MEMORANDUM FOR: John T. Greeves, Director
Division of Waste Management, NMSS

January 24, 1997

FROM: Margaret V. Federline, Deputy Director
Division of Waste Management, NMSS

SUBJECT: MEETING OF THE ICRP TASK FORCE ON RADIATION PROTECTION RECOMMENDATIONS AS APPLIED TO DISPOSAL OF LONG-LIVED SOLID RADIOACTIVE WASTE, NOVEMBER 30 - DECEMBER 7, 1996, PARIS, FRANCE

The Chairman of the International Commission on Radiological Protection (ICRP) invited me to participate in a Task Group on Radiation Protection Recommendations as applied to Disposal of Long-lived Solid Radioactive Waste. The terms of reference of this task group are to produce a short, yet comprehensive, report on the current recommendations of ICRP as they apply in the context of radioactive waste disposal. It is intended that this report will clarify the guidance in ICRP 46 to make it more useful in the decision-making process.

The Task Group is composed of six international experts in the fields of radiation protection and waste management and is chaired by Dr. Annie Sugier, Director of Protection at the Institute for Nuclear Safety and Protection (IPSN) in France. The December 1996 meeting was the first of five planned for the Task Group in order to complete the necessary guidance in 1998. The development of the guidance by 1998 will be particularly valuable to the Nuclear Regulatory Commission because it will address all of the difficult issues which will be faced in revising NRC's high level waste regulations considering a Yucca Mountain specific Environmental Protection Agency standard based upon National Academy of Sciences recommendations.

During the meeting, I made written contributions and presentations on considerations for selecting compliance periods for long term waste disposal and recommendations on the use of institutional controls to protect against inadvertent intrusion, as well as discussing the applicability of these concepts to different types of waste (Attachment). The next meeting of the Task Group will be held at the NRC March 10-14, 1997, at which time the group will review the first draft of the guidance document which will be developed by the Task Group members by the end of February.

Attachment: Trip Report

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TRIP REPORT

OFFICIAL TRAVELER: Margaret V. Federline
TRAVEL TO: Paris, France
DATES OF TRAVEL: November 30 - December 7, 1996
OFFICE: NMSS
MEETING TITLE: ICRP 46 Working Group
ORGANIZED BY: International Commission on Radiation Protection Committee 4

Summary of Meeting Results:

Margaret V. Federline, Deputy Director of the Division of Waste Management, Office of Nuclear Material Safety and Safeguards, was invited by the Chairman of the International Commission on Radiological Protection (ICRP) to participate in a Task Group on Radiation Protection Recommendations as applied to Disposal of Long-lived Solid Radioactive Waste. The terms of reference of this task group are to produce a short, yet comprehensive, report on the current recommendations of ICRP as they apply in the context of radioactive waste disposal. It is intended that this new guidance will clarify ICRP 46 recommendations so that they may be more useful in the decision-making process considering the long time frames and large spatial scales inherent in waste disposal. The Task Group is composed of six international experts in the fields of radiation protection and waste management and is chaired by Dr. Annie Sugier, Director of Protection at the Institute for Nuclear Safety and Protection (IPSN) in France. The December 1996 meeting was the first of five planned for the Task Group in order to complete the necessary guidance in 1998. The development of the guidance by 1998 will be particularly valuable to the Nuclear Regulatory Commission because it will address all of the difficult issues which will be faced in revising NRC's high level waste regulations considering a Yucca Mountain specific Environmental Protection Agency standard based upon National Academy of Sciences recommendations.

During the initial meeting, the Task Group traced the historical evolution of ICRP ideas and considered their applicability to waste disposal. ICRP 26 proposed a system of dose limitation applicable to "normal situations" or circumstances where the doses are reasonably certain to occur with a magnitude that can be estimated with a predictable degree of uncertainty. ICRP 46 acknowledged that this system of dose limitation required modification in order to cover future exposures from waste disposal. ICRP 46 recommended that dose limits be applied to the most likely exposures and that a risk limit be

applied to probabilistic situations. ICRP 60 extended the system of dose limitation to include probabilistic situations by introducing the concept of potential exposures. ICRP 64 developed an overall framework for potential exposures and explains that guidance will be given in three areas including radioactive waste disposal. During the first meeting, the Task Group reviewed these ideas in order to define the extent of guidance necessary to clarify ICRP 46 for long-lived waste disposal and developed a framework for the guidance document.

Initial discussions focused on the three most prominent concerns in applying radiation protection principles to the disposal of long-lived radioactive wastes: (1) increasing uncertainty in the calculation of doses and risks over the long time periods of interest in considering exposures to individuals and populations; (2) the extent to which passive and active controls can be relied on to ensure safety of future generations; and (3) appropriate guidance for demonstrating compliance with radiological protection criteria. During the first meeting, the Task Group developed and documented proposals to address some of the most difficult underlying issues including appropriate time frame for determining compliance, appropriate safety indicators, definition of critical group, and appropriate role for active and passive institutional controls in demonstrating long term safety. During the meeting, Mrs. Federline made written contributions and presentations on considerations for selecting compliance periods for long term waste disposal and recommendations on the use of institutional controls to protect against inadvertent intrusion, as well as discussing the applicability of these concepts to different types of waste. The next meeting of the Task Group will be held at the NRC March 10-14, 1997, at which time the group will review the first draft of the guidance document which will be developed by the Task Group members by the end of February.

BACKGROUND INFORMATION

THOUGHTS ON THE USE OF INSTITUTIONAL CONTROLS TO PROTECT WASTE DISPOSAL SITES FROM FUTURE INADVERTENT INTRUSION

Future human actions may contribute significantly to the risks associated with the disposal of long-lived hazardous waste, including radioactive wastes. Such actions by persons who unknowingly enter and occupy a site and engage in normal activities (*e.g.* agriculture, dwelling construction, exploration for or production of mineral or water resources, *etc.*) may result in hazards to the intruders themselves, or to others. These hazards may arise either from material brought directly to the surface or because the integrity of the disposal system's engineered or geologic barriers have been compromised by the intrusion.

It must be remembered, however, that this finite potential risk to some hypothetical inadvertent intruder and to the surrounding public from any material exhumed as a result of this postulated intruder's actions is an inescapable consequence of the decision to "optimize" protection of the public by isolating wastes in a discrete disposal facility, rather than by diluting or dispersing them. In the absence of a clear intent to release disposal sites or contaminated areas for unrestricted use, such facilities should be viewed as a permanent commitment of real estate that must be restricted and maintained for the express purpose of protecting public health and safety.

There exists no scientific basis for predicting the nature or probability of human activities which, in the far future, could affect the Earth's near surface or subsurface environment and potentially impair performance of a disposal system. Likewise, there is only limited technical basis for assigning an expected duration to the long-term efficacy of institutional controls. Any analyses or projections of the magnitude of intrusion risks are, by necessity, wholly dependent upon whatever assumptions are made regarding the behavior and motivations of future human societies. Because it is not possible to quantify the risks of such intrusion, it is not appropriate, therefore, to include the probabilities of such risks in a probabilistic performance assessment that is to be compared to strict dose or risk criteria developed for the expected evolution of the disposal system. The expected evolution of the site should be estimated solely based on current rates and known variations of natural processes as they are projected to occur over the course of an appropriate period of consideration. Protection from the effects of inadvertent intrusion is best accomplished using design standards and constraints that, to the greatest extent practicable, inhibit human intrusion.

Because it is impossible to anticipate and design against all possible future actions which can be imagined and which could potentially degrade the ability of disposal facilities to isolate waste, a number of *reasonable* countermeasures and disincentives to intrusion should be implemented, which may include, but ought not be limited to, institutional controls. The purpose of such measures is to reduce the probability and mitigate the consequences of future intrusions, in the knowledge that absolute prevention of such hazards is not possible.

Selection of appropriate countermeasures for all long-term hazardous waste facilities should proceed based on *reasonable* and *uniform* assumptions regarding the actions of future human societies and potential future intruders. It is reasonable, for example, to assume that some manner of overall societal organization and institutional controls will continue to exist into the far future. It is not reasonable, however, to assume, that such controls will continue to function perfectly as they are intended or envisioned today, anymore than it is reasonable to assume that such organization and controls will utterly vanish. In the event that future intruders encounter unusual materials or unexpected structures, it is reasonable to assume that they will take sensible actions to investigate, and that technology to detect and mitigate hazards will exist that is at least as sophisticated as that required to initiate the intrusion.

Disposal standards and licensing criteria for the disposal of long-lived hazardous wastes should incorporate specific requirements for *multiple* control measures. The selection of the specific measures, and their relative importance to waste isolation, should be made as a function of the nature of the hazard, physical characteristics of waste, the disposal technology employed and the accessibility of the disposed waste at a given site. Taken together, *multiple* control measures can be expected to reduce the overall likelihood and mitigate the consequences of future inadvertent human actions that could impair the effectiveness of the disposal system. Such measures may include:

- Siting a disposal facility in a location where intrusion is less likely, such as in sparsely-populated areas or areas where there exist no known natural resources.

- Incorporating robust design features which make intrusion more difficult such as fences, multi-layered covers, concrete vaults, *etc.*

- Limiting the characteristics of the hazardous materials disposed at a given site or using a given disposal method. For example, in certain cases, limits may be placed on the concentration of the materials such that if intrusion occurs, the hazard would be bounded, or for sites where the hazard decreases over time, the absence of a significant hazard would be ensured after some elapsed time.

- Employing long-term institutional controls, active and/or passive, that restrict access to the sites, warn about the hazards presented by the waste materials, and maintain physical barriers. Such controls may also be applied to site maintenance and monitoring of the disposal system to ensure continued waste isolation. The discussion that follows primarily addresses those institutional controls whose primary functions are to protect sites from inadvertent intrusion.

- Establishing long-term financial mechanisms to ensure adequate resources to support and implement the appropriate institutional controls.

Generally speaking, active institutional controls are deliberate human actions physically carried out at the site to restrict access to and use of the site. They may be ongoing, such as security surveillance, or infrequent, such a periodic repairs to a fence. Passive institutional controls, such as a durable monument, land use records, or restrictive land covenants, are those measures which do not directly involve deliberate human action at the site after they have been put in place. Passive controls are undertaken primarily to limit access and future use of the waste disposal site. It is expected that certain passive institutional controls may persist, even if active controls are interrupted or discontinued.

Despite the absence of clear technical justification, for most categories of radioactive waste disposal, it has become generally accepted practice to assume that institutional controls of either type should not be relied upon for longer than a few hundred years following closure, and reliance on active controls is usually limited to one hundred years post closure. As a result facility performance assessments must demonstrate that the necessary level of protection is achieved assuming some manner of intrusion occurs in the absence of most, if not all institutional controls.

Analytical assessments of facility performance explicitly assuming intrusion is generally not done in the case of uranium mill tailings disposal. Rather, reliance is placed on a combination of cover design requirements and both passive and active institutional controls to ensure proper isolation of tailings, to support remedial action and to clean up contaminated groundwater.

Disposal of hazardous chemical wastes is generally subject to a fairly short post-closure period (*i.e.* 30 years) during which active controls are explicitly required and assumed to be effective to ensure public protection. Considerable latitude is afforded the responsible agency to extend this period, as needed, following periodic reviews (which themselves are a form of active control), for sites containing wastes which do not appreciably degrade with time. Quantitative assessments of the risk to a potential intruder or the disruption that intruder might cause are typically not required in the permitting of either hazardous waste facilities or municipal landfills.

Normally, no intruder protection measures are required or permitted for closure of contaminated sites, where the object is the removal of contamination to levels acceptable for unrestricted use. That being said, however, there is a growing recognition that it may not be reasonable or even possible to restore some near-surface sites to acceptable levels of contamination for release without further controls. Under such circumstances consideration is being given to the conditional release of such sites subject to institutional controls, but also limited by an upper bound on the risk should the institutional control measures fail.

Such an approach may have broader applicability when considering the role of institutional controls in ensuring protection from disposed waste generally. It may be worth considering the establishment of a risk upper bound -- in a range of risk comparable to between 1 and 5 mSv per year--above which it would

not be acceptable to rely on the effectiveness of institutional controls. Protection from risks above this level, should be ensured by robust design criteria implemented according to a defense-in-depth philosophy. Because risks comparable to 1 mSv and below are considered acceptable, and because it is not expected that institutional controls, under any reasonable circumstances, will fail completely, it should be appropriate to rely on the effectiveness of such controls to prevent or mitigate risks of human intrusion at levels below the upper bound.

Based on the above discussion, we offer the following "strawman" options for discussion and consideration as possible approaches to addressing the role of active institutional controls in protecting waste disposal facilities from inadvertent intrusion:

1. Design for robustness and require active and passive controls; exclude any consideration of potential intrusion in quantitative assessment of facility performance; assume that design plus controls will be effective.

2. Design for robustness and require active and passive controls; limit long-term reliance on institutional controls to achieving protection below an established risk upper bound.

3. Design for robustness and require active and passive controls; require a quantitative consequence analysis which includes stylized human intrusion scenario(s) to demonstrate that risks from intrusion are either (a) kept below risk upper bound or (for assessments of near-surface facilities) are within a range of risks from intrusion comparable to those for other wastes currently found acceptable for near-surface disposal.

4. Design for robustness and require active and passive controls; permit <u>no</u> long-term reliance on effectiveness of institutional controls; include human intrusions scenario(s) in quantitative performance assessment using a stylized scenario.

United States
Nuclear Regulatory Commission

THOUGHTS ON THE USE OF INSTITUTIONAL CONTROLS TO PROTECT WASTE DISPOSAL SITES FROM FUTURE INADVERTENT INTRUSION

Presentation to:

ICRP-46 WORKING GROUP

December 4, 1996

Presented by:

Margaret V. Federline
Division of Waste Management
Office of Nuclear Material Safety & Safeguards
U.S. Nuclear Regulatory Commission

OVERVIEW

- Nature of Intrusion Risk
- Basic Assumptions
- Countermeasures and Disincentives
- Current Approaches Vary
- Options for a Uniform Approach

FUTURE HUMAN ACTIONS AND RISKS TO DISPOSAL OF LONG-LIVED WASTES

- May Contribute Significantly to Risks of Disposal of Long-lived Hazardous Wastes
  - Persons May Unknowingly Occupy Site and Engage in Normal Activities
    - Agriculture
    - Dwelling Construction
    - Exploration and Production of Resources
- Direct Hazards to Intruder and Others
- Indirect Effects on Engineered and Geologic Barriers

FINITE INTRUSION RISK IS UNAVOIDABLE CONSEQUENCE OF WASTE ISOLATION

- Isolation of Long-lived Wastes vs. Dilution & Dispersal
- What Protection Objective Should be "Optimized"– Protection of Public Health or Protection Against Intrusion?
- Permanent Commitment of Land to Ensure Isolation

INTRUSION RISK PREDICTIONS DEPEND ON ASSUMPTIONS

- No Scientific Basis for Predicting Nature or Probability of Intrusion
- Limited Basis for Predicting Effectiveness of Institutional Controls
- Dose or Risk Criteria Should Apply to Expected Evolution of Site Based on Known Rates of Natural Processes
- Protection from Intrusion Best Accomplished With Reasonable Countermeasures and Disincentives that Inhibit Intrusion
- Basic Assumptions re: Future Society and Potential Intruders should be Uniform for All Types of Long-lived Wastes

EXAMPLES OF BASIC ASSUMPTIONS

- Some Form of Societal Organization and Institutional Control will Persist
- Controls Will Not Function Perfectly As Currently Intended or Envisioned
- Intruders Encountering Unusual Materials or Unexpected Structures Will Take Sensible Actions to Investigate
- Technology to Detect and Mitigate Hazards will be Comparable to that Required to Intrude

COUNTERMEASURES AND DISINCENTIVES

- Design Standards and Constraints that Reduce Likelihood and Mitigate Consequences of Intrusion
  - Siting
  - Robust Design of Engineered Barriers
  - Limit Characteristics of Waste
  - Active and Passive Controls
  - Financial Mechanisms
- Multiple Control Measures Should be Required
- Specific Mix of Measures and Relative Importance will Vary
  - Nature of Hazard
  - Disposal Technology
  - Accessibility
  - "Recognizability"

VARIETY OF APPROACHES TO INTRUSION RISK FOR DIFFERENT WASTES

HLW AND ILW

- No Reliance on Active Controls >100 yrs
- Passive Controls Assumed Effective for "Few Hundred" yrs
- Quantitative Performance Assessments Must Demonstrate Long-term Compliance Assuming Intrusion Occurs in Absence of Most, if not all, Controls

Uranium Mill Tailings

- No Explicit Assessment Including Impact of Intrusion
- Indefinite Reliance on Combination of Design Requirement and Institutional Controls to Ensure Isolation and Support Remediation

VARIETY OF APPROACHES TO INTRUSION RISK FOR DIFFERENT WASTES (cont.)

Hazardous Chemical Wastes

- No Quantitative Assessments of Intruder Risk
- Design plus Active Controls Assumed Effective for Specified Post-Closure Period (*e.g.* 30 yrs)
- Subject to Periodic Reviews, Control Period May be Extended

Decommissioned Sites

- Remediation Required to Restore Near-surface Sites to Acceptable Levels of Radioactive Contamination
- Reliance on Further Controls not Permitted
- Unrestricted Release of Some Sites not Possible or Practical
- Consideration of Conditional Release
- Limit Risk if Controls Fail

UNIFORM APPROACH TO PROTECT WASTE DISPOSAL SITES AGAINST POTENTIAL FUTURE INTRUSION

-Options for Consideration-

(1) **Design for Robustness and Require Active and Passive Controls; Assume that Design Plus Controls will be Effective**

(2) **DESIGN FOR ROBUSTNESS AND REQUIRE ACTIVE AND PASSIVE CONTROLS; LIMIT LONG-TERM RELIANCE ON CONTROLS BY ESTABLISHING RISK UPPER BOUND SHOULD CONTROLS FAIL**

(3) **DESIGN FOR ROBUSTNESS AND REQUIRE ACTIVE AND PASSIVE CONTROLS; REQUIRE CONSEQUENCE ANALYSIS USING ASSUMED INTRUSION SCENARIO TO DEMONSTRATE THAT INTRUSION RISKS ARE EITHER**

   (A) **BELOW RISK UPPER BOUND; OR**
   (b) **Comparable to Intrusion Risks for Other Wastes Currently Acceptable for Near-Surface Disposal**

(4) **DESIGN FOR ROBUSTNESS AND REQUIRE ACTIVE AND PASSIVE CONTROLS;**
permit <u>no</u> long-term reliance on effectiveness of controls; include human intrusions scenario(s) in quantitative assessment subject to limiting assumptions

United States
Nuclear Regulatory Commission

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VARIETY OF APPROACHES TO INTRUSION RISK FOR DIFFERENT WASTES (cont.)

Hazardous Chemical Wastes

- No Quantitative Assessments of Intruder Risk
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-Options for Consideration-

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