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# Physical and Managed Risk of Nuclear Waste\*

Lennart Sjöberg & Britt-Marie Drottz-Sjöberg\*\*

## Introduction

Risks are usually implicitly construed as the net outcome of physical and social processes. For example, the risk associated with nuclear waste is the outcome of physical processes in the radioactive waste material and all the measures taken to protect the environment from the emitted radiation. Hence, both physical and social aspects enter the picture, and the final overall risk assessment must be taken into account. How risk judgments may differ with respect to physical and social dimensions of the issue, however, is seldom discussed.

Trust in those responsible for managing a risk is often an important factor in risk perception.<sup>1</sup> It is reasonable to believe that trust is primarily important with respect to social risk dimensions. Yet, it may also enter into the assessment of physical dimensions, since belief in the accuracy of risk estimates has an element of trust in expert credibility.

Nuclear waste disposal is highly controversial in most countries, including Sweden. Earlier statements to the effect that the issue has been “solved” in Sweden<sup>2</sup> were based on single-question polling data, in which 58% of the public sampled said they “accepted” a local repository of high level nuclear waste. Several other studies,<sup>3</sup> sampling

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<sup>1</sup> Lennart Sjöberg, *Perceived Competence and Motivation in Industry and Government as Factors in Risk Perception*, presented Bellingham Int'l Conf., Social Trust in Risk Management, Western University of Washington, July 1996.

<sup>2</sup> James Flynn et al, *Time to Rethink Nuclear Waste Storage*, 8 Issues Sci. & Tech. 42 (1992); James Flynn et al., *One Hundred Centuries of Solitude: Redirecting America's High-Level Nuclear Waste Policy* (1995).

<sup>3</sup> Lennart Sjöberg & Britt-Marie Drottz-Sjöberg, *Risk Perception of Nuclear Waste: Experts and the Public* (CRR 1994).

broader populations and allowing for anonymous responses, however gave much lower percentages of "acceptance."

In addition, the first local referendum on nuclear waste disposal in Sweden, in September 1995, resulted in a large majority rejecting further surveying for a local repository site. It was conducted in Storuman, a sparsely populated northern community of about 7,000. A brief discussion of the referendum, the most recent major political event concerning nuclear waste in Sweden, is therefore warranted.

In October 1992, the Swedish Nuclear Fuel and Waste Management Company (SKB) informed all Swedish communities of the development of a program for the disposal of high level radioactive materials. Storuman was one of the few communities to respond to SKB's proposal for a preliminary study to determine the feasibility of locating a repository in the area.

An invitation to SKB to conduct a preliminary study quickly resulted in opposition and the formation of a "no to nuclear waste in Storuman" group. People in favor of inviting SKB or who believed that the idea at least should be investigated responded by forming another group. The pro-invitation group focused on the economic possibilities of community development and particularly organized local business interests. The local government continuously kept the public informed about developments by organizing a "reference group," and inviting local political parties as well as all active interest groups. In early 1995, it decided to hold a local referendum the following September. The question presented was whether SKB should be allowed to continue the search for a final repository location in Storuman. The outcome was an overwhelming "no" (70.5%).

Following the referendum, Drottz-Sjöberg conducted in-depth interviews with both proponents and opponents.<sup>4</sup> She found that trust in the risk management process was not the most crucial issue. Rather, a host of social, health related, economic and political issues that had arisen from intense discussions in the community over a period of several years prior to the referendum, were found more important. The main results of the interviews were summarized in several value dimensions, including a main dimension of individualism (personal

<sup>4</sup> Britt-Marie Drottz-Sjöberg, *Stämningar i Storuman efter folkomröstningen om ett djupförvar* (SKB 1996).

success) vs. collectivism (solidarity). Further, repository opponents often relied on values or explanations emphasizing tradition, small-scale establishments, personal control, the need for high level security, risk for future generations, and the importance of preserving nature and keeping the wilderness intact.

In contrast, those in favor of permitting SKB to continue its search in the area emphasized the importance of increased investment and its spin-off effects, the need to sustain current and future employment levels, possible influence on local development, and the need for economic and social change.

The conclusions drawn from the overall referendum process in Storuman agreed with the different attitudes revealed, e.g., optimism demonstrated by the display of strong public involvement by repository opponents to the prospecting, and pessimism regarding future development among proponents. The entire process was democratic, shifting from representative principles to direct public participation.

The nuclear waste issue had already become very important in Swedish politics fifteen to twenty years ago. Despite agreement among Swedish experts that the issue has been resolved, the public has not yet accepted the premise that a safe method for storing nuclear waste exists.<sup>5</sup> Differences between expert and public perceptions of nuclear waste risk are tremendous. Current tensions are well documented in a symposium report dealing with the role of environmental impact assessment in connection with final waste disposal.<sup>6</sup>

Sweden, however, has had some success in dealing with low and medium level nuclear waste. Comparatively speaking, there may be less intense social and political conflicts over nuclear waste in Sweden than many other countries. Confidence in government authorities and experts may be at a higher level.

Previous work on the perceived risk of nuclear waste has involved extensive mapping of the risk perception of the public, nuclear and environmental experts, and local politicians specializing in environmental matters.<sup>7</sup> In this paper, we further develop the

<sup>5</sup> Sjöberg & Drottz-Sjöberg, *supra* note 3.

<sup>6</sup> Swedish National Council for Nuclear Waste, KASAM, Nuclear Waste and the Environment (1995).

<sup>7</sup> Lennart Sjöberg & Britt-Marie Drottz-Sjöberg, Attitudes toward Nuclear Waste

distinction between the perceived physical and managed risks of nuclear waste. Physical risk is construed as the time during which nuclear waste is perceived as dangerous, whereas managed risk is measured by a judgment of how deep such waste must be buried in bedrock. Three levels of waste are studied and comparisons between the perceptions of the public, politicians and nuclear experts are made.

It was originally hypothesized that the public would demand a deeper repository than either the experts or politicians. The latter two groups are assumed to be more trustful of the risk management process. No hypothesis was formulated about beliefs concerning the physical risk, which is reflected in time ratings.

### Method

We report results from five data sets. The numbers of respondents and response rates are given in Table 1.

Table 1  
Characteristics of Used Data Sets

<i>Set</i>	<i>No. of respondents</i>	<i>Response rate (%)</i>
Public, 1987	590	48
Public, 1992–93	1179	65
Public, 1995	541	53
Experts, 1992–93	138	69
Politicians, 1995	330	63

The questionnaires asked for the judgment of the time during which the waste remains dangerous, and the desired depth of a bedrock repository. These judgments were to be made for three levels of waste: low; medium; and high.

The three levels were explained in the questionnaires as follows:

Radioactive waste from nuclear power plants can, from the standpoint of handling, be categorized in three main groups: (a) low level waste, e.g., protective clothing; (b) middle level waste, e.g., filter material and certain demolition material, and (c) high level waste, consisting mostly of used nuclear fuel.

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(CRR 1993); Lennart Sjöberg & Britt-Marie Drottz-Sjöberg, *supra* note 2 and Lennart Sjöberg, Risk Perceptions by Politicians and the Public (CRR 1996).

Respondents were asked to rate the time in years during which they believed that the three levels of waste could possibly injure people and, given that storing in bedrock was the method used, at what depth (in meters) would storage be appropriate.

### Results

All analyses reported below were performed on log ratings of time and depth. As a preliminary analysis, time and depth ratings were correlated with each other, and the correlations were factor analyzed. Two factors accounted for 83% of the total variance. The rotated factor loadings (varimax) are shown below. As seen, depth and time ratings were clearly distinguished, with only a slight overlap.

Table 2  
Factor Loadings for Time and Depth Ratings.

	<i>Factor 1</i>	<i>Factor 2</i>
Time, low level	0.26	0.82
Time, medium level	0.17	0.95
Time, high level	-0.02	0.84
Depth, low level	0.91	0.16
Depth, medium level	0.97	0.14
Depth, high level	0.87	0.08

Table 3<sup>8</sup>  
Correlations Between Log Ratings of Time and Depth, A Pooled Index of Perceived Nuclear Waste Risk and an Index of Trust in Nuclear Waste Experts

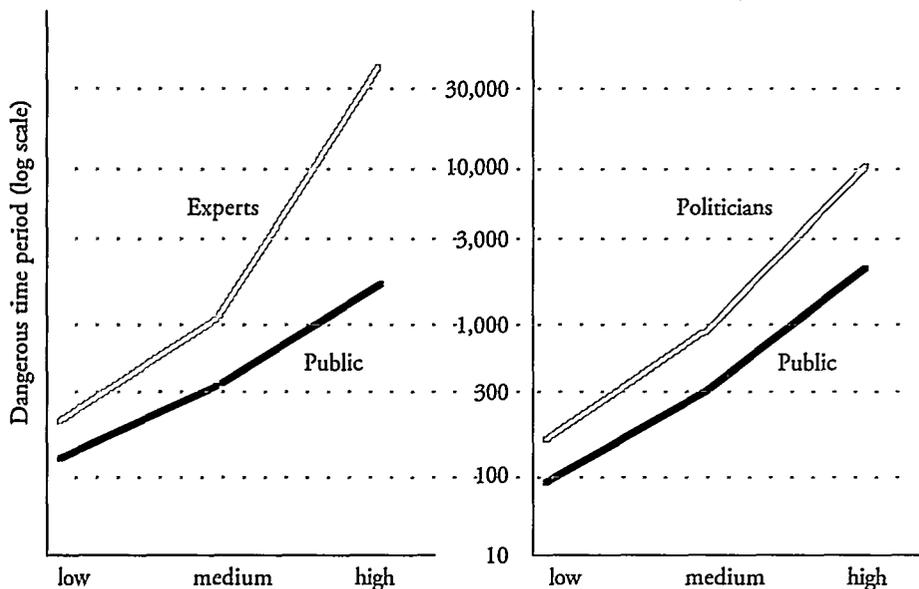
	<i>Nuclear waste risk</i>	<i>Trust in management experts</i>
Time, low level	0.094*	-0.092*
Time, medium level	0.022	-0.095*
Time, high level	-0.073	-0.042
Depth, low level	0.201***	-0.136**
Depth, medium level	0.206***	-0.146**
Depth, high level	0.186***	-0.162***

In data obtained from politicians and the public, a pooled index of perceived nuclear waste risk was correlated with time and depth ratings. As expected, the strongest correlation was observed between the overall

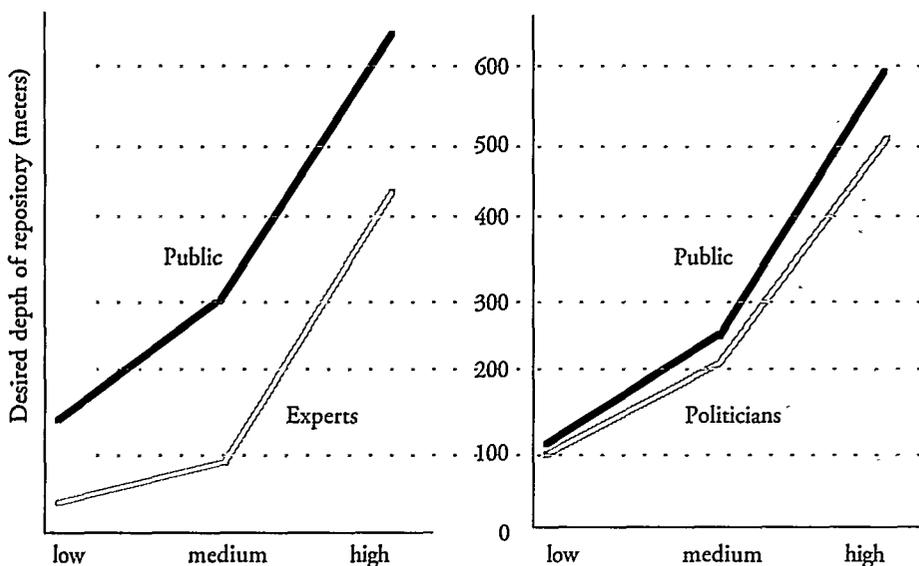
<sup>8</sup> \*\*\* p<0.001, \*\* p<0.01, \* p<0.05

perceived risk of nuclear waste and depth ratings. In contrast, perceived risk correlated poorly with time ratings.

Perceived Dangerous Time Period



Desired Depth of a Repository in Bedrock



A pooled index of trust in waste risk management was correlated with time and depth ratings, as shown in Table 3. It is clear from these

results that the depth ratings were most consistently related to trust, whereas time ratings were virtually independent of trust.

Because of the skewed distributions, geometric means were computed for all three levels of waste. See the figures above.

It is seen that:

- Compared to the public, experts gave longer time estimates, especially regarding high level waste, and estimated a lesser desired repository depth.
- Although the differences between politicians and the public were smaller, the same trend in disagreement as that seen between experts and the public was observed.

Some differences were very striking. Note, for example, that experts estimated high level waste to be dangerous for about 20,000 years whereas estimates given by the public and politicians were only 2,000 and 500 years, respectively. Differences among the estimates given by the different groups were much smaller for the depth required for a repository. Due to the large sample sizes, all of the measured group differences were statistically significant. It is also noteworthy that there was closer agreement between the public and politicians than between the public and experts.

### Discussion

Time and depth ratings differed when it came to their relationships with other variables. Time and depth ratings correlated weakly, and time ratings were virtually independent of the trust and general hazard ratings for nuclear waste. These findings support the suggestion that time ratings reflect perceptions about physical rather than managed risk, and that managed risk has broader implications and relationships to other types of data than physical risk. Further study of the concepts of physical and inherent risk is called for.

Both experts and politicians gave less extreme ratings of depth than the public, indicating more trust in the risk management process. Yet they exhibited more knowledge of associated physical dangers — especially those of high level waste — and gave more extreme time ratings than members of the public. It should be noted that the politicians were closer to the public than they were to the experts.

It is noted that the more dangerous waste should be placed at a greater depth, although a small minority believed that high level waste

should be stored closer to the surface,<sup>9</sup> presumably to allow more effective monitoring and control.

Other data have shown that experts in particular were much more likely to trust the risk management of nuclear waste.<sup>10</sup> Politicians, on the other hand, responded more like the public, although not quite as distrustful.<sup>11</sup> The results of the present study are quite consistent with these general trends.

The present Swedish plans call for burial of high level nuclear waste in bedrock at a depth of about 500 meters. The fact that people require a greater depth, despite being unaware of the very long time ranges involved, is an interesting observation. It is possible that times beyond several hundred years are discounted by a majority of the public, despite the existence of groups having a significantly different set of beliefs and values.<sup>12</sup> Aspects other than the long term perspective, as illustrated by the previously discussed Storuman referendum, can therefore account for opposition to a nuclear waste repository.




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<sup>9</sup> Sjöberg & Drottz-Sjöberg, *supra* note 8.

<sup>10</sup> Sjöberg & Drottz-Sjöberg, *supra* note 3.

<sup>11</sup> Sjöberg, *supra* note 8.

<sup>12</sup> Ola Svenson & Gunnar Karlsson, *Decision-Making, Time Horizons, and Risk in the Very Long-Term Perspective*, 9 *Risk Anal.* 385 (1989).