VOLUME 2: APPENDIX E

RISK INFORMING THE MATERIALS AND WASTE ARENAS:

A Case Study on Risk Informing Uranium Recovery

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ABSTRACT

This report documents a case study of the use of risk information for uranium recovery by Brookhaven National Laboratory under the sponsorship of the Risk Task Group of the NRC Office of Nuclear Material Safety and Safeguards. This case study focused on uranium mill sites and in-situ leaching facilities. This report discusses previous studies of uranium recovery, the potential use of risk information, the characterization of risk, past and potential approaches to its risk assessment, and the formulation of safety goals in uranium recovery. The study follows the approach in the Case Study Plan that was developed by the Risk Task Group. Preliminary responses are given for the Draft Questions and the Draft Screening Criteria in the Plan.

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1. INTRODUCTION

A case study exploring the use of risk information for the uranium recovery process has been initiated by Brookhaven National Laboratory (BNL) under the sponsorship of the Risk Task Group of the U. S. Nuclear Regulatory Commission (NRC) Office of Nuclear Material Safety and Safeguards (NMSS). The uranium recovery process primarily consists of the milling and disposal aspects of uranium recovery after the uranium ore is removed from the ground. In a conventional mine, either deep mining or shallow open pit, the rock containing the uranium ore is removed and processed at a uranium mill, where an extraction process concentrates the uranium into yellowcake. Uranium can also be leached out of the ground by pumping a water solution through wells to dissolve the uranium in the ore. The uranium is then pumped to the surface in a liquid solution, and then processed. Waste from milling operations are disposed of in a tailings pile. Mill tailings are fine-grained sand-like waste materials left over from uranium processing. Wastes from in-situ leach (ISL) facilities may be disposed of in several ways, including release to surface water, evaporated from lined ponds, onsite applications (irrigation) or returned to the aquifers via deepwell injection. The NRC does not regulate mining operations (underground or surface), and its regulations only apply to the ISL process and subsequent milling processes.

In order to perform this study in a meaningful way, some specificity with regard to facilities was needed. Sites were chosen for typicality, ready current access, and availability of information. For these reasons, this study, BNL has chosen the White Mesa mill in Blanding Utah which is the only NRC-licensed conventional mill processing uranium ore into yellowcake and the Smith Ranch ISL facility in Wyoming.

This report presents information on the uranium recovery operation, the regulations governing these operations, and the past and potential future use of risk information. The characterization of risk, past and potential assessment methods, and the formulation of safety goals for uranium recovery are discussed. This study follows the approach outlined in the case Study plan (Reference 1), which was developed by the Risk Task Group. Preliminary responses are presented for the Draft Questions and the Draft Screening Criteria contained in the Plan.

A framework for risk-informed regulation in NMSS has been issued as SECY 99-100 (Reference 2). For the convenience of the reader we excerpt some of the key elements of the NRC definition of "risk-informed" from Reference 3 and present them here.

> *A "risk-informed" approach to regulatory decision-making represents a philosophy whereby risk insights are considered together with other factors to establish requirements that better focus licensee and regulatory attention on design and operational issues commensurate with their importance to public health and safety. Where appropriate, a risk-informed regulatory approach can also be used to reduce unnecessary conservatism in purely deterministic approaches, or can be used to identify areas with insufficient conservatism in deterministic analyses and provide the bases for additional requirements or regulatory actions. "Risk-informed" approaches lie between the "risk-based" and purely deterministic approaches. The details of the regulatory issue under consideration will determine where the risk-informed decision falls within the spectrum.*

It was subsequently noted that identification of candidate regulatory applications that are amenable to expanded use of risk assessment information is a key step in implementing the framework. Draft screening criteria were developed by the NRC staff to identify the candidate regulatory applications. It was determined that a series of case studies would be performed that spans a wide range of materials use and waste activities. The Case Study Plan delineates the strategy for accomplishing this objective.

As part of the case study, a stakeholder meeting was held on June 13, 2001 to solicit stakeholder input. The transcript of this meeting can be found on the ADAMS Reference System (Reference 4) on the website maintained by NRC. The authors of this case study also toured a conventional uranium mill site and an in-situ leach facility to gain familiarity with their operation.

Uranium recovery is one of eight case study areas that have been identified in Reference 3 for evaluation. In this study specific milling and ISL facilities will be used as the focal point for evaluation. The objective of this case study is to test the draft screening criteria and to derive safety goals, implicit or explicit, or elements of safety goals from NRC decisions related to uranium recovery. The NRC prepared a series of draft questions, which define the approach to be taken in this case study evaluation.

2. URANIUM RECOVERY

2.1 Process Overview

Today, two primary methods used to provide uranium for the nuclear industry, mining (either by open pit or underground mining) or in-situ leaching. They are very different, and the choice of mining method may depend upon the relative costs for a given output, and is a function of many factors (e.g., size, shape, grade, depth, and thickness of ore deposits). The decision as to which method to use is based on determining the maximum mining limits (the maximum amount of uranium that can be obtained for a profit) and upon an economic analysis. Presently there are more operating ISL facilities than operating conventional uranium mills.

Regardless of the method chosen to recover uranium, uranium mining companies must comply with a host of Federal, State, and local regulations. As discussed in the following section, the NRC does not regulate uranium mining operations, which fall primarily under the purview of the Mine Safety and Health Administration (MSHA) and the individual States. The NRC does however regulate in-situ leaching facilities and all subsequent ore processing at conventional uranium mills and waste disposal sites.

At conventional uranium mills (Figure 1), ore mined from open pits and underground mines is transported to the mill site, where it is stockpiled on site until it is to be processed. During processing the ore is crushed, ground, and leached to dissolve the uranium, followed by solvent extraction or ion exchange processes to extract the dissolved uranium. The resulting uranium (U_3O_8 yellowcake) is filtered, dried, and packaged in 55-gallon drums (References 5 and 6).

In-situ leach extraction is carried out on unconsolidated sandstone uranium deposits located below the water table in a confined aquifer (Figure 2). Injection wells for the leaching solutions, and production wells for the mobilized uranium in solution, are drilled to the required depth and constructed with PVC. Interflow between wells and an aquifer having regional flow can be controlled by varying the inflow and effluent rates, by the spacing between the wells, and by properly aligning the wells at specific angles to the direction of the groundwater flow (Reference 7).

During the subsequent uranium recovery operation for both techniques, liquid and solid wastes are generated and disposed of in licensed facilities. Following depletion of the ore at ISL facilities, the circulating water must be treated to restore the groundwater to the baseline quality. For some deposits, this may consist of a relatively simple washing process, while for others a more complex combination of washing and chemical treatment may be necessary. Once the remediation is complete, the wells are sealed, wellheads are evacuated, and the site remediated. In conventional mills, lined evaporation ponds are used. Following evaporation, the remaining sludge and other byproduct material waste is buried, and topped with an earthen cover to limit radon exposure and wind dispersion of the tailings. Under the provisions of the Uranium Mill Tailings Radiation Control Act of 1978 (UMTRCA), these facilities will eventually be turned over to the Department of Energy (DOE) for long-term custodial care. By comparison, the amount of wastes generated from an ISL facility is much less than that generated from a conventional mill.

Detailed information and specific descriptions of these various uranium milling processes are provided in Appendix A.

FIGURE 1

Typical Conventional Uranium Mill

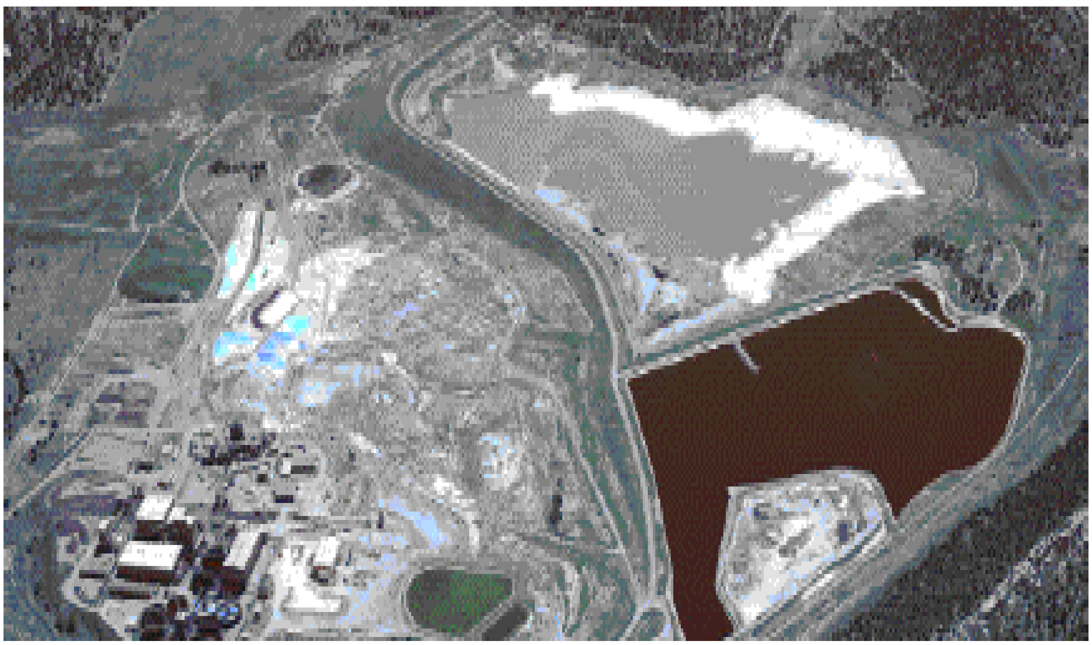

FIGURE 2

Typical In-Situ Leach Facility Well Field

2.2 Tailing and Waste Disposal (References 8 and 9)

Uranium mill tailing wastes consist of excavated rock residuals which have too low uranium content for economic extraction plus material from the uranium extraction process. Both radioactive and non-radioactive wastes are generated from uranium processing. Tailings are usually classified as sands (consisting of solids greater than 75 microns), slimes (consisting of solids less than 75 microns), and liquids (chemical solutions from the ore and process reagents).

The actual chemical composition of the tailings depends upon the mineralogy of the ore body. The radioactivity of the tailings is proportional to the ore grade. Approximately 15% of the total radioactivity is accounted for in the mill product, the remainder is discharged with the tailings. The principal radioactive materials present are thorium-230, radium-226, lead-210, and other radon daughters.

Uranium recovery facilities, including conventional milling and in-situ leach facilities, generate liquid wastes, which require proper disposal. At ISL facilities, effluent is generated from four liquid waste streams: two involving the host aquifer and the other two originating at the main uranium recovery plant. Liquid waste streams involving the host aquifer includes production bleed and groundwater sweep. Production bleed is the ground water extracted from the aquifer during uranium recovery, in excess of injected water, in order to maintain a net groundwater inflow into the recovery zone to minimize or eliminate the migration of lixiviant and dissolved uranium outside the recovery zone. Groundwater sweep is ground water extracted at the end of a uranium recovery operation to restore groundwater quality in the recovery zone. Liquid waste streams originating at the uranium recovery plant include wastewater from yellowcake processing and reject brine from the reverse osmosis treatment of the contaminated water.

Methods designed to reduce the harmful effects of the tailings are directed towards recycling the waste waters in the mill, precipitation and removal of radium from solution, and neutralization to precipitate the heavy metals. Slurried tailings materials are pumped from the mill to a lined impoundment basin where solid particles settle out, and contaminants are removed to a tailings dam. The tailing dam is also lined (pre circa-1980 impoundments are unlined) and is designed to comply with all applicable regulatory specifications. The operators of the mill monitor the water quality, surrounding environment for seepage, and the presence of radon gas. Upon cessation of milling operations, the tailings are permitted to dry out, and are then covered with an appropriate rock and earthen cover, and the surface is re-planted (if the climate will support vegetation).

3. REGULATION OF URANIUM RECOVERY

Uranium milling operations are strictly regulated. Underground and surface uranium operations provide tailing impoundment sites designed to account for such factors as the geology, seismic activity, groundwater levels, availability of naturally occurring clay, and potential flooding. During the operation of a mill, people and wildlife are excluded from the impoundments area. When milling operations cease, the impoundment area is reclaimed and permanently isolated from the environment. The area is first sealed with a soil and rock cover of varying thickness (10 feet typical). The adjacent disturbed land is then returned to its pre-operational condition by planting the area with native vegetation. These actions are designed to effectively reduce the radon emissions from the natural soils.

To provide for the disposal, long-term stabilization, and control of uranium mill tailings, Congress enacted the Uranium Mill Tailings Radiation Control Act of 1978 (UMTRCA). This Act established two programs to protect the public and the environment from uranium mill tailings. The UMTRCA Title I program established a joint Federal/State program for remedial action at abandoned mill tailings sites from the weapons program, with ultimate Federal ownership under license from the NRC. The DOE is responsible for cleanup and remediation of these abandoned sites. The NRC evaluates DOE's design and implementation plans for the cleanup, to ensure compliance with the EPA standards.

The Title II program is directed towards uranium mill sites licensed by the NRC (or Agreement States), and is discussed in this section. After successful remediation and cleanup of these sites, ownership will be maintained either by the States or the Federal government, under NRC license.

In conformance with the US Atomic Energy Act, as amended by UMTRCA, the uranium recovery industry must also address ground water quality. Typically, the water released at any point during the milling processes must meet strict regulatory standards and is of higher quality than the natural water found in the area. The above ground tailings disposal area must be sealed after reclamation. Recently constructed mill sites also provide for lined disposal areas. The underground sealing mechanism consists of clay and special liners designed to prevent seepage.

The NRC is the sole regulatory agency for uranium recovery facilities. The UMTRCA charged the EPA the responsibility for issuing standards for the control of uranium mill tailings, and in 1983, the EPA issued standards for both Title I and II sites. The NRC changes its regulations to be consistent with EPA Title II standards.

EPA estimated that its mill tailings standards would significantly reduce radon emissions such that 600 lung cancer deaths per century would be avoided. EPA standards require that mill tailing impoundments be designed for 1000 years, but in no case less than 200 years. It is assumed that the actual engineered structures will degrade slowly over the 1000 year period. Therefore, the combination of the standards and NRC regulations could avoid thousands of calculated radon-related lung cancer fatalities Reference 10).

The NRC has the authority to control radiological and non-radiological hazards, while the EPA has the authority to establish generally applicable standards for both radiological and non-radiological hazards. From the NRC perspective, the applicable requirements are found in 10 CFR Part 40 "Domestic Licensing of Source Material" and Appendix A to Part 40 "Criteria Relating to the Operation of Uranium Mills and the Disposition of Tailings or Wastes Produced by the Extraction or Concentration of Source Material from Ores Processed Primarily for Their Source Material Content". These regulations cover both the processing of the ore as well as the disposal of wastes. Other regulations, which apply, are contained in:

- 10 CFR Part 20 "Standards for Protection Against Radiation";
- 10 CFR Part 51 "Environmental Protection Regulations for Domestic Licensing and Related Regulatory Functions";
- 40 CFR Part 190 "Environmental Radiation Protection Standards for Nuclear Power Operations"; and
- 40 CFR Part 912 "Health and Environmental Protection Standards for Uranium and Thorium Mill Tailings".

In addition to these, specific provisions of the Safe Drinking Water Act (SDWA), are also applicable to ISL facilities through overlapping authority with EPA..

The specific regulations, which apply, are a function of the facility type (in-situ leach or conventional uranium mill). The NRC regulations for conventional uranium milling are prescriptive by nature, since the NRC was Congressionally mandated to conform to the EPA regulations (40 CFR 192). The same restrictions were not applied to the regulations of ISL facilities. Compared to uranium milling, the regulations for these facilities are more risk-informed.

The National Mining Association (NMA) a uranium recovery industry lobbying group , issued a White Paper in 1998 (Refs. 11 through 13) which discussed many of the key issues affecting uranium recovery from the industry viewpoint. Among the issues discussed:

- jurisdiction of non-Agreement States over non-radiological aspects of 11.e(2) byproduct material,
- jurisdiction over in-situ leach operations,
- guidance on disposal of non-11e.(2) byproduct material, and
- alternate feed policy.

The first issue centers around the question of concurrent jurisdiction, by both the NRC and non-agreement states, over all non-radiologic aspects pertaining to uranium recovery facilities. In a 1980 legal opinion, the NRC concluded that the federal law was not clear on this issue, and eventually opined in favor of concurrent jurisdiction. This has created a hardship for the industry, particularly when attempting to close sites and terminate licenses. The main concern is that the non-Agreement States could impose any requirement pertaining to remedial action over what the NRC may require. This could result in a closure delay as well as increased costs without a commensurate increase in site safety. This, in the NMA opinion, goes against the primary goal of UMTRCA, namely the orderly closure and remediation of mill tailings sites.

Similarly, the second issue deals with NRC's jurisdiction over the underground portions of ISL facilities. In the opinion of the NMA, the EPA's Underground Injection Control (UIC) program provides comprehensive protection for subsurface mining. This program requires any ISL project to undergo an EPA permitting process to ensure that no underground drinking water sources are affected. NRC regulations for the underground portion of these ISL facilities are duplicative and costly.

The third issue deals with the difficulty experienced by licensees in the disposal of low-level radioactive materials, and in siting new facilities. The NRC imposes nine criteria relating to material, which can be disposed of in tailings impoundments. The purpose of these criteria is to prevent co-mingling of mill tailings with other waste materials which could lead to duplicative EPA and /or state regulation.

The fourth issue deals with allowing uranium mills to process material other than natural uranium ores. The NRC imposes three requirements for accepting alternate fee: 1) the material must classify as ore in the regulatory sense, 2) the material must not contain any listed hazardous waste, and 3) the material must be processed primarily for its source material content. The overriding intent is to insure that there will be no regulatory complications as to final custody of mill tailings impoundments. The industry feels that the policy is overly restrictive and should be modified to allow extraction of valuable source material, which would better utilize the waste disposal capacity at mill tailing sites.

Recognizing the fact that several issues needed to be better addressed in the regulations, the NRC staff issued several Commission papers (SECY-99-011, -012, -013 and 277) (Refs. 14 through 17) to clarify specific issues and request policy decisions by the Commission.

<u>SECY-99-011:</u> This NRC staff memorandum discussed several significant concerns pertaining to the current Part 40 regulations. As discussed, the current regulations deal primarily with conventional uranium mills, and not ISL facilities. Regulating ISL facilities, in the absence of specific regulations, has become problematic and complicated. At conventional mills, groundwater requirements are codified in 10 CFR Part 40. Since there are no similar requirements in Part 40 for ISL facilities, the aquifers are restored to pre-extraction levels after uranium extraction operations are completed. The NMA has argued that this is overly restrictive, since many of the aquifers were not suitable for drinking prior to uranium extraction. The NRC imposes regulations through licensee conditions, which rely heavily upon groundwater standards from the EPA or States.

Other problems with the current requirements in Part 40 related to uranium and thorium recovery facilities include:

1) 10 CFR 40, Part A, Criterion 4 provides specific requirements covering the long term stabilization of mill tailings impoundments, which are more restrictive than the performance objective contained in Criterion 6 (which address a design to provide reasonable assurance of control of radiologic hazards to be effective for a period of 1000 years to the extent practicable, but no less than 200 years.

2) The NRC has identified the use of performance-based licenses as a way to provide flexibility. While such a license has never been established through regulation as an agency policy, such licenses have recently been issued to uranium recovery facilities.

3) Both the NRC and the industry recognize the potential cost-savings without compromising safety, which could be realized through using mill tailings impoundments for disposal of materials resulting from reclamation of other fuel cycle facilities.

SECY-99-012: This SECY discussed two concerns raised by the industry: 1) disposal of material other than 11e.(2) byproduct material in tailings impoundments, and 2) process material other than natural uranium ores.

With regard to item 1, the industry views the current regulations of byproduct material in mill tailings impoundments to be overly restrictive. The industry thinks that this disposal capacity should be used to accelerate the cleanup of contaminated sites. Further the industry thinks that such disposal would pose no additional hazards to public health and safety because the long-term design requirements are more stringent than that applied to hazardous waste in low-level waste (LLW) cells. The industry also believes that some material from contaminated sites contains enough uranium for processing through an operating uranium mill, and that current NRC guidance on alternate feed processing should not contain financial considerations.

The primary purpose of the prohibitions regarding alternate feeds is to reduce the potential for the regulation of tailings impoundments by more than one regulatory agency. Since this guidance, the DOE has allowed the placement of TSCA waste (transformer oil containing PCB) in at least one 11e.(2) mill tailings impoundment. This case involved obtaining the approval of DOE before disposal. As currently written, the NRC criterion requires DOE approval before the NRC will allow such disposals. This current approach highlights the likelihood of multiple regulation of the disposal site by EPA, the States, and NRC. Such multiple oversight is what UMTRCA sought to avoid.

The second issue this SECY addresses pertains to alternate feed material. Currently, the mill operator is required to demonstrate that the alternate feed will be processed primarily for the source-material content. This can be based on the high uranium content of the material, financial considerations, or other factors. The industry is concerned that the NRC has exceeded its legislative authority by including financial considerations. The NRC has reviewed and approved applications for alternate feed processing. Interveners have questioned whether such approval is allowing “sham” disposal. The NRC proposed revised guidance to allow the processing of alternate material without obtaining prior NRC approval through the issuance of a performance-based license amendment authorizing such processing for the source material content. In the event a hazardous waste is contained in the proposed feed material, NRC approval would be required for processing if the licensee was not already licensed to accept this type of material.

SECY-99-013: This SECY addressed ISL-related issues raised by the NMA: 1) NRC’s jurisdiction over groundwater protection at ISL’s, and 2) concerns relating to NRC guidance on liquid effluent discharges.

The industry has claimed that NRC’s regulation of groundwater is duplicative of the EPA administered SDWA. Historically, the NRC has imposed conditions on ISL licensees to ensure that groundwater quality is maintained during facility operation (Refs. 11 and 12), and restored following cessation of operations. In addition to the NRC review, licensees must also obtain a UIC permit from the EPA, which conducts many of the same types of reviews as the NRC. The positions of the industry and the NRC are directly opposite over defining who has control over groundwater in the well field. In a legal opinion, the Office of General Counsel (OGC) determine that the NRC could rely on an UIC for groundwater protection, while still maintaining jurisdiction. Under this arrangement, the NRC would defer active regulation to the EPA or EPA-authorized site.

The second issue addressed by the SECY pertained to the disposal of radioactively contaminated sludge from ISL evaporation ponds. In early licensing actions, the NRC took a narrow view on this issue, and classified waste waters and associated solids produced during the extraction processes as 11e.(2) byproduct material. Wastewater and solids produced after extraction (i.e., groundwater restoration) were classified as mine wastes water and subject to regulations by the States under their mining programs. These wastes were considered naturally occurring radioactive material. However both wastewaters from uranium extraction and post-extraction activities are disposed of in the same evaporation ponds, the resulting solids are a commingled waste consisting of 11e.(2) byproduct material and sludge derived from mine waste.

Subsequent guidance from the NRC identified 10 criteria that licensees should meet before the NRC could authorize the disposal of non-11e.(2) material in tailings impoundment. One of these criteria prohibits disposal of radioactive material not covered by the AEA, which includes naturally occurring radioactive material. The intent of this criterion was to avoid the possibility of dual regulation at mill tailings facilities.

Taken together, this guidance left no option to allow for the disposal of radioactively contaminated sludge in the ISL evaporation ponds. The NRC identified four avenues to resolve this problem: 1) maintain the current distinction between wastewaters; 2) classify all liquid effluents as 11e.(2) byproduct material; 3) classify only post-ion exchange wastes as 11e.(2) byproduct material, or 4) clarify the classification issue through legislative initiative.

One possible avenue the NRC was investigating as a means to clarify these issues was through a new Part 41 rulemaking. This would consolidate the regulations pertaining to uranium recovery in one part, while also allowing for the regulations to be risk-informed. It is noted that the concept of "risk-informed" that we use in this case study is the one advanced in the NRC White Paper on the subject.

<u>SECY-99-277</u>: This SECY addressed the issue pertaining to concurrent jurisdiction between the NRC and Non-Agreement States in the regulation of non-radiological hazards associated with 11e. (2) byproduct material. In an April 28, 1980 memorandum from the Executive Legal Director (ELD), it was concluded that the NRC and Non-Agreement States share concurrent jurisdiction over the non-radiological components of 11e. (2) byproduct material at uranium sites. In the White Paper, the NMA took issue with this opinion. The NMA felt that the new policy statement should state that under UMTRCA, the Federal Government preempts the regulation of non-radiological hazards associated with 11e. (2) byproduct material. In addition to challenging the ELD legal analysis of concurrent jurisdiction, the NMA identified two significant consequences of concurrent jurisdiction:

1) It could lead to impediments to the timely closure and subsequent transfer to government custodial care of mill tailings sites; and

2) It could interfere with the NRC’s ability to impose a consistent and efficient regulatory scheme on mill tailing sites.

Though no problems were experienced to date, the NRC agreed with the NMA’s assessment of the potential consequences of concurrent jurisdiction. In particular, the NRC was concerned with these implications with respect to section 83b.(7) of the Atomic Energy Act which requires that a site be turned over at no cost to a long term custodian.

However, the Office of the General Counsel's recent analysis concluded that there was no legal basis to reverse the current staff practice of allowing concurrent jurisdiction. The 1980 ELD legal analysis did recognize that the NRC could exercise preemption on a case-by-case basis, if state actions inhibited the implementation of the UMTRCA as intended by Congress.

The NRC and uranium recovery industry recognized the need for a single set of regulations pertaining to the uranium recovery industry, and proposed a new Part 41 to serve this need (References 18 and 19). However, as with all rulemaking activities, such an endeavor would be licensee fee recoverable, and given the current depressed state of the uranium industry, this prospect presented a hardship. The industry, while supporting the idea in principle, requested relief from these fees to the Commissioners. In response to this, the Commissioners instructed the staff to stop development of a new Part 41. In lieu of this, any changes will be made to the existing NRC guidance documents (e.g., Regulatory Guides and Standard Review Plans) (Reference 20).

4. RISK-INFORMING URANIUM RECOVERY

Several risk studies have been performed in the uranium recovery area (Refs. 21 through 24). The environmental impact statements for the specific facilities assess risk posed by alternative options for siting and conducting operations at a facility. Facility owners have also conducted risk studies for various purposes. Recently a risk study for in situ leach extraction facilities has been performed by the Center for Nuclear Waste Regulatory Analyses has been performed under NRC sponsorship. In this section, a summary is provided of some of these studies in order to give a sense of the state of the art in this area.

4.1 Final Generic Environmental Impact Statement on Uranium Milling (Reference 25)

In this document, referred to here as the GEIS, the NRC evaluated a wide range of issues for the US uranium milling industry. This includes controlling of emissions from mills and mill decommissioning. The latter includes, of course, the large volume of mill tailings that are produced in mill operations. In accord with its mission to protect health, safety and the environment, the NRC considered a full range of perspectives in the GEIS. This includes health risks to individuals living near a mill, to mill workers, and to large populations that can be exposed to radon. In addition to routine releases, the GEIS evaluated the impact of accidents. It was found that total releases, radiation exposures, and environmental impacts from accidents will be a small fraction of routine releases from a mill. The most severe accidents are those involving the shipment of yellowcake. It was determined that a worst case scenario in a relatively populated area would lead to total exposures that are 10 times greater than a single mill's annual implied operational exposure.

The GEIS considered various operational alternatives. For example, for airborne emission control, the report considered:

- Water cover, sprinkling and chemical sprays to control sources of dust
- Wind shielding and dust collecting hood
- Stack controls
- Process modifications
- Progressive reclamation of tailings disposal areas.

The report also considered alternatives for tailings disposal decommissioning of mill sites and structures. Alternatives were evaluated in terms of doses to: nearby individual, average individual, average mill worker. To the extent that dose can be equated with risk, this study can be considered to be risk-informed.

4.2 Risk Studies for the Atlas Mill Site

The Atlas Mill in Moab, Utah operated from 1956 to1984 and processed over 10.5 million tons of ore and produced a comparable amount of tailings that were deposited on the site. After it ceased operations, Atlas began, in 1988, a process of dismantling, decontamination, salvaging, and burying buildings, foundations and equipment. They then began to consider the reclamation of the tailings pile, which required remediation to ensure that the radiation exposures would not be unacceptable. This included an assessment, requested by the NRC, of an alternative reclamation concept in which tailings would be relocated to a site 18 miles from the original location. Disposal of tailings at the original site became an issue because the site is adjacent to the Colorado River and is near the town of Moab and Arches National Park. Clearly, there would be a large expense, and possible bankruptcy, for Atlas with the alternative option. It would also result in two sites that would have to be reclaimed, secured , and monitored.

In order to obtain a more comprehensive perspective, Atlas performed an assessment of the doses and risks that would be implied by the two options (Reference 26). The authors also considered a “do nothing” option, which was added for comparison purposes. For these options, Atlas estimated the potential societal risks from radiation doses to the public and to the workers. In addition, Atlas assessed the nonradiological risks to worker that would result from construction and transportation accidents from the reclamation activities. For each option they tabulated:

- Population Cancer Risk
- Cancer Risk to Workers
- Risk of Fatality from Construction Accidents
- Risk of Fatality from Transportation Accidents

These were then summed to obtain total (lifetime) risk of fatality in each option. Atlas reported that overall the relocation scenario was approximately five times more risky than the on-site reclamation option. It was also found that the relocation option was of comparable risk to the “do nothing” option. While population risks were 4 to 6 times higher for the relocation option, it was about 10 times higher for the other three risk indices reported in the paper. In all cases the risk was low. Only in the most pessimistic relocation scenario was the expected total additional lifetime fatality expected to equal one.

In a closely related study (Reference 27), the NRC Final Environmental Impact Statement, NUREG-1531, by the USNRC, risk-informed techniques were used to decide on whether or not to approve the Atlas Corporation’s request for a license amendment on its proposal for onsite reclamation of the tailings. In accordance with 10 CFR 40, Appendix A, NRC must determine compliance of the Atlas proposal with the requirements.

As part of NUREG-1531, the NRC performed an assessment of the radiological impact associated with transport of mill tailings by conveyor and by rail from the Atlas site to the alternative site. A risk methodology was used in this analysis to characterize the mill tailings, describe the transportation process and to compute the associated risks. The RADTRAN-4 computer code was used to perform the radiological risk assessment. The risk came from two sources. One was the risk associated with potential accidents (episodic risk) that were severe enough to cause release of radioactive material. The other was term “incident-free” and referred to the risks (chronic risk) associated with normal transport.

In this risk assessment, NUREG-1531 reported latent cancer fatalities in the following categories:

- Incident-Free Risk to the Railroad Crew
- Incident-Free Risk to the Total Population
- Exposures to the Total Population due to Accidents
- Maximum Exposed Individual Dose Risk

It was found that risks to the railroad crew due to chronic exposures by far exceeded their risk due to accidents. Chronic population risks for this transportation process were about two orders of magnitude smaller than the crew risk and five orders of magnitude below the national lifetime average risk of cancer from all causes. The analysis also showed that there would be no fatalities from acute radiation exposure as a result of the release of radioactive material from any hypothetical accidents.

These two studies, by the Atlas Corporation and by the USNRC, taken together demonstrate that risk methods can be used in the uranium recovery area. Moreover, they illustrate that useful relative insights can be gained by systematically identifying and analyzing contributors to risk and computing their probabilities and consequences. These studies help to illuminate the impact of alternatives and ultimately facilitate and inform choices that need to be made.

4.3 Smith Ranch Baseline Risk Assessment Program

As part of this case study on uranium recovery, the study team visited a representative in situ leach facility to gain first-hand familiarization of such an operation and to discuss the safety and risk programs of the facility with its personnel. Smith Ranch is located near Casper Wyoming and is owned by the Rio Algom Mining Corporation. The tour of the site provided insight to its operation and also provided a sense of the commitment of the personnel to its safe operation. In our discussion with the personnel, it was learned that Smith Ranch performed a risk assessment of its facility. This assessment was not done to satisfy a requirement of the regulator nor was it provided to the regulator at any time. Rather, it was performed as an internal study to gain perspective on the relative potential hazards at the site and to help prioritize resources and programs, which would ensure the continued safe operation of the facility.

The baseline risk assessment was performed by a special task group of approximately one dozen Smith Ranch employees to establish the current (2000 year) risks and to mitigate undesirable and unacceptable levels of risk. The study identified 18 potential risk categories and resulting risk mitigations. At the outset the team developed an implementation procedure for conducting the risk assessment. The study was conducted in three phases. In the first phase, a list was developed of systems or processes along with a list of credible accident scenarios for each system or process. This phase was a risk procedure screening in which each credible scenario was ranked according to likelihood and consequence. In the second phase, risk mitigation strategies were proposed for each system or process to lower its rank to an acceptable level. New risk rankings were computed for each category on the basis of the mitigation proposals. In the third phase, any remaining unacceptable or undesirable risk rankings were to be mitigated to an acceptable level.

Seven consequence categories were identified for the risk-screening phase. They were:

- Public Consequence
- Employee Safety
- Environmental Consequences
- Production Loss/Project Delay
- Capital Loss/Facility Damage

- Loss of Market Share
- Regulatory Fines/Enforcement/Reputation/Litigation

Each of these consequences was tabulated into four severity levels (minimal impact to maximum impact). Similarly, a set of four frequency levels was used to screen events according to likelihood. From these consequence and frequency levels a 4x4 matrix of risk space was constructed and risk scenarios were binned accordingly. Examples of hazard categories were: Deep Disposal Well, Ammonia, Electrical, and Yellowcake Transport.

After the Phase II study was completed, the environmental safety and health group at Smith Ranch continued to review existing assessments to ensure continued applicability and to generate new risk assessments for existing systems or processes, which not have been formally assessed. This is a good example of how a safety management program can be risk-informed. The Smith Ranch operators ensure that the prediction of their low risk will remain that way by implementing strategies and mitigations accordingly. It is commendable that Smith Ranch undertook this project. Apparently they recognized the value of risk assessment not only to protect health and environment, but also to protect their business assets. This is evident from the consequence categories that they have defined.

4.4 CNWRA Risk Study for In Situ Leach Uranium Extraction

The regulation of in situ leaching facilities has some aspects in common with conventional uranium milling facilities. Specifically, they share the same drying process for yellowcake in their respective final stages of processing. While the entire milling process is governed by 10 CFR Part 40, Appendix A, the ISL is not covered by this part of the Code of Federal Regulation for those aspects of the ISL that are not in common with the uranium mill. Rather, ISL facilities are regulated to protect the health and environment through a set of requirements that are known as license conditions. These license conditions are subject to legal challenges, imply economic and operational risk to the ISL owners, and may not be uniformly applied across licensees. To remedy this situation NRC has contemplated the development of a new rule, 10 CFR 41. However, because of the already difficult financial state of the uranium recovery business, the Commission decided to not pursue new rulemaking at this time, mainly because of the additional financial burdens to the industry that would result from this process.

Nevertheless, there remains a need to have a more rational and predictable approach to licensing and regulation of ISL facilities. For this reason, the NRC had tasked (prior to the Commission’s decision not to proceed with rulemaking) the Center for Nuclear Waste Regulatory Analyses (CNWRA) to assist in developing a risk-informed, performance-based foundation for regulation of ISL facilities. The results of their study have been recently issued as NUREG/CR-6733 (Reference 28). CNWRA evaluated operations associated with extracting and processing uranium into yellowcake and restoring groundwater quality subsequent to ore extraction activities.

In performing this study, the authors realized that the conventional (reactor-type) probabilistic risk analysis approach would need to be modified for the ISL application. They noted that it had to be tailored to the nature of the specific materials, activities, and regulatory requirements associated with ISL facilities. Based on the hazards that come under NRC purview for ISL facilities, CNWRA defined three top-level categories for further analytical decomposition. They are:

- Surface environmental chemical hazards
- Surface environmental radiological hazards
- Groundwater chemical and radiological contamination hazards.

The authors noted that NRC considers chemical mishaps only to the extent that they could imply radiological releases.

CNWRA examined the Nuclear Materials Events Database (NMED) and determined that release of radioactive material and contamination of groundwater occurred with relatively high frequency (within the lifetime of an ISL facility). Thus they focused on the evaluation of the consequences of these accidents. They also assessed the consequences of various accidents in a conservative way. If they found that the consequences were unacceptable from a regulatory standpoint, they explored mitigation actions. They wanted to avoid dealing with the uncertainties and difficulties associated with calculating the likelihood of occurrence with a small amount of data available.

The foregoing is one approach to risk management. It avoids the development of uncertainty distributions by eliminating, or minimizing the impact, of the source of the uncertainty. However, in some instances this may not be practical or cost-effective. Even if probabilities are very low and have large uncertainties associated with them, methods exist to characterize these uncertainties. This alternative approach would allow a balancing of consequence against probability and thus provided a relative risk perspective for the various events considered in the CNWRA study. It would help to prioritize the sundry recommendations provided in that study. In order to do this, risk would have to be expressed in common units (or a valuation would have to be placed on risk parameters in different units).

NUREG/CR-6733 is a good starting point for a more complete probabilistic risk assessment for ISL's. Facility-specific studies would help to reveal and correct weaknesses and vulnerabilities in facility design and/or operation. As was indicated for the Smith Ranch Facility, above, a probabilistic risk study can become an important safety management tool.

5. DRAFT SAFETY GOALS FOR URANIUM RECOVERY

5.1 Introduction

Safety goals are objectives designed to guide regulatory requirements and to assist regulators in such a way that NRC's mandate to protect public health, safety, and the environment is met. Safety goals are statements of NRC philosophy and approach to safety that provide a clear definition of the objectives, which are the foundations of regulatory actions. Safety goals are not requirements. Instead, they are used in formulating an answer to "How safe is safe enough?"

The NRC's approach to strategic goals (References 29 through 31) is set forth in the Strategic Plan (Reference 29). NMSS's regulatory philosophy is defined through strategic and performance goals, and specific measures. NMSS has identified one strategic goal: Prevent radiation-related deaths and illnesses, promote the common defense and security, and protect the environment in the use of source, byproduct and special nuclear material.

The NMSS performance goal for uranium recovery is to maintain safety and protection of the environment and the common defense and security. For uranium recovery, the maintenance of safety and protection of the environment are most applicable.

The NRC has identified specific measures to assess the success in achieving this strategic goal. Though these goals are applied throughout the NMSS arena, the three specific ones applicable to uranium recovery are:

- No more than 20 events per year resulting in radiation overexposures from radioactive material that exceed applicable regulatory limits;
- No more than 40 releases per year to the environment of radioactive material from operating facilities that exceed the regulatory limits; and
- No non-radiological events that occur during the NRC-regulated operations that cause impacts on the environment that cannot be mitigated within applicable regulatory limits using reasonably available methods.

The allocation of these numerical targets to the various disciplines under NMSS purview is not specified. NMSS encompasses approximately 26 operating uranium recovery sites, 21 uranium recovery sites under decommissioning, 10 major fuel cycle facilities, and more than 20,000 specific materials licensees. In addition, there are approximately 100,000 general materials licensees within this arena. Clearly these measures cannot apply solely to uranium recovery facilities. However, the relative risks associated with each specific area regulated need to be assessed and a graded approach may need to be applied when establishing specific events for each major area. For example, the comparative risk for uranium recovery may be relatively large compared to a fixed gauge, which may pose a potential impact to a small number of persons.

For uranium recovery, oversight is accomplished by the NRC and Agreement States. In non-radiological area, the NRC uses EPA-developed regulations. At ISL sites there is a joint oversight by the EPA and NRC. The NRC encourages Agreement States to maintain a large share of the program responsibilities, and as such they play an important role in ensuring that the goals are met.

In addition to these goals, numerous radiation dose limits and contamination limits pertaining to uranium recovery have risk implications. Appendix A to 10 CFR Part 40 contains maximum contamination values for groundwater protection. Milling operations producing or involving thorium byproduct material must be conducted in such a manner that the annual dose equivalent does not exceed:

- 25 millirem whole body
- 75 millirems to the thyroid
- 25 millirems to any other organ

Regulations are also provided for the safe disposal of uranium mill tailings. As discussed previously, the uranium recovery industry is seeking regulatory approval to use these disposal sites as a means to dispose of alternate materials. Regulations pertaining to the material disposal (subsurface or in impoundments) provide a goal for the protection of the environment for a period of 200 to 1000 years.

An important distinction must be made when differentiating between goals and regulatory limits. A goal is an aspiration: it may or may not be achievable. A limit is a quantity: it must be complied with. The draft safety goals are based on a combination of quantitative limits and qualitative statements, that have been proclaimed, either directly or indirectly by the NRC in various documents.

5.2 Draft Safety Goals

The draft safety goals presented below are qualitative in nature. They are intended to serve as strawmen to foster thoughts and discussions on safety goals appropriate for uranium recovery. They reflect the insights gained from the preparation of this case study.

(1) Maintain Public Confidence in the Uranium Recovery Industry

This draft safety goal reflects the importance of preserving the safe aspects of the uranium recovery industry as it relates to public health. These facilities tend to be in isolated areas and contain low inventories of high-hazard materials. Thus they generally do not pose a health or safety threat to large populations. Therefore, public scrutiny tends to be low. However, this should not be misconstrued to mean that minimal oversight is needed. Given the potential to affect groundwater in the event of an off-normal incident, potentially large numbers of persons may be affected. In this case, the public confidence could quickly be eroded.

(2) Maintain Safety and Protection of the Environment

The uranium recovery industry poses a potential threat to the environment, particularly groundwater. ISL facilities, as a result of the leaching process, tend to increase the amounts of certain hazardous constituents in the groundwater. The effect on the environment is measurable; but the ultimate impact is not obvious. The industry claims that facilities are being required to remediate the groundwater to a state, which in some instances is better than the original condition. In other instances, the industry claims that the aquifers have never been, and never will be used as a drinking water source, and as such, to require them to return the aquifer to such standards is burdensome and unnecessary. Other stakeholders maintain that one can never predict the future with absolute accuracy, so returning the aquifer to the drinking water standards provides a level of protection for future generations.

(3) Prevent Significant Adverse Impacts From Radioactive Waste to the Current and Future Health and Safety and the Environment

This draft safety goal is designed to address both human and environmental protection from the mill tailings. As discussed, tailings are either disposed of in subsurface, lined and covered pits, or in above ground mounds. In both cases, the regulations are designed to ensure the safety from the disposed material for a period of 1000 years to the extent practicable, but no less than 200 years.

(4) No Significant Adverse Impact on Occupational Health From Uranium Recovery Activities

From the documents reviewed with this Case Study and site visits, it became obvious that chemical risk poses the largest risk to occupational workers. Chemicals are used both in the recovery process in traditional mills and ISL facilities. The NRC does not specifically regulate chemicals, but through understandings with other agencies (OSHA, MSHA) provides a certain degree of oversight as part of the regulatory and inspection process. Though this oversight provides some protection, the inspectors are not necessarily experts in chemicals and their hazards. Regulatory oversight may need to be strengthened and consolidated in this area.

6. REVIEW OF DRAFT QUESTIONS

6.1 Screening Criteria Analysis/Risk Analysis Questions (Reference 32)

(1) What risk information is currently available in this area? (Have any specific risk studies been done?)

As outlined in Section 4, there have been various risk-related studies for uranium recovery. The site-specific environmental impact statements as well as the generic EIS's all have a risk-related flavor to them. The EIS's are examples of the NRC's NEPA review, which include risk assessments and cumulative impacts. The work associated with the Atlas mill site is a good example of how risk information can be used to present and evaluate alternatives. The operators of the Smith Ranch facility performed their own risk assessment to help manage safe operation at this ISL facility. A generic risk assessment of ISL facilities was recently performed for the USNRC by the Center for Nuclear Waste Regulatory Analyses. In the 1988 time frame, the National Academy of Science examined the risk bases for the regulation of the uranium industry. It was noted at the stakeholder meeting that NIOSH is also performing an epidemiological study of risk to mine and mill workers. Internationally, a reference was made to a study performed by the German Ministry of Finance where a risk-based approach was applied to the decommissioning of the former East German uranium mines.

(2) What is the quality of the study? (Is it of sufficient quality to support decision-making?)

These studies appear to have been of sufficient quality for their intended purposes. Additional quantitative information could have, perhaps, been developed to enhance the perspective for a decision. The CNWRA study on ISL facilities provides a generic risk assessment focused on the Smith Ranch facility, but could be relevant to all ISL facilities.

(3) What additional studies would be needed to support decision-making and at what cost?

Facility-specific studies would identify scenarios that are unique to a particular site. Development of the likelihood of occurrence of events and their associated uncertainties would be helpful in determining the relative importance of specific scenarios, issues, and topical areas.

(4) How is/was risk information used and considered by NRC and licensee in this area?

The EIS's, by their nature, contain risk-related information and provided the supporting framework for the decision to be made. Smith Ranch used their risk information to upgrade the safety of their facility. As noted, the Atlas facility examined a range of risk indices when evaluating alternate sites for their waste. After evaluating the risks, including transportation risk, it was concluded that it would be less risky to dispose of the wastes on site.

At the stakeholders meeting on this case study, the value of risk information to conventional milling practice was questioned by some stakeholders. There appeared to be support from the industry and the public for the use of risk methods and results in assessments of alternate siting and transportation associated with conventional mills.

(5) What is the societal benefit of this regulated activity?

Uranium ore is the source of fuel for nuclear power and for nuclear test and research reactors. It is essential that all aspects of the nuclear power industry be operated in a safe and environmentally friendly manner.

(6) What is the public perception/acceptance of risk in this area?

Residents who live nearby to a facility tend to be supportive. This is likely to be true where the facility provides a positive economic and social benefit to the community. However, some sectors of the public do not accept the nuclear industry and therefore resist this first step in the fuel cycle. Public perception was highlighted by discussions with the operators at White Mesa. They had been transporting ore for processing at White Mesa. When they recently began accepting material from out-or-state sites for alternate feed processing, the public's awareness increased since the material was placarded as nuclear waste. The risk posed by this material was in reality no greater than that posed by transporting natural ore.

(7) What was the outcome when this application was put through the draft screening criteria? Did this application pass any of the screening criteria? Does the outcome seem reasonable? Why and why not?

The application led to a favorable outcome. This is a reasonable outcome because the regulated risk is expressed in terms of an excess dose. To the extent that dose implies risk (chronically), one would expect this result.

6.2 Safety Goal Analysis Questions

(1) What is the basis for the current regulations in this area (e.g. legislative requirements, international compatibility, historical events, public confidence, undetermined, etc.)?

The Uranium Mill Tailings Radiation Controls Act of 1978 was a dominant piece of legislation in this area. Appendix A to 10 CFR40, was legislatively required to be deterministic in character. Most recently, the NRC Commissioners decided to forgo 10 CFR 41 rulemaking due to the fact that the economically-depressed uranium industry could not afford to have it proceed (even though this rule would result in a more consistent approach to regulation). There are working memorandum of understandings with other agencies (EPA, OSHA) in this area. From Chapter 10 of the Code of Federal Regulations, the relevant Part are: 2, 20, 40, 51. Also 40 CFR Parts 190 and 192 are relevant. By Congressional mandate, the regulations for conventional uranium milling are not risk-informed.

(2) Are there any explicit safety goals or implicit safety goals embedded in the regulations, statements of consideration, or other documents (an example would be the acceptance of a regulatory exemption based in part on a risk analysis and the outcome)?

The GEIS, NUREG-0706 (Reference 31), it is stated that: “Operation of uranium mills and the management of mill tailings... to appropriately assure the public health and safety and the preservation of environmental values”. Also SECY 99-100 notes that both public and worker risks should be considered. It also provides four strawman safety goals for consideration.

(3) What was the basis for the development of the strategic goals, performance goals, measures and metrics? How are they relevant/applicable to the area being studied and how do they relate/compare with the regulatory requirements? How would they relate to safety goals in this area?

Appendix A to 10 CFR 40, is the basis for the current approach. It was written when it was though that the mill industry would be vibrant. Currently, ISLs are more competitive in a nevertheless depressed industry. ISLs, however are partially outside the scope of 10 CFR Part 40, Appendix A. As a result, regulation of ISLs is granted through issuance of a licensing condition (most recently performance-based), which tend to be ad hoc and more easily subject to challenge than a rule. Generally, the standards are set by the EPA and implemented by NRC. Individual State’s also set standards, which can differ from those promulgated by NRC.

(4) Are there any safety goals, limits, or other criteria implied by decisions or evaluations that have been made that are relevant to this area?

Limits for NRC radiological concentrations and for air and water effluent, the EPA standard for groundwater, and occupational protection guides and standards.

(5) If safety goals were to be developed in this area, would tools/data be available for measurement?

Generally there would be tools and data that could be used, modified or generalized for this area. There are quantitative tools available to the licensees. RESRAD has been used for the assessment of risk from pre and post-remediation activities at mill tailings sites. MILDOS-AREA calculates the dose within an 80-km radius of an operating uranium recovery facility. This code also looks at air and groundwater pathways (Refs. 33 and 34).

(6) Who are/were the populations at risk?

During normal operations it is mainly the workers who are at risk. For off-normal events, it is possible that the nearby population could be at risk. After operations cease, it is those who would come in contact with the site, including via liquid pathway exposures.

(7) What are/were, and what could be/have been, the various consequences to the populations at risk?

For workers the concern would be for industrial, transportation, and chemical risk as well as exposure to radon and other radionuclides. For the public the concern would be for exposure to effluents from off-normal events (e.g., wind-blown particulate, groundwater contamination) and from transportation accidents.

(8) What parameters should be considered for the safety goals (e.g., workers vs. public, individual vs. societal, accidents vs. normal operations, acute vs. latent fatality or serious injury, environmental and property damage)?

The full range of parameters noted here should be considered. However, it is not likely that acute radiation exposure would be possible. Other parameters to be considered include public acceptance, and the integration of all regulations and regulatory bodies such that duplicative regulations are deleted, and all risks from this industry are regulated in a structured and defined manner.

(9) On the basis of the answers to the questions above, would it be feasible to develop safety goals in this regulatory area?

Yes, it is likely that safety goals can be developed here. Input received from stakeholders have been beneficial to this determination.

(10) What methods, data results, safety goals, or regulatory requirements would be necessary to make it possible to risk-inform similar cases?

For some low-level waste facilities, the approaches may be similar. Also, byproduct material disposal should be given some consideration in this regard.

6.3 Questions Upon Developing Draft Safety Goals

Responses to these questions are based on the draft safety goals that are presented in Section 5 of this report.

(1) Are the current regulations sufficient in that they reflect the objectives of the draft goals? Would major changes be required?

10 CFR 40, Appendix A provides adequate protection to the public health and safety for uranium milling sites. ISL regulation may need to be more coherently focused to have counterparts in overarching safety goal statements as presented here.

Draft goals related to the workers do not currently have counterparts in the NRC regulations, except for the exposures covered under 10 CFR 20. Other-agency jurisdiction for non-radiological accident conditions would need to be examined for consistency with these draft goals.

The environmental goals presented here are new and tentative. As such, they have no direct touchstones with existing regulations. It is worth noting that potential safety goals related to land contamination have been discussed for reactor accidents for some time now. In the Staff Requirements Memorandum (June 27, 2000) on SECY-00-0077, the Commission disapproved the NRC staff's recommendation that the Safety Goal Policy Statement include "there be no adverse impact on the environment".

(2) Would the regulations need to be tightened?

As discussed above, 10 CFR 40, Appendix A provides adequate protection within its scope. However, if the suggestions for worker protection and environmental protection were to be adopted, then it is possible that an associated regulatory framework would need to be developed.

(3) Are the regulations overly conservative and/or too prescriptive with respect to the goals?

No, 10 CFR 40, Appendix A allows limited flexibility in meeting the regulations. Also, the "license condition' approach for ISLs is not overly prescriptive.

(4) If these were the safety goals, what decisions would be made?

These goals may be helpful in decisions related to non 11e.(2) material, alternate feed, and groundwater remediation.

(5) Would these goals be acceptable to the public?

This was an important topic for the Stakeholders Meeting to be held in October, 2001. At the meeting, there was general agreement by the stakeholders that NRC should proceed with development of safety goals in the nuclear materials use and waste area.

7. RESPONSES TO THE DRAFT SCREENING CRITERIA QUESTIONS

In Section 4 of the Case Studies Plan, draft screening criteria are provided. The intent of these criteria is to identify candidate regulatory applications that are amenable to expanded use of risk assessment information. These questions are presented here along with our preliminary responses for the case study.

(1) Would a risk-informed regulatory approach help to resolve a question with respect to maintaining or improving the activity's safety?

Yes, this is evident from the risk studies associated with the evaluation performed for an alternate site for the Atlas site tailings. In addition, recent studies, as well as discussions with facility operators, indicate that a large source of risk is occupational, primarily chemical. At present, the NRC does not regulate this risk. A risk-informed regulatory approach would be able to focus additional oversight to this area. However, all risk is not equivalent. For example, the total risk (radiologic and environmental) associated with a mill tailings pile needs to be assessed for a much longer time period (1000 years to the extent practicable, but no less than 200 years), compared to the risks (primarily chemical) from an operating ISL facility, which has no comparable disposal issue.

(2) Could a risk-informed regulatory approach improve the efficiency or effectiveness of the NRC regulatory process?

Yes, and a prime example of this is the alternate siting study performed for the Atlas tailings. A risk-informed approach may produce a result which was not considered seriously initially (such as leaving wastes in-place rather than transporting them elsewhere). It is likely that the development of 10 CFR Part 41 would have been risk-informed. This would have led to regulatory efficiency and effectiveness. In addition, oversight could be lessened at non-risk-sensitive areas and processes, and focus on the more sensitive portions of the process.

(3) Could a risk-informed approach reduce unnecessary regulatory burden for the applicant or licensee?

Yes. A more consistent approach to ISL regulation could benefit a licensee. The current license condition approach does not enhance regulatory stability and predictability. As discussed above, a reduction in the oversight of regulatory agencies on non-risk sensitive areas could also benefit the licensees. In addition, the use of performance-based licenses provide licensees with more ownership of their process, which if used properly, can decrease the amount of regulatory oversight needed. However, as discussed at the stakeholder meeting, a risk-informed process is a double-edged sword, which can cut both ways. While it may reduce regulatory oversight, it may just as likely re-focus attention on a totally new area, which may result in an appropriate increased regulatory burden.

From both the regulatory and stakeholder point of view however, a risk-informed process may serve to answer the question “How safe is safe enough?”. When that answer is obtained and understood for uranium recovery facilities, the regulations can then be focused on the risk important issues.

An example discussed at the stakeholders meeting as well as identified by the NMA in the White Paper, is disposal of non-11e.(2) material in tailings impoundments, which is prohibited by present regulations. The requirements for disposal of this material (e.g., synthetic liners, earthen cover and ground vegetation) are very similar to those for the tailings. If space exists at the tailings disposal area, and agreement can be reached regarding regulatory oversight, it appears to be reasonable to dispose of this material in such a location, rather than having to construct another one.

(4) Would a risk-informed approach help to effectively communicate a regulatory decision or situation?

Yes. Risk information can allow for a broader perspective and help provide justification for a decision. In addition, such an approach would tend to focus the licensee's oversight and resources on those identified as being risk significant, which would ultimately lead to a safer operation. A well-written and well-thought-out regulatory approach, which is justifiable from a risk viewpoint, would be useful in communicating a regulatory decision. This is not to say that every stakeholder will agree with it. However, when the benefits are weighed against the risks, it may be assumed that a majority of the stakeholders would understand the reasons behind the decision.

(5) Does information (data) and analytical models exist that are of sufficient quality or could they be reasonably developed to support risk-informing a regulatory activity?

Yes. Models can be adapted or used directly in this area. There are quantitative tools available to the licensees. RESRAD has been used for the assessment of risk from pre- and post-remediation activities at mill tailings sites. MILDOS-AREA calculates the dose within an 80 km radius of an operating uranium recovery facility. This code also looks at air and groundwater pathways. A significant amount of risk work has been done on transportation accidents, and the chemical industry has incorporated the HAZOP approach for many processing plants. Parallels between the nuclear and chemical industry could be drawn and useful insights obtained.

(6) Can startup and implementation of a risk-informed approach be realized at a reasonable cost to the NRC, applicant or licensee, and/or public, and provide a net benefit?

This appears to be the case. Efforts in this area should proceed in an evolutionary way with special issues addressed at specific facilities given that work on a new Part 41 has been halted for the present. However, as discussed previously, the uranium recovery industry, due to its depressed economic state, has resisted any additional NRC fees being imposed, and in fact has sought relief from the current fees.

(7) Do other factors exist (e.g., legislative, judicial, adverse stakeholder reaction) which would preclude changing the regulatory approach in an area, and therefore, limit the utility in implementing a risk-informed approach?

None are apparent. Many stakeholders recognize the areas where regulations need to be reexamined, and are in favor of work proceeding. However, as discussed, the depressed state of the industry will lead the industry to seek regulatory relief from the fees associated with this work. Another potential problem identified was the potential difficulties associated with the licensing process. Any time changes are considered to the current regulations; the opportunity is available to all stakeholders to submit items for review and comment. This poses the potential for allowing the process to be slowed down considerably by interveners, and the desired purpose of the proposed change clouded, if the information submitted is voluminous. However, this is not to say that all opinion's brought forth by interested parties should not be given due consideration. It is important to realize that just because some members of the public may be against a specific action does not mean it should not be considered. The fact that the licensing process is used does not mean that a regulatory change will result.

8. SUMMARY AND CONCLUSIONS

This Technical Report presents the results of this case study. The report also provides a review of the Draft Questions that are presented in the Case Study Plan. These responses are subject to revisions as more information is obtained in documents and from interactions with interested parties. Responses to the Draft Screening Criteria are given in this report. The uranium recovery area passed the screening evaluation and thus can be regarded as a candidate for risk-informed regulation.

There are no explicit safety goals for the uranium area, but implicit goals can be discerned for the existing regulatory fabric. The most overarching goal (apart from not doing undue harm to the public and workers) is that " Operation of uranium mills and the management of mill tailings... to appropriately assure the public health and safety and the preservation of environmental values ".

Draft safety goals have been developed in this report for uranium recovery. They cover public and worker health and safety and environmental protection. They have been developed for uranium milling sites and in situ leach facilities.

With regard to the objectives of the Case Study Plan, we have concluded the following.

(1) This case study provides useful information for the development of a final version of the screening criteria. The draft screening criteria have been useful for this study and apart from some change of emphasis in the wording, the essential thrust of the draft screening criteria will remain.

(2) As suggested in this study, risk information would be useful in developing perspectives for alternate feed, non-11e.(2) byproduct materials, and groundwater remediation. Chemical risks are important for uranium recovery and they can be addressed in a risk-informed approach.

(3) This study considered the feasibility of safety goals and has, in fact, developed draft goals in relation to uranium recovery.

(4) This study has begun the process of identifying suitable methods for developing a risk-informed approach. It shows how performance assessment could be used and extended to develop the appropriate analytical tools.

With regard to the broad objectives of the NRC, we have given preliminary consideration to how risk-informing the uranium recovery area might be a worthwhile enterprise. With regard to improving safety, it has been demonstrated in the GEIS for the Atlas facility that a risk perspective is helpful in decision-making for uranium recovery. This is evident from the risk studies associated with the evaluation performed for an alternate site for the Atlas site tailings. With regard to regulatory effectiveness and efficiency a risk-informed regulatory approach could help focus the regulatory process on areas of highest safety concern. It is likely that the development of 10 CFR Part 41 would have been risk-informed, and this would have led to more effective regulation than the current license condition approach. With regard to reducing unnecessary burden, risk-informed arguments could have strengthened the arguments put forth in the White Paper of the National Mining Association. Finally, with regard to effectively communicating a regulatory decision or situation, it is helpful to support a decision or relate information on a situation by providing as broad a perspective as possible. Understanding the risks and their trade-offs can only enhance the perspective. It is also important to communicate benefits as well as the risks of a given situation or decision.

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APPENDIX A - Uranium Recovery Process Descriptions

- Conventional Mill

Ore Processing

Metallurgical processes for the treatment of uranium ores following mining are characterized by the leaching method used and by the technique for purification and concentration of the leach. The selection of the uranium extraction process is site specific and is strongly a function of geology and mineralogy.

Feed Preparation - Crushing and Grinding

Though the uranium feed preparation requirements vary for different types of uranium ores, relatively standard crushing and grinding systems are used for particle size reduction. In the past, conventional crushing and rod mill/ball mill circuits were used. Presently, semi-autogenous or autogenous grinding has been widely used when suited to the ore, with crushing being phased out. Avoiding crushing reduces dust and the associated radiation hazards in the area of the mill.

Pre-concentration

Where possible, uranium ore is pre-concentrated prior to leaching to enhance the feed grade, which has the economic advantage of increasing uranium production from installed mill capacity. This process also removes minerals that are likely to prove deleterious in the leaching and recovery stages, and produces clean tailings which can be rejected with less environmental concerns. However, most uranium ores cannot be pre-concentrated due to their finely disseminated nature, and thus lower cost processes such as heap or in-situ leaching are chosen.

Acid Leaching

This is the predominant process used for leaching and dissolving uranium because of its relatively low cost and high availability. The uranium concentration of the slurry is oxidized and dissolved in acid leach tanks. Both mechanical and air agitation may be used depending upon particle size, size distribution, and abrasive nature of the feed slurry. The reagent addition procedures are generally tailored to meet the requirements of the ore being processed, but most use sulphuric acid. Choice of oxidant is also based on availability or economics, but usually manganese dioxide or sodium chlorate is used. Elevated temperatures and long residence times (up to 48 hours) may be necessary to obtain good leach extractions. Leaching reagents contribute heavily to the operating costs of a uranium mill; therefore close process control is exercised to increase leach contact thereby controlling reagent use and tails.

- Ore Processing - In-situ leaching

In this commonly used operation, a suitable leach solution (lixiviant), which usually contains oxygen, hydrogen peroxide or carbon dioxide, is injected into the ore zone below the water table. The leach solution migrates through the sandstone, comes into contact with the uranium minerals, oxidizes them, so they are readily complexed by the bicarbonate, or carbonate solutions. The uranium is mobilized as a soluble complex and pumped to the surface where it is typically recovered by ion-exchange.

- Yellowcake Recovery

Solid-Liquid Separation

After leaching, the extraction processes separate the leached solids from the uranium-bearing solution. The solids are washed to minimize the amount of dissolved uranium, using thickeners, drum filters, disc filters, horizontal belt filters, cyclones, rake classifiers, or spiral classifiers. The resulting uranium bearing solution is ready for concentration and purification to yield the final high-grade uranium product.

Concentration and Purification - Ion Exchange

This process is used to recover and concentrate uranium from both pulps and clarified solutions in either the acid or alkaline circuit. Strong and intermediate base anion resins are utilized which preferentially adsorb the uranium anion complexes present in the solution and also which exclude metallic cations, resulting in a high degree of purification. The resins are loaded from either a sulphuric or a carbonate leach feed solution and then stripped by eluting with a chloride, nitrate, or bicarbonate solution. The uranium contained in the resulting eluate is then precipitated and dried. There are three main types of ion-exchange processes:

Fixed bed: This type consists of stationary columns packed with resin and requires a clarified feed solution because the solids are filtered out by the bed. The leach solution is fed to the columns and the uranium is adsorbed on the resin. The resin is washed and the uranium extracted.

Moving bed: This exchange operation has multiple designs, all of which are based upon the concept of stationary columns with the resin being transferred to separate columns for the loading, washing, and eluting operations. The main advantage of this operation is that the required resin inventory is considerably less than that required for a fixed bed.

Screen Mix Resin-In-Pulp: This type uses a series of tanks for resin adsorption, washing, and uranium extraction. The resin and solution flow counter currently in the tanks and are separated by screens, with forced air agitation.

Solvent extraction

This conventional technique is widely used for recovering and concentrating dissolved uranium from clarified acid solutions. The uranium in the clarified feed solution is extracted into the organic phase and stripped into an aqueous phase. The extraction and purification from one aqueous solution to another involves the use of reagents. The solvent extraction circuit consists of a series of extraction tanks with the feed and solvent solutions flowing counter currently. Modifiers are added to the solvents to increase the solubility of the extracted species and to inhibit the formation of stable emulsions. Next the organic solution is mixed with ammonium sulphate, chloride, or sodium carbonate solutions to strip the uranium into an aqueous phase ready for precipitation.

Combined Ion Exchange and Solvent Extraction

In this process, the uranium is adsorbed on the ion exchange resins, the resins are eluted with a sodium chloride brine wash, and the resulting eluate fed to a solvent extraction process. The advantages of this process are a purer end product, elimination of the need for nitrate and chloride reagents, and reduced operating costs.

Uranium Precipitation and Drying

Following extraction, the pregnant aqueous solution produced by the ion exchange process passes to the precipitation process area. In some instances, the concentration of contaminants is too high to permit precipitation of sufficiently pure uranium. Therefore, intermediate impurity removal using lime and/or magnesia is performed. The uranium is precipitated from solution using a wide variety of precipitants such as ammonia, magnesia, caustic soda, or hydrogen peroxide. The precipitated uranium is dewatered in thickeners and then filters and washed in a drum, plate, or frame filters. The ease of dewatering depends upon the size and shape of the precipitate crystals. The resulting filter cake still contains considerable moisture and is dried in a continuous steam-heated dryer at very high temperatures.

The dried U_3O_8 product (yellowcake) is remotely packaged and sealed in steel drums. Dust emission during product drying and packaging can be controlled by a dust separation system before discharge to the atmosphere by a vent.