Chapter 1

Why are we Here ?

The Executive Director of the Environment Protection Agency also holds the position of Supervising Scientist, a position which was originally established in 1978 to supervise, coordinate and undertake research related to the protection of the environment from the effects of uranium mining operations. The Executive Director has identified items of risk that are of current concern to environmental protection. These are:

1. **Risk from individual chemicals and risk from contaminated sites**

   The issue here is whether quantitative risk methods or qualitative risk methods are most appropriate to assess the risk of new, and sometimes of old, chemicals in Australia.

   There are two issues related to contaminated sites. The first is the component of risk and consequence associated with determining priorities for clean-up, containment or do-nothing approaches for that contamination. There is also a major risk component in determining the degree of clean-up and the level of clean-up that is satisfactory. Risk in this sense is risk of physical or biological contamination, but is equally risk in terms of financial liability for acceptability of any of the above alternatives.

2. **Risk to people from development**

   The possible occurrence of a large industrial accident such as Bhopal in India, the LPG explosion in Mexico City, Seveso in Italy, Chernobyl in the Ukraine and Piper Alfa in the North Sea needs to be considered as part of an assessment of risk related developments. It is now accepted that quantitative risk assessment is a proper part of such an assessment. A Commonwealth position is needed in relation to quantitative risk, consequences analysis, hazard reduction and other such matters.

3. **Risk to the natural environment from development**

   It would be advantageous for the EPA and the Office of the Supervising Scientist to do a quantitative analysis of the risks of potential impacts from major development and their consequences for environmental protection. The need is for a quantitative assessment of the risks associated with activities and the consequences associated with those risks. This is to allow a consideration of hazard reduction activities, a better basis for priorities for research and a better basis for priorities for environmental management.

4. **Risks of the uncertainty of nature**

   Does Australia understand the risks of changing climate? What are the consequences of nature conservation and for production?

5. **The risk associated with political decision-making**

   The term sovereign risk is used for a part of this. The aim is to systematise, if not quantify, those factors that lead to the risk of a new project not being allowed or being severely constrained.

Approach

The approach adopted to the study of these six issues revolves around the following elements:

1. A literature review followed by extensive consultation to determine present Australian practice and international practice in the application of quantitative risk assessment.

2. The choice of appropriate case studies. Each case study deals with an apparently contentious topic and the discussion of the case study seeks to determine whether the contentious aspects of the topic could have been minimised through application of quantitative risk assessment.
3. The search for a generic framework that can be used for quantitative risk assessment in Australia.

History

Environmental risk deals with the probability of an event causing an undesirable effect. Quantitative risk assessment thus deals with statistics, because probability is the mathematical measure of risk, and with hazard assessment; which ties together the effects of a pollutant with the exposure to the pollutant. Over the past two decades, risk assessment has attained a certain maturity as an engineering discipline assisted by seminal reports from the United States National Research Council (NRC, 1983) and by the Royal Society (Warner, 1983).

The subject recently received renewed interest. The Royal Society considered it timely to update their original report (Royal Society Study Group, 1992). In the United States there has been an almost continuous process of studying and refining risk assessment. The National Research Council has produced at least three recent books dealing with various aspects of the topic (National Research Council, 1989, 1993, 1994) namely: risk communication; toxicological and ecological risk assessment; and risk assessment of hazardous air pollutants respectively.

There are certain areas in which risk assessment has long been applied by environmental protection agencies, principally, the risks to human health arising from chemicals in the environment. Examples of this are to be found in the legal limits on chemical pollutants in air and water. In the United States, the Environmental Protection Agency (US EPA) moved quickly to implement the National Research Council (1983) recommendations and in 1986 adopted a set of guidelines for carcinogen risk assessment. The agency also extended the uses of risk assessment to decisions regarding pesticide residues in food, industrial chemicals, carcinogenic contaminants of drinking water supplies and industrial emissions of carcinogens to surface waters. Particularly important was US EPA's adoption of risk assessment as a guide to decisions at hazardous waste sites.

More recently, there has been a realisation that existing tools of systems analysis can be applied to environmental problems in a manner which is being called ecological risk analysis (Suter, 1993). There has also been a realisation that risk assessment can be used to determine environmental priorities. The US EPA initiated a program, nowadays called comparative risk assessment, that compared the relative residual risks posed by a range of different environmental problems. This was done by systematically generating informed judgements from US EPA managers and technical experts. This resulted in two reports: *Unfinished Business* (US EPA, 1987) and its sequel *Reducing Risk* (US EPA, 1990); and a *Guidebook to Comparing Risks and Setting Environmental Priorities* (US EPA, 1993).

All of these documents emphasise that risk assessment is an overall process of which risk analysis is only a part. The means by which risk is managed, the means by which risk is communicated to the public and the consequences of failing to undertake adequate risk assessment, or undertaking incorrect risk assessments, need to be known and appreciated by environmental practitioners.

Setting Environmental Priorities

There has been a number of recent environmental issues in Australia that led to vigorous public debate. Toyne (1994) recounts a number of the most virulent including Coronation Hill, and the Wesley Vale pulp mill. Coleman (1994), writing from an industry perspective in a recent article, pointed out that the lack of a consistent

government environmental policy has led to community uncertainty and identified three associated risks:

- risk of permanent environmental damage if the most pressing issues are not tackled;
- business risk of industry allocating scarce funds to environmental improvements which turn out to be too far ahead of compliance; and
- risk of losing international competitiveness if Australia adopts (or fails to adopt) new environmental policies.

So, what are the most pressing issues and how can they be determined? The US EPA (1987) did this by using its managers and technical experts as risk analysts. The universe of environmental problems was divided into 31 problem areas (eg. air pollutants, hazardous waste sites, pesticide residue in food etc.) with the problem areas corresponding generally to existing US programs or statutes. Four different types of risk were considered for each problem area: cancer risk, non-cancer health risks, ecological effects and welfare effects, but the risks were treated separately and not aggregated. Economic aspects, or technical controllability of the risk, were not considered and neither were the voluntary or involuntary nature of the risk.

Harwell et al. (1992) and Morgenstern & Sessions (1988), in reviewing the project, point out that it involved more judgement and less objective analysis than was expected. They also make much of the difference between the rankings of the experts and the rankings of the public. For example, the public at the time ranked the risks from active and inactive hazardous waste sites as most serious, whereas the EPA experts ranked the risks from these sites as medium/low. At the other end of the scale, the public ranked the seriousness of indoor air pollution and global warming as relatively low, while the EPA experts ranked them as high. In a number of other areas there was agreement between public and experts.

The views of the Australian public on environmental issues have been determined by a number of different groups on a number of occasions (Lothian, 1994). The most recent of these was the 1993 survey conducted by ANOP (1993), a firm that had previously conducted a similar poll in 1991. The respondents' ranking of the priorities that they believe that the Federal Government should have are given in Table 1.1

Table 1.1 Desired Federal Government priorities for the most important environmental issues

Rank	December 1991	September 1993
1	Disposal of chemicals and industrial waste	Disposal of chemicals and industrial waste
2	Water pollution	Water pollution
3	Land degradation	Air pollution
4	Recycling	Recycling
5	Air pollution	Protection of native forests
6	Depletion of ozone layer	Depletion of ozone layer
7	Greenhouse effect	Land degradation
8	Endangered plants and animals	Endangered plants and animals
9	Energy conservation	Protection of coastlines
10	National parks and heritage areas	Greenhouse effect
11	Schemes for environmentally friendly products	Land clearance controls
12	Urban sprawl	Protection of grazing lands
13	Preservation of Antarctica	Urban sprawl

The rankings in Table 1.1 are determined on the basis of responses to pre-determined questions. When respondents were asked spontaneously to nominate the main issues

of concern in Australia, then industrial waste was ranked fifth (in 1993), being mentioned by only 12% of those surveyed.

There is little doubt that the opinions of the public should underlie the evaluation of risk. There is, however, no agreement on how to ascertain the opinions of the public in such a way that they can be used reliably as the basis for risk evaluation. Layfield (1987) (quoted in Royal Society Study Group, 1992, p. 93) states that: "As in other complex aspects of public policy where there are benefits and detriments to different groups, Parliament is best placed to represent the public's attitude to risk."

Perceived risk versus actual risk

The historical antecedents of risk assessment are in operations research. The field thus has a long history of quantifying industrial operations to determine the probability of an untoward consequence. For example, the working paper on hazard analysis and risk assessment for the Sydney Third Runway Proposal (ACARRE, 1990) cites accident rates for airline operations that were deduced from data obtained from the Bureau of Air Safety Investigation and the Civil Aviation Authority. These are given in Table 1.2

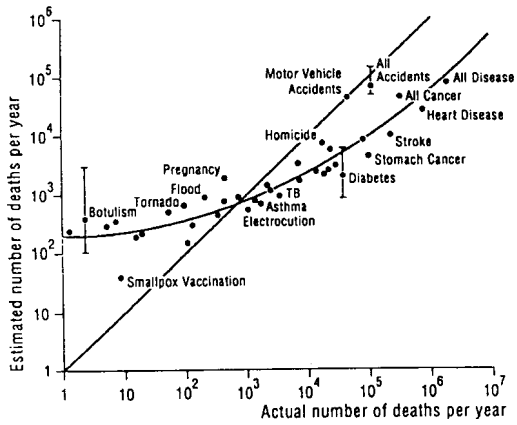
Table 1.2 Accident rates for Australian airline operations, 1978-87

	International	Domestic	Total
per 100 000 hours flown	0.230	0.188	0.198
per 100 000 landings	1.126	0.229	0.297
per 100 million km flown	0.391	0.452	0.429
per 100 million passenger km	0.0012	0.005	0.0026

Provided that information on the flying habits of people are known, then it is possible to use the data in Table 1.2 to calculate the risk of an accident to an individual. Because the calculation is based on objective data, such a risk is called the actual risk. The perceived risk, or subjective risk, is the risk estimate obtained by surveying the public either for their estimate of the hazard involved (very safe, safe, marginal, dangerous, very dangerous) or for their estimate of the number of airline accidents.

To a certain extent it is impossible to provide a truly objective measure of risk. Choosing numbers from one of the four rows of Table 1.2, rather from another row, involves a subjective decision. There is also an impression that the public does reasonably well at estimating risk. Figure 1.1 depicts the scatter plot when educated lay subjects' estimates of the annual frequency of death in the US from 40 hazards are plotted against the best available US public health statistics. Respondents tend to overestimate the deaths from infrequent causes such as botulism and tornadoes, but to underestimate the deaths from frequent causes such as cancer and diabetes.

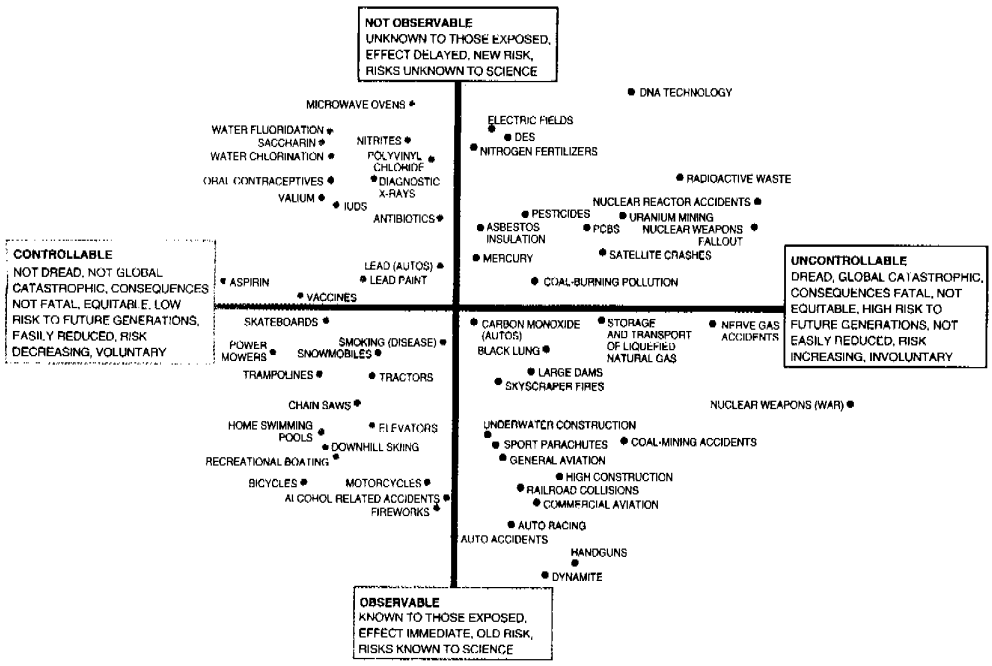
Figure 1.1 Relationship between judged frequency and statistical estimates of the number of deaths per year (US) for 40 causes of death. (From Fischhoff et al, 1981)



People do not perceive risk solely as the expected number of deaths or injuries per unit time. People also rank risks based on how well the process is understood, how equitably the danger is distributed, how well individuals can control their exposure and whether risk is voluntarily assumed. These items can be combined into three major factors. The first is an event's degree of dreadfulness, as determined by features such as the scale of its effects and the degree to which it affects innocent bystanders; the second is a measure of how well the risk is understood; and the third is the number of people exposed. (Morgan, 1993; Slovic, 1994).

The three factors can be used to define a risk space. The location of a hazard within this space indicates how people are likely to respond to it. Risks carrying a high level of dread, for example, provoke more calls for government intervention than do some more workaday risks that actually cause more deaths or injuries (Figure 1.2).

Figure 1.2 Two dimensions of a three-dimensional risk space link a hazard's controllability (dreadfulness) and observability (understanding). *(From G Morgan, July 1993).*



Risk and uncertainty in policy analysis

Subsequent parts of this document will make it clear that we envisage risk analysis as a formal set of tools that enable one to deal with uncertainty. Morgan & Henrion (1990) point out that societies have long made decisions with less than complete attention to the associated uncertainties, and then ask the rhetorical question: why does technical uncertainty in risk assessment and other forms of policy research and analysis really matter? Their answer is three-fold:

1. A central purpose of policy research and policy analysis is to help in identifying the important factors and the sources of disagreement in a problem, and to help in anticipating the otherwise unexpected. An explicit treatment of uncertainty forces careful thought, helps identify important and unimportant factors, and assists in contingency planning.

2. It is hard to make decisions when experts differ in their judgement. If one insists that the experts divulge the uncertainties of their judgement, then it is easier to determine how much they think they know and whether they really disagree.

3. Problems are rarely solved permanently. To use, or adapt, past policy analyses to help with present problems, then the task is made easier when the uncertainties of the past work have been carefully described. One can then have confidence that the earlier work is being used appropriately.

References

ACARRE (Australian Centre of Advanced Risk and Reliability Engineering Ltd.) 1990, *Hazard Analysis and Risk Assessment*, Working Paper prepared for Kinhill Engineers Pty. Ltd., Ultimo, NSW.

ANOP 1993 *Community attitudes to environmental issues*: ANOP report on 1993 national research program, Department of Environment, Sport & Territories, Canberra.

Coleman, L., 1994. The risks of uncertain environmental policy, *Clean Air (Aust.)*, **28**, 22-26.

Fischhoff, B., Lichtenstein, S., Slovic, P., Derby, S.L. & Keeney R.L. 1981 *Acceptable Risk*, Cambridge University Press, Cambridge

Harwell, M.A., Cooper, W. & Flaak, R. 1992 Prioritizing ecological and human welfare risks from environmental stresses, *Environmental Management*, **16**, 451-464.

Layfield, Sir Frank & Sizewell, B. 1987, *Public enquiry: summary of conclusions and recommendations*, HMSO, London.

Lothian, J.A. 1994 Attitudes of Australians towards the environment: 1975 to 1994, *Aust. J. Env. Management*, **1**, 78-99.

Morgan, M.G. 1993 Risk analysis and management, *Scientific American*, **269**, 32-42

Morgan, M.G. & Henrion, M. 1990 *Uncertainty: a guide to dealing with uncertainty in quantitative risk and policy analysis*, Cambridge University Press, Cambridge.

Morgenstern, R. & Sessions, S. 1988 Weighing environmental risks: EPA's Unfinished Business, *Environment*, **30**, (6), 15-39.

National Research Council 1983, *Risk assessment in the Federal Government: managing the process*, National Academy Press, Washington, DC, .

National Research Council 1989, *Improving Risk Communication*, National Academy Press, Washington, DC.

National Research Council 1993, *Issues in Risk Assessment*, National Academy Press, Washington, DC.

National Research Council 1994, *Science and Judgement in Risk Assessment*, National Academy Press, Washington, DC.

Royal Society Study Group 1992, *Risk: analysis, perception and management*, Royal Society, London.

Slovic, P. 1994 Perceptions of risk: paradox and challenge, in Brehmer, B. & Sahlin, N. (eds.) *Future risks and risk management*, 63-78, Kluwer, Dordrecht.

Suter, G.W. 1993., *Ecological Risk Assessment*, Lewis Publishers, Boca Rotan, Florida,

Toyne, P. 1994 *The Reluctant Nation: Environment, law and politics in Australia*, ABC Books, Sydney, NSW.

US EPA, Office of Policy Analysis 1987, *Unfinished Business: a comparative assessment of environmental problems*, EPA, Washington, DC.

US EPA, Science Advisory Board 1990, *Reducing Risk: setting priorities and strategies for environmental protection*, EPA, Washington, DC.

US EPA 1993, *A Guidebook to Comparing Risks and Setting Environmental Priorities*, EPA, Washington, DC.

Warner, F. 1983, *Risk assessment: report of a Royal Society Study Group*, Royal Society, London.