this risk calculation and to simplify the calculation, the accident risk goal will be considered met if the Contractor can demonstrate that no postulated accident could result in doses sufficient to cause a prompt fatality outside the facility controlled area. Additional information on this position is provided in Appendix A to this paper.

3.4 Worker Accident Risk Goal

The worker accident risk goal is prescribed in DOE/RL-96-0006, Section 3.1.3:

> "The risk, to workers in the vicinity of the Contractor's facility, of fatality from radiological exposure that might result from an accident should not be a significant contributor to the overall occupational risk of fatality to workers." (For evaluation purposes, workers are assumed to be located within the controlled area.)

The OSR's position on this goal is as follows:

1. This risk goal may be considered to be numerically equivalent to a fatality risk of 1×10^{-5} per year from both prompt and latent cancer fatalities.[5]

2. To determine conformance with the worker accident risk goal, two separate calculations are necessary:

   - A risk calculation for facility workers. The calculated risk should be distributed over facility workers who are potentially affected by the accidents.

   - A risk calculation for a hypothetical individual located 100 m from the release point. Conformance with the goal is demonstrated if the sum of the risks associated with the facility does not exceed the goal for the hypothetical individual.

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[3] The numerical equivalence of 4×10^{-7} per year was established in RL/REG-98-01. Additional discussion on the relationship between risk goals and average annual doses is provided in Appendix B.

[4] Note that "prompt", when used in this context, is intended to imply that consequent fatalities are the result of acute exposures. Such fatalities would be expected to occur from a few to many days after the associated exposure.

[5] The numerical equivalence of 1×10^{-5} per year was established in RL/REG-98-01 and has been acknowledged by the previous Contractor in topical meetings and associated documentation. Additional discussion on the relationship between risk goals and average annual doses is provided in Appendix B.

4.0 ANALYSIS

The RPP-WTP facility regulatory framework established by the Contract includes risk goals which, when accomplished, are expected to be part of a comprehensive integrated safety management process that provides adequate safety.

The following sections provide the bases for the OSR's position concerning limitations on the calculation of risk, and on appropriate assumptions concerning calculation of conformance with the risk goals.

4.1 Limitations Concerning the Calculation of Risk

From the principles of DOE/RL-96-0006, the Contractor is expected to calculate the risk of facility operation prior to operation of the facility. However, the design information for risk analysis available for the Construction Authorization submittal is limited. Reliability data for many of the important-to-safety structures, systems, and components that will be used in the facility is not well determined. In some instances, new technology is being used in the treatment of waste, for which reliability data is limited. In addition, operational data does not yet exist for all elements of the facility. Finally, simplifications permitted and used in the accident analysis process for this facility may introduce additional, potentially significant uncertainty in the calculated risk of the facility for this submittal. In these analyses, some uncertainties are quantifiable, and some are not. For all these reasons, using the risk that was calculated based on the preliminary design to significantly influence the final design may be premature and inappropriate.

The RPP-WTP facility risk goals are derived primarily from the Secretary of Energy Notice SEN-35-91, "Nuclear Safety Policy," and the NRC safety goals expressed in "Safety Goals for the Operation of Nuclear Power Plants; Policy Statement," 1986. However, the NRC guidance on application of the safety goals indicates that a methodology for design decisions, which relies heavily upon application of overall facility risk goals, must be supported by a fully detailed probabilistic risk assessment (PRA). Important characteristics of PRAs for making such design decisions are as follows:

- Quantitative accumulation of facility risk from all individual accident scenarios (i.e., quantitative consequence and frequency estimation).

- Parameter and model uncertainty estimates that are propagated through the calculation of total risk to obtain exceedance frequency curves. These curves can be used to calculate mean values of risk and extreme values of risk for comparison to risk goals.

- Plant-specific reliability data supporting frequency estimates for accident sequences.

The method for facility risk estimation presented by the previous Contractor at the January 2000 topical meeting is different than the one cited above, and does not have the above characteristics common to reactor PRAs. Specifically, the method presented:

- Employs a qualitative accumulation of total risk by binning accidents within a DBE group rather than estimating the frequency and consequence of each scenario separately.

- Calculates only a point-estimate of risk as opposed to assignment of parameter uncertainty distributions and calculation of exceedance frequency curves.

- Lacks plant-specific reliability data in many areas due to the new technology employed in the design and the lack of operating experience.

Moreover, for this unique, non-reactor nuclear waste vitrification facility, this divergence in methodology is unlikely to be resolved until considerable operating experience with the facility has been gained. However, the PRA method described in the NRC guidance cited above is not required by the RPP-WTP regulatory program. As stated in SEN-35-91:

> *"DOE recognizes that there are large uncertainties in the data and available methods for assessing risk levels especially with respect to potential health effects from nuclear facility operations. Therefore reasonable analyses based on available data using standardized approaches may be employed while more rigorous approaches and better data are developed. . . The adoption of safety goals should not be construed as a requirement to conduct probabilistic risk assessments."*

In particular, it is inappropriate to ascribe high confidence to the calculated risk of the vitrification facility, using the Contractor methodology described above. Detailed event and fault tree analysis at the preliminary design stage (i.e., the construction authorization or design confirmation stage) is not required. The design should use insights gained from the Top-Level Standards and Principles, viz., risk analysis, safety/quality culture, safety responsibility, radiation protection, proven engineering practices and margins, and defense-in-depth in the design of the plant. The Top-Level Standards and Principles, in turn, are further elaborated by implementing standards in the Safety Requirements Document.

For these reasons, the OSR has developed the position on limitations on the calculation of risk described in Section 3.1 above.

4.2 Operations Risk Goal

In 1986, the U.S. Nuclear Regulatory Commission (NRC) established qualitative safety goals and quantitative safety objectives for nuclear power plants in *"Safety Goals for the Operation of Nuclear Power Plants; Final Policy Statement*, 51 FR 30028, August 4, 1986. One of these quantitative safety objectives stated:

> "The risk to the population in the area near a nuclear power plant of cancer fatalities that might result from nuclear power plant operation should not exceed one-tenth of one percent (0.1 percent) of the sum of cancer fatality risks resulting from all other causes."

In elaborating on this objective, the NRC stated:

> "In applying the objective for cancer fatalities as a population guideline for individuals in the area near the plant, the Commission has defined the population generally considered subject to significant risk as the population within ten (10) miles of the plant site."

During the development of the RPP-WTP regulatory program, the operations risk goal evolved from the NRC safety objective cited above. The only significant difference between the two is the phrase in the RPP-WTP operations risk goal that states "public and workers." A close examination of the NRC discussion of the safety objectives reveals the source of this phrase. In the first sentence of the summary preceding the presentation of the goals and objectives, the NRC stated, "This policy statement focuses on the risks to the public from nuclear power plant operation." However, the subsequent discussion included the following statement:

> "The 0.1 percent ratio to other risks is low enough to support an expectation that *people living or working* [emphasis added] near nuclear power plants would have no special concern due to the plant's proximity."

The term "public and workers" in the RPP-WTP operations risk goal is believed, therefore, to have been intended to be consistent with the NRC's statement that the objective is to protect persons both living and working near a facility.

For simplicity, a calculation of risk at the most limiting hypothetical location of a person (i.e., the public and Hanford Site workers) at the Hanford Site boundary is considered acceptable to demonstrate conformance with the RPP-WTP operations risk goal. The most limiting hypothetical location was established by the previous Contractor in the SRD (Volume II, Appendix D, Section 3.5.3). This position avoids the averaging of co-located workers and the public in the calculation and ensures consistency with the previously established position in both RL/REG-98-18, *Regulatory Unit Position on Radiological Safety for Hanford Co-located Workers*, and DNFSB/TECH-20, *Protection of Collocated Workers at the Department of Energy's Defense Nuclear Facilities and Sites*, that co-located workers should not be considered members of the public in risk assessments. Such averaging may be appropriate in populated areas found near many nuclear power plants. However, such averaging is not appropriate for the RPP-WTP facility considering the sparse public population distribution outside the Site boundary but within ten miles of the facility, as compared with the large number of co-located workers within ten miles of the facility.

It is possible that in the future, the location of the Hanford Site boundary will be moved closer to the RPP-WTP facility location. On the basis of a comparison between the relative magnitudes of the worker accident risk goal (10^{-5} per yr.) and the operations risk goal (2×10^{-6} per yr.), it might appear that there is opportunity to move the site boundary inward considerably, since exposures from accidents generally decrease rapidly with distance, and workers are typically much closer to the accident source than the site boundary. However, the National Emission Standards for Hazardous Air Pollutants (40 CFR 61, or NESHAP) limit the release of radioactivity from a DOE nuclear facility (e.g. the Hanford site) to 10-mrem/year effective dose equivalent to any member of the public. The RPP-WTP Contract, Section C.7 Facility Specification (a)(13), requires that "the WTP shall be designed and operated to ensure that exposure to the maximally exposed offsite individual (nonacute exposure) is As Low As Reasonably Achievable (ALARA) but not more than 1.5 mrem per year…" Per Appendix B, the operations risk goal is equivalent to an average dose of 4 mrem/year. The NESHAP limit, rather than the risk goals, is therefore likely to control the location of any future site boundary.[6]

The origin of the position that the operations risk goal applies to both routine emissions and accidents is the NRC safety goals policy statement. Specifically, the NRC stated:

> "This policy statement focuses on the risks to the public from nuclear power plant operation. These are the risks from release of radioactive materials from the reactor to the environment from normal operations as well as from accidents. The Commission will refer to these risks as the risks of nuclear power plant operation."

The OSR position concerning the operations risk goal was adopted because it is consistent with the intent of this NRC safety goal.

4.3 Accident Risk Goal

The previous section discussed an NRC safety objective that served as the basis for the RPP-WTP operations risk goal. The NRC concurrently established a safety objective regarding prompt fatalities from nuclear reactor accidents (51 FR 30028). This goal stated:

> "The risk to an average individual in the vicinity of a nuclear power plant of prompt fatalities that might result from reactor accidents should not exceed one-tenth of one percent (0.1 percent) of the sum of prompt fatality risks resulting from other accidents to which members of the U.S. population are generally exposed."

In elaborating on this objective, the NRC stated:

> "In applying the objective for individual risk of prompt fatality, the Commission has defined the vicinity as the area within one (1) mile of the nuclear power plant site boundary…. If there are no individuals residing within a mile of the plant boundary, an individual should, for evaluation purposes, be assumed to reside one (1) mile from the site boundary."

Like the operations risk goal, the RPP-WTP accident risk goal evolved from this NRC safety objective. Additionally, the supporting discussion clearly indicates that the NRC safety objective was meant to apply to members of the population residing (or working) near the Site, not to workers at the Site.

The anticipated radionuclide inventories suggest that prompt fatalities are not likely outside the controlled area boundary. Prompt fatalities from radiation exposure require *acute* radiation doses (i.e., doses delivered in their entirety in a matter of hours or days) of at least 100 rem. However, for most accident scenarios, the radionuclides that would result in the greatest doses to individuals (e.g., americium-241) would deliver those doses over many years. Consequently, a

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[6] There is one qualification that needs to be pointed out relative to this argument. Releases from normal operation are likely to be elevated, whereas accident releases typically occur at ground level. Theoretically, it is possible (albeit unlikely) that the 4 mrem/year ground level release could be controlling, depending on the height of the stack.

committed dose (which accounts for the doses received over a 50-year period) of tens of thousands of rem from such radionuclides would be required to cause an acute dose sufficient to result in a prompt fatality. Additional information on this topic is presented in Appendix A to this paper.

For the reasons outlined above and provided that criticality events have been prevented at the RPP-WTP facility, the accident risk goal will be considered to be met if the Contractor can demonstrate that no postulated accident could result in doses sufficient to cause a prompt fatality (as described in the Appendix A) outside the facility controlled area to Hanford Site workers.

4.4 Worker Accident Risk Goal

The draft DOE document, EH-12-94-01, *Method for the Assessment of Worker Safety Under Radiological Accident Conditions at Department of Energy Nuclear Facilities*, was cited in the original RPP-WTP Contract (via DOE/RL-96-0006) as relevant guidance for developing worker and co-located worker dose standards. The document contains the following quantitative goal:

> "The estimated annual fatality risk from radiological accidents to a worker at a DOE site should not be significantly greater than 1 x 10^{-5} per year. This goal applies to either prompt or latent cancer fatalities."

In elaborating on this goal, the document states:

> "The risk to a worker consists of both the in-facility and ex-facility risk."

The OSR has considered the guidance in EH-12-94-01, and the information contained in previous OSR position papers in developing its position on this risk goal. The risk calculation for facility workers should distribute the risk over the facility workers who are potentially affected by the accidents evaluated. This population would be adequately represented by the radiation workers in the facility. This approach ensures that the calculated risk value does not overstate the true worker risk considering that most accidents will result in significantly higher doses to a few workers than to other workers. In other words, it is not appropriate to calculate a sum of the maximum risk to any worker from each accident and compare that sum to the risk goal.

The OSR position paper on the calculation of facility worker doses from seismic and non-seismic events (ORP/OSR-2001-17) discusses why the OSR considers that, in general, quantitative estimates of facility worker doses are not necessary to demonstrate conformance to this Worker Accident Risk Goal. To summarize this discussion, for seismic events it was determined that the contribution to risks from seismic events is likely to be significantly less than the risk goal. For non-seismic events, only a few DBEs are expected to potentially result in significant doses to facility workers because the facility ventilation and HEPA filtration system will ensure, with a high degree of confidence, that any radioactive material that becomes airborne due to an accident will not be inhaled by facility workers. As a result, the Contractor will find it necessary to perform only a limited number of quantitative assessments to demonstrate that the Worker Accident Risk Goal is met. ORP/OSR-2001-17 should be consulted for additional details on this topic.

The calculation for a hypothetical individual located 100 m from the release point is performed to address ex-facility workers consistent with the discussion in EH-12-94-01. In this case, since the hypothetical individual could be at risk from any accident at the facility, it is appropriate to calculate a sum of the risks from each accident for comparison to the risk goal. The distance of 100 m was selected to facilitate dose calculations near the facility and is considered a representative value. The appropriate exposure times for this calculation should be addressed in the Contractor's dose assessment methodology.

4.5 Chemical Hazards

The Department of Energy has recognized that the risks from its facilities are not limited to radioactive materials. For example, in 1994 the DOE published a draft document that presents methods for assessing worker safety under radiological accident conditions at DOE facilities (EH-12-94-01). This document stated, "ONS [Office of Nuclear Safety] did not address…chemical or industrial types of accidents that might occur at DOE nuclear facilities. Ultimately, however, all types of risks to which the worker may be exposed at the facilities need to be considered together and addressed." This statement suggests that the DOE would support an attempt to establish risk goals that consider non-radiological risks in addition to radiological risks. However, to date the DOE has not established numerical non-radiological risk goals similar to those for radiation exposure established in EH-12-94-01 (and which are consistent with the risk goals promulgated in the Top-Level Standards).

DOE Order DOE O 151.1, "Comprehensive Emergency Management System" specifies the use of Emergency Response Planning Guides (ERPGs) for event classification and protective action planning. ERPGs are developed and published by the American Industrial Hygiene Association (AIHA 2001), and represent concentrations of chemicals that can result in various levels of health effects. Specifically, the AIHA provides three ERPGs for each chemical:

> ERPG-1: The maximum airborne concentration below which it is believed nearly all individuals could be exposed for up to one hour without experiencing more than mild, transient adverse health effects or without perceiving a clearly defined objectionable odor;
>
> ERPG-2: The maximum airborne concentration below which it is believed nearly all individuals could be exposed for up to one hour without experiencing or developing irreversible or other serious health effects or symptoms that could impair an individual's ability to take protective action;
>
> ERPG-3: The maximum airborne concentration below which it is believed nearly all individuals could be exposed for up to one hour without experiencing or developing life-threatening health effects.

In its Safety Requirements Document (SRD), the RPP-WTP Contractor committed to meeting the ERPG-2 and ERPG-3 limits for protection of the offsite public and co-located workers, respectively, from chemical releases.

This discussion is provided for information only. The OSR has no position on the need for or desirability of risk goals for process chemical hazards, considering it to be a matter of Agency wide policy and beyond the scope of the OSR.

5.0 OTHER CONSIDERATIONS

In addition to the specific elements of determining conformance with the risk goals identified above, additional considerations relevant to the risk goals are discussed briefly below:

- Best-estimate analysis – Risk assessment often relies on professional judgment, limited data, and extrapolation from known situations to estimate risks for infrequent events. Further, the results of the risk assessment are used to establish conformance with the risk goals and are not viewed as numerical acceptance criteria. As a result, a best estimate of the individual risks associated with postulated accidents to demonstrate conformance with the risk goals is acceptable. Where estimating the uncertainties associated with a risk assessment is difficult because of insufficient data, a qualitative evaluation of uncertainties associated with a best estimate of facility risks should also be provided.

- Consideration of accidents with frequencies $<10^{-6}$ per year – To demonstrate conformance with these risk goals, the risk assessment should consider the risk of events that are less frequent than the extremely unlikely event category (i.e., with frequencies less than 10^{-6} per year).

6.0 CONCLUSIONS

The radiological and nuclear safety objectives in the top-level standards document DOE/RL-96-0006 include three risk goals and the set of "overall principles" for process hazards. In this paper, the OSR has established positions that describe important aspects of an acceptable method to demonstrate conformance with the goals. These positions consider the origin and intent of the risk goals and the unique characteristics of the RPP-WTP facility, the Hanford Site, and the worker population.

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8.0 LIST OF TERMS

ALARA	as low as reasonably achievable
BNFL	BNFL Inc.
DNFSB	Defense Nuclear Facilities Safety Board
DOE	U.S. Department of Energy
HEPA	High Efficiency Particulate Air
ICRP	International Commission on Radiological Protection
ISM	integrated safety management
LET	linear energy transfer
NRC	U.S. Nuclear Regulatory Commission
OSR	Office of Safety Regulation
RPP-WTP	River Protection Project Waste Treatment Plant
SRD	Safety Requirements Document
SRO	Safety Regulation Official
TWRS-P	Tank Waste Remediation System, Privatization
UNSCEAR	United Nations Scientific Committee on the Effects of Atomic Radiation

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Appendix A. Additional Perspective Concerning the Accident Risk Goal at the RPP-WTP Facility

The evaluation in this appendix provides additional information on the OSR position on the accident risk goal in Section 3 of the main body of this paper.

The dose required to induce a prompt fatality is extremely large. Fatalities from high radiation doses typically do not occur instantaneously. Most radiation-induced fatalities (other than cancer) occur several weeks or months after exposure as a result of the depletion of cells that comprise the gastrointestinal (digestive) and/or hematopoietic (blood-forming) systems. Only after incurring an extremely high dose over a short period of time can death occur within hours or days; in these cases, death occurs primarily from the destruction of the central nervous system cells.

A common measure of the doses required to induce a prompt fatality is the $LD_{50/30}$ value. This value is the acute dose that will cause death in 50% of individuals within 30 days of the exposure. The $LD_{50/30}$ depends on numerous factors, including the level of medical intervention. Cember (1983) reported that this value for humans falls in the range between 200 and 700 rem. More recently, the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) reported that the $LD_{50/60}$ (the acute dose that will cause death in 50% of individuals within 60 days of the exposure) for a healthy adult is generally considered to be approximately 400 to 500 rem (UNSCEAR, *Sources, Effects and Risks of Ionizing Radiation*).

The majority of doses arising from most accidental releases of radioactive materials from the RPP-WTP facility will not be delivered acutely. The principal radionuclides in the RPP-WTP source term have extremely long half-lives and remain in the body for a significant period following inhalation. As a result, the majority of the doses that would occur from an accident at the RPP-WTP facility would be delivered chronically as opposed to acutely. Thus, the doses required to cause a prompt fatality would be significantly higher than the $LD_{50/30}$ or $LD_{50/60}$ for an acute radiation dose cited above.

Information on the doses from inhalation of long-lived radionuclides required to cause prompt fatalities is provided in the International Commission on Radiological Protection (ICRP) Publication 31, *Biological Effects of Inhaled Radionuclides.* Figure 9 of ICRP 31 summarizes the lung doses from inhalation of alpha-emitting radionuclides that have been observed to cause acute (days to weeks) or subacute (weeks to months) deaths. The figure indicates that lung burdens of ~0.3 to 10 microcuries per gram result in acute death and lung burdens of ~0.02 to 0.3 microcuries per gram result in subacute death. Applying standard ICRP dose conversion factors for plutonium-239 (a representative alpha-emitting radionuclide), the following inhalation dose ranges are necessary to cause "prompt" fatalities:[7]

- Acute death: 130,000 to 4.3 million rem
- Subacute death: 8600 to 130,000 rem.

[7] As in Section 3.3 above, the word "prompt" in this context implies that consequent fatalities result from acute exposures.

Similar estimates can be determined from NUREG/CR-4214, *Health Effects Models for Nuclear Power Plant Accident Consequence Analysis, Low LET Radiation, Part II: Scientific Bases for Health Effects Models*. That report indicates that different lung doses are required to produce prompt fatalities depending on the dose rate. For example, at extremely high dose rates (10,000 rads/hr or greater[8]), lung doses of only 1000 rads can cause a pulmonary-syndrome lethality, according to the report. For protracted dose rates (e.g., 5 rads/hr or less, a reasonable assumption for inhalation of long-lived radionuclides), the median dose estimate related to pulmonary-syndrome lethality is 61,000 rads. Converting this value to effective dose equivalent results in a dose estimate of ~60,000 rem,[9] which is within the range of doses for subacute effects estimated from ICRP Publication 31.

Previous analysis by the OSR has suggested that committed effective dose equivalents of tens of thousands of rem from inhalation of radioactive materials are not predicted outside the controlled area of the RPP-WTP facility from beyond design-basis earthquakes (RL/REG-99-22, *Analysis of Potential Radiological Consequences from Postulated Design Basis Earthquakes at the TWRS-P Facility)*. If this analysis is representative, it is anticipated that the Contractor can demonstrate that doses necessary to cause prompt fatalities[10] will not occur outside the RPP-WTP controlled area from any postulated accident that has been considered in the accident analysis. Thus, calculations of the risks of prompt fatalities will not be necessary to demonstrate conformance with the accident risk goal.

[8] Such a dose rate might apply to certain radiation therapy medical procedures or criticality accidents; however, the dose rates would be much lower from a non-criticality accidental release from the RPP-WTP facility.

[9] The cited lung dose of 61,000 rads is relevant to low-linear energy transfer (LET) radiation. Dividing by the suggested factor of 7 to account for the increased effectiveness of high-LET radiation in producing deterministic effects results in a lung dose of 8,700 rads of high-LET radiation necessary to cause a prompt fatality. This dose converts further to a dose equivalent of 170,000 rem using the ICRP quality factor of 20. According to data in ICRP Publication 30, *Limits for Intakes of Radionuclides by Workers*, for plutonium-239, a committed dose equivalent of 170,000 rem to the lung equates to an effective dose equivalent of ~60,000 rem.

[10] Prompt fatalities could be caused, for example, by committed effective dose equivalents of tens of thousands of rem from inhalation of alpha-emitting radionuclides or acute effective dose equivalents of hundreds of rem from exposure to beta- or gamma-emitting radionuclides.

Appendix B. Annual Average Dose Equivalents for the Risk Goals

It is useful to compare the average annual dose associated with the RPP-WTP risk goals with equivalent figures from neighbouring facilities, particularly the Tank Farms. The purpose of this appendix is to provide the information and guidelines necessary to make such comparisons.

In order to compare the risk goals to dose, appropriate conversion factors must be applied. The conversion factors commonly applied are those published by the Biological Effects of Ionizing Radiation (BEIR) Committee V (BEIR-V, 1990). As indicated in the table below, the conversion factors depend on the characteristics of the affected population and the level of dose received.

Table B-1. Dose to Risk Conversion Factors (Fatal Cancer Probability per rem)

Population Type	**Conversion Factor for Doses Less than 10 rem**	**Conversion Factor for Doses 10 rem or Greater**
Public	5×10^{-4}/rem	1×10^{-3}/rem
Workers	4×10^{-4}/rem	1×10^{-3}/rem

Based on the factors in Table B-1 and the discussions in the main body of this position paper, the risk goals can be roughly compared to average annual doses as follows:

Operations Risk Goal – As stated in Section 3.2 of this position paper, the operations risk goal may be considered numerically equivalent to a latent cancer fatality risk of 2×10^{-6} per year. As shown in Table B-1, there is a risk of 5×10^{-4} per rem for low doses to members of the public. Thus, the risk to the public associated with this goal can be considered equivalent to the risk associated with an annual average dose of **4 mrem** (2×10^{-6} cancer fatalities per year X 1000 mrem per rem /5×10^{-4} cancer fatalities per rem). If the doses are received infrequently but acutely (such as from an accident) and are greater than 10 rem, the risk can be considered equivalent to the risk associated with an annual average dose of **2 mrem** (2×10^{-6} cancer fatalities per year X 1000 mrem per rem /1×10^{-3} cancer fatalities per rem)

Accident Risk Goal – As stated in Section 3.3 of this position paper, the accident risk goal may be considered numerically equivalent to a prompt fatality risk of 4×10^{-7} per year. However, for the reasons stated in 4.3, this goal is not controlling and exercises no influence on the design. Therefore, there is no equivalent dose that corresponds to this goal.

Worker Accident Risk Goal - As stated in Section 3.4 of this position paper, the worker accident risk goal may be considered numerically equivalent to a risk of 1×10^{-5} per year from both prompt and latent cancer fatalities. Although the comparison of this risk to an average annual dose is problematic because of the inclusion of prompt fatalities in the definition, it is highly likely that the risk to workers will be dominated by doses less than those that would cause a prompt fatality (detailed information on this topic was provided in Appendix A). Thus, the risk to workers associated with this can be considered equivalent to the risk associated with an annual average dose of **25 mrem** (1×10^{-5} cancer fatalities per year X 1000 mrem per rem /4×10^{-4} cancer fatalities per rem). If the doses are received infrequently but acutely (such as from an accident) and are greater than 10 rem, the risk can be considered equivalent to the risk associated with an annual average dose of **10 mrem** (1 x 10^{-5} cancer fatalities per year X 1000 mrem per rem /1 x 10^{-3} cancer fatalities per rem)

The material presented above is provided in order to facilitate a rough comparison between the potential risks associated with the RPP-WTP and neighbouring facilities, particularly the Tank Farms. However, such comparisons must be made with caution since they assume the validity of the linear no-threshold hypothesis, which is well known to have logical inconsistencies.