Communication About Environmental Cleanup

The Unacknowledged Transfer of Risk

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Abstract. Government Agencies of the United States are currently involved in large land remedial actions to remove radioactive material from the environment. For reasons not entirely clear, the public perceives risk from radiation exposure to be much greater than the evidence would suggest (Boice Jr. 1996). As a result of this risk perception and ongoing debate surrounding environmental contamination, cleanup criteria in the United States have been set very conservatively. Internationally, the guiding principle is that any remedial action should "do more good than harm". (International Commission on Radiological Protection 1990) This author is concerned that not enough consideration is given to the routine physical risk taken by construction workers to accomplish these cleanups. For the most part, remedial actions take place on land that is not currently occupied by residents and in many cases most likely won't be for the indeterminable future. By using very conservative soil cleanup criteria, large quantities of soil and debris are subject to construction activities resulting in increased worker injuries and fatalities. This paper examines two historical case studies and discusses the actual physical injuries and fatalities, which occurred, and contrasts them with the post-cleanup risks to hypothetical people from potential exposure to residual radionuclides.

Abbreviations: **ACS:** American Cancer Society; **AEC:** U.S. Atomic Energy Commission; **BLS:** U.S. Bureau of Labour Statistics; **CAIRS:** Computerised Accident/Incident Reporting System; **CRE:** Center for Risk Excellence; **DOE:** U.S. Department of Energy; **EIS:** Environmental Impact Statement; **EPA:** U.S. Environmental Protection Agency; **FRC:** U.S. Federal Radiation Council; **HB:** Handbook; **HPS:** Health Physics Society; **IAEA:** International Atomic Energy Agency; **ICRP:** International Commission on Radiological Protection; **LWC:** lost workday case; **MEI:** maximum exposed individual; **NBS:** National Bureau of Standards; **NCRP:** National Council on Radiological Protection; **NRC:** U.S. Nuclear Regulatory Commission; **NSC:** National Safety Council; **OSWER:** Office of Solid Waste and Emergency Response; **TRC:** total recordable cases; **UMTRA:** Uranium Mill Tailings Remedial Action Project

Keywords: Annual risk; case studies; clean up; construction workers; Enewetak Atoll; environmental contamination; fatalities; injuries; lifetime risk; observed worker risk; Plutonium; probability; radioactive material; remedial action; risk standards; risk; routine risk; Uranium Mill Tailings Remedial Action Project

1 Introduction

The history of radiation protection standards for workers and members of the general public has been one of a continued downward spiral to lower and lower limits (**Tables 1** and **3**). This has been the trend even though the scientific evidence for doing so has been less than compelling. Recently, a significant meeting sponsored by the Council of Scientific Society Presidents, with many other co-sponsors, gathered noted authorities at Racine, WI (Wingspread Conference 1997). One of the significant conclusions of this conference was that "A substantial body of scientific evidence demonstrates statistically significant increases in cancer incidence for acute whole-body exposures of adults to ionizing radiation at doses of about 10 rem and greater." This implies that a substantial body of scientific evidence for cancer incidence DOESN'T exist for acute exposures below 10 rem. The current U.S. Environmental Protection Agency's (EPA) objective for acceptable risk of latent cancer induction is 15 mrem per year (Environmental Protection Agency 1997). This equates to an increased lifetime risk of approximately 3.0 E-4 (Environmental Protection Agency 1997) or an annual risk of 4.3 E-6. In their attempts to achieve these levels, regulators and managers to date have given little

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consideration from a risk management standpoint to the impact these ultra conservative standards may have on workers. The risk of detriment when exposed to radiation at 15 mrem/y is extremely low when compared to everyday risks generally accepted by the public. For example, the American Cancer Society has published that cancer, the second leading cause of death in the United States, exceeded only by heart disease, accounts for 1 of 4 deaths (American Cancer Society 1999). In 1999 about 1,221,800 new cancer cases was expected to be diagnosed. For all cancer sites, US males have a probability of 50% or 1 in 2 of developing invasive cancer from birth to death, females 1 in 3 (American Cancer Society 1999). Another commonly accepted risk is driving. The average US driver travels 14,000 miles per year with a 1 in 13 chance of having a automobile crash with damages, 1 in 119 of a crash with disabling injures and about 1 in 5000 for a fatality per year (National Safety Council 1998).

Table 1: Brief history of external whole body exposure guides for a member of the public

Year	Exposure guide	Reference
1951 [a]	3.0 R/10 weeks	AEC (Buster Jangle Nuclear Weapons test series)
1953	0.03 rem/wk	NCRP (NBS/HB-52) [b]
1955	3.9 R/y	AEC (Teapot test series)
1957	0.5 rem/y	NCRP (NBS/HB-59)
1958	5.0 rem/30 y	ICRP Pub. No. 1
1959	0.5 rem/y	NCRP (NBS/HB-69) ICRP Pub. No. 2
1960	0.170 rem/y (group) 0.5 rem/y (Ind.)	FRC Report No. 1
1971	0.170 rem/y (group) 0.5 rem/y (Ind.) 0.1 rem/y (student)	NCRP Report No. 39
1977	0.5 rem/y	ICRP Pub. No. 26
1987	freq. exp. 0.1 rem/y infreq. exp. 0.5 rem/y remedial action when freq. exp. >0.5 rem	NCRP Report No. 91
1991	0.1 rem/y (Ind.)	ICRP Pub. No. 60
1993	0.1 rem/y	NCRP Report No. 116
1997	0.015 rem/y (Ind.)	USEPA/OSWER No. 9200 (cleanup criteria)

[a] Earliest published criteria for the public that could be found.

[b] The NCRP reports succeeded the US NBS Handbooks.

During site cleanup, large source terms are fairly easily and rapidly removed from facilities and land. What remains is the much longer and labor-intensive process of demolition, excavation, packaging and transportation of the large volumes of low level contaminated soil and debris. The process of removing and disposing of these remaining hazards is the major source of increased risk to workers. In most cases, the increased risk for death to remediation workers vastly exceeds the benefit gained in risk reduction by the general public. In addition, worker deaths happen to real people, while the benefit of site cleanup is typically calculated by considering hypothetical populations assumed to live under site conditions that do not currently exist. For example, the majority of U.S. Department of Energy (DOE) facilities are located in isolated areas and are currently unoccupied by residents. This unoccupied land gives planners, managers, regulators, and stakeholders a choice concerning future land use. If highly conservative cleanup standards are invoked across the board without evaluating the risk/cost benefit, what can develop is the unnecessary expansion of volumes of material and soil to be remediated with an accompanying increase in worker injuries and fatalities. The case studies that follow illustrate this point.

The 64-year history of construction worker fatalities compiled by the National Safety Council (National Safety Council 1998) shows a steady decrease in fatality rates from 1933 (37-fatalities/100,000 workers) to 1991 (8 fatalities/100,000 workers). Because of changes in the method of compiling total workers, rates before 1991 cannot be directly compared with 1992 and those years after. However since 1992 the fatality rate for all workers has changed very little. This same plateau is observed for the Construction Division and for the period 1992 to 1998 (National Safety Council 1999) deaths per 100,000 workers varied less than 5% (the 7 year average was 14.0 deaths per 100,000 construction workers). While construction is not the most hazardous occupation (it is ranked 5th among occupations, with fishers, and loggers ranked 1st and 2nd), the point to be made is that whenever construction work is involved in the remediation of a hazardous waste site, there will be worker injuries and fatalities. It is important that remediation activities be seriously questioned under conditions where the human cost in worker injuries and deaths vastly exceeds the risk reduction gained by the general public.

2 Enewetak Cleanup Case Study

The Enewetak Atoll was used by the U.S. for nuclear weapons testing during the 40s and 50s. When the native population was removed for the testing the U.S. Government promised them that they would be able to return and resume Atoll habitation. To facilitate that return a 'radiological cleanup' took place during 1977-1980. In preparation for the cleanup radiological surveys were completed, and an Environmental Impact Statement (EIS) was prepared. The EIS compared the risk on returning inhabitants of a NO cleanup case with various other lifestyle and cleanup cases. The Enewetak EIS estimated 3 latent health effects or less in a population of 1000 individuals over 30 years, i.e., cancer deaths for the NO cleanup case (Defense Nuclear Agency 1975). These calculated latent health effects were from exposure to environmental ^{90}Sr, ^{137}Cs, and ^{239}Pu contamination. Specifically less than 1 latent cancer death was calculated from the inhalation of the Plutonium. The resulting cleanup, which primarily focused on the cleanup of Plutonium, had little if any impact (e.g., still < 1 latent cancer fatality) on further reducing the estimated latent lung cancer deaths due to Plutonium, as estimated from post cleanup dose assessments (Robison et al. 1986). No estimates were made in the EIS of the risk to those who would perform the actual cleanup work.

The cleanup standard that drove the construction effort to remove the contaminated soil and debris was 1 mrad/y to the lung (Friesen 1982). This translated to 1.4 E-4 lifetime risk, or 2.0 E-6 annual risk of premature cancer deaths. During the course of the cleanup project 6 fatalities occurred to workers, and 63 lost time accidents were recorded (Defense Nuclear Agency 1981) (**Table 2**). Today, 20 years later the islands that were remediated are still not inhabited and the dose from Plutonium and the resultant risk remains very small (Robison et al. 1998).

3 Uranium Mill Tailings Remedial Action Project (UMTRA) Case Study

The United States Congress enacted the Uranium Mill Tailings Radiation Control Act in 1978, which authorized the remedial action at 22 inactive uranium mill sites and vicinity properties. The US DOE has now completed this project at a cost of $1.45 billion (Miller et al. 1999).

The Law authorized the Administrator of the EPA to issue, and to periodically revise, generally applicable standards and criteria for the protection of the environment from radiological and nonradiological environmental hazards located at inactive tailings sites. These standards have subsequently been codified in 40 CFR 192.12. These standards set a hallmark for conservatism. For Ra-226 in soil a limit of 5 pCi/g averaged over the first 15 cm below the ground surface was required. Below 15 cm the limit is 15 pCi/g averaged over any 15 cm thick layer. For indoor radon the objective was set at 0.02 working levels (WL) including background in any occupied or habitable building. The indoor gamma radiation level was set at 20 µR/h above background in any occupied or habitable building (Miller et al. 1999).

Typically for vicinity properties the total gamma exposure reading was 15-17 µR/h and the typical gamma background ~ 12 µR/h. The average reduction of gamma exposure was 3.3 µR/h. The typical radon progeny total reading was 0.1 WL with a typical reduction of 0.086 WL accomplished. M.E. Miller et al., using these average reductions calculated the cost per death prevented for 20 sites and vicinity properties. They range from 0.24 million per death prevented in Salt Lake City, UT, most cost effective to 18 billion per death prevented, at Slick Rock, Colorado, the most costly. These imaginary deaths were estimated by taking the total excess health effects estimated from continued exposure under conditions of no remedial action occurring over 100 years minus the total health effects estimated during and after the proposed remedial action for 100 years, resulting in the net number of radiological health effects prevented by the remedial action. The authors acknowledge that the Health Physics Society recommends that health risks not be calculated for dose equivalents of less than 5 rem/y in excess of background. However, to illustrate the cost effectiveness (or lack thereof) of UMTRA the authors followed the U.S. federal agency practice of calculating risks due to annual dose equivalents much lower than 5 rem.

In examining the worker-related risk the authors noted that for 5 of the sites the predicted nonradiological fatalities exceeded that of the predicted radiological cancer deaths. From U.S. Department of Energy – Computerized Accident/Incident Reporting System (CAIRS) data it was determined that 144 lost time accidents and 1 fatality occurred (U.S. Department of Energy 1999). From discussion with project participants it was learned that because one worker was killed in a commercial plane crash, even though on duty, his death does not appear in the CAIRS statistics (Cornish 1999). Thus 2 worker fatalities occurred. While, anecdotal evidence suggests that others were killed while involved in transportation activities, including two non-project civilians, until confirmed they have not been included in the calculations in **Table 2**.

4 Discussion

Table 2 compares the observed worker risk of the Enewetak and UMTRA case studies with those obtained from the National Safety Council (National Safety Council 1998) for all industry and the construction industry. It also includes a comparison for a DOE wide, 15-year average (U.S. Department of Energy 1999), related worker injury and fatality experience. The data presented for the case studies is for the total project period, which is the only data set available. The two projects ran about 3 and 20 years respectively. The

Table 2: Observed worker risk

Case study	Total workers	Total injuries and illnesses	Total fatal injuries	Rate		Risk	
				Injuries per 10^5 workers	Fatal injuries per 10^5 workers	Worker injury	Worker death
ENEWETAK 1)	8,033	63 LWC	6	784 LWC	75	$7.8\ 10^{-3}$	$7.5\ 10^{-4}$
UMTRA 2)	13,880	378 TRC 144 LWC	2	2,723 TRC 1,037 LWC	14.4	$2.7\ 10^{-2}$ TRC $1.0\ 10^{-2}$ LWC	$1.4\ 10^{-4}$
NSC/BLS All Industry 3) (1997)	$1.3081\ 10^{8}$	$3.8\ 10^{6}$	5,100	2,905	3.9	$2.9\ 10^{-2}$	$3.9\ 10^{-5}$
NSC/BLS Construction 3) (1997)	$7.844\ 10^{6}$	$3.9\ 10^{5}$	1,060	4,970	13.5	$4.9\ 10^{-2}$	$1.35\ 10^{-4}$
DOE wide 2) 1984-1998	$2.36\ 10^{6}$	74,363 TRC 36,026 LWC	66	3,150 TRC 1,526 LWC	2.8	$3.1\ 10^{-2}$ TRC $1.5\ 10^{-2}$ LWC	$2.8\ 10^{-5}$

1) The Radiological Cleanup of Enewetak Atoll, Defense Nuclear Agency, August 1980.
2) Department of Energy, Computerized Accident/Incident Reporting System, 1999.
3) National Safety Council, Accident Facts, 1998.

data is expressed in the standard injury or fatality rate per 100,000 workers, which makes the comparison independent of time. The risk is an expression of the probability of the individual of experiencing one of the two endpoints. The statistics in this table show the significant worker fatality and injury experience that construction workers have compared to all industry. Additionally it illustrates that remedial action projects carry with them risks to workers that are real and comparable to or greater than national construction injury and fatality risks. It should be remembered that these data are not mere fabricated or imaginary statistics where models are used, assuming the maximum exposed individual (MEI), assumed population numbers projected over long time periods, and maximum or most conservative lifestyle parameters: These data reflect actual injuries and fatalities.

utility and that it was highly unlikely that many people would be exposed if no action were taken. The 5 UMTRA sites where the predicted non-radiological risks were greater than the predicted radiological risk especially exemplify this. This is an example of what can happen when standards and criteria are legislated and or one size fits all.

Land use can be chosen such that the risk to future users will be the same as those who will be engaged to perform the remedial action. For example when a freeway is built the risk to workers as seen in Table 2 is a fourth order risk for fatalities and a second order risk for injuries. Those of us who use the freeway do it subjecting ourselves to about the same level of risk, (**Table 3**), (i.e., a second order risk for a crash with disabling injury and a fourth order risk for a crash with a fatality) as those who built it.

Table 3: Comparable dose and risk standards

Individual Dose (mrem/y)	Risk Level* (fatalities/y)	Radiation Standard and Observed Experience
1	5.00E-07	IAEA Exemption Level (IAEA Safety Series No. 89)
4		EPA Drinking Water Limit (40 CFR 141)
10	5.00E-06	ENEWETAK Pu Soil Cleanup Dose Standard; EPA NESHAPS Air Dose Limit (40 CFR 61, Subpart I) ~ UMTRA Dose Limit
15	4.30E-06	Proposed EPA Soil Cleanup Limit (Source EPA OSWER No. 9200.4-18, 22 Aug., 1997)
25		NRC D&D Limit; Health Physics Society Screening Level
100	5.00E-05	Public Dose Limit _ ICRP, NCRP, HPS, IAEA, NRC (10 CFR 20 [6]); DOE (5400.5)
300		Average U.S. Background Radiation Level (NCRP Report No. 94)
	2.00E-04	Probability of being involved in a automobile crash with a fatality per year; construction worker annual fatality rate Source NSC
1000	5.00E-04	IAEA Proposed Intervention Level _ optional but rare
2000		Worker Dose Limit DOE (Administrative Level, RADCON Manual)
5000		Worker Dose Limit NRC (10 CFR 20), DOE (Order 5480.11)
10000	5.00E-03	IAEA Proposed Intervention Level _ Almost Always Justified; Level of which scientific evidence demonstrates statistically significant increase in cancer incidence, 10 rem and greater (source Wingspread Conf.); Annual probability of developing invasive cancer- Men 0.007; Women 0.005 Source ACS
	5.00E-02	Construction worker annual injury rate Probability of being involved in a automobile crash with disabling injuries (~ 0.01) per year Source NSC
	0.5	Probability of men developing invasive cancer from birth to death (Women-0.3) Source ACS

* Fatalities for radiation risk are projected for cancer; fatalities for construction workers are from fatal injuries!

A counter argument is that these workers would be exposed to construction risk anyway (voluntary risk), so the risk to the worker is the same. Additionally, the argument has been made that workers are being paid (their salaries) to assume that risk. These arguments are nonsense, because workers are paid to do work not to take risks. Typically when industry engages construction workers it is to build something that yields benefit to society, such as a building, bridge or freeway. However, when uninhabited land is being considered for remediation there is a choice (voluntary risk) of how the land will be used. As in the case of the remote sites cleaned up during the UMTRA project, workers were put at risk with decision-makers knowing that the land had little

5 Conclusions

Table 3 compares some national and international radiation risk and dose standards as well as the risks discussed in this paper. It is noteworthy that the benefit gained in reduction of hypothetical deaths by the general public is 2 to 3 orders of magnitude smaller than the physical risks imposed on workers asked to perform the remediation. It also shows a disparity with risks the United States public accepts on an annual basis. It is the thesis of this author that standards should be set more in line with accepted public and worker risk. Additionally it shows how much the United States is out of step with the radiation dose level the International Commission on Radiological Protection (ICRP) (International Commission on Radiological Protection 1990) and the International Atomic Energy Agency (IAEA) (International Atomic Energy Agency 1999) are proposing for intervention levels when considering the statement made by the conferees at the Wingspread Conference.

These two international groups argue that radiological rehabilitation SHOULD DO MORE GOOD THAN HARM. It is the opinion of this author that this philosophy should be of paramount concern when we in the United States plan and execute a remedial action. This is particularly true when we have choices concerning land use, and especially so when the land being rehabilitated is and has been uninhabited for a long time and is unlikely to be inhabited after the remediation.

Acknowledgements. The author wishes to express his thanks for the sponsorship of this work by the Center for Risk Excellence (CRE), US Dept. of Energy, Chicago Operations Office. Additionally thanks and gratitude expressed to Seth D. Guikema, CRE 1999 Summer Intern, for UMTRA contractor accident data research using the CAIRS database. To Robert E. Cornish, DOE Albuquerque Operations Office for assistance in identifying the UMTRA contractors and subcontractors and for encouragement in writing this paper. To David Charelton, M. K. Ferguson for assistance in identifying the contractors and subs, and bringing to the author's attention the aircraft fatality. To William Bunn, DOE, Nevada Operations Office who assisted in expediting the understanding and utility of the DOE/CAIRS database.

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