1-1-1998

Fear itself: Assessing the risks of transporting high-level nuclear waste

Fred Carl Dilger
University of Nevada, Las Vegas

Follow this and additional works at: https://digitalscholarship.unlv.edu/rtds

Repository Citation
https://digitalscholarship.unlv.edu/rtds/886

This Thesis is brought to you for free and open access by Digital Scholarship@UNLV. It has been accepted for inclusion in UNLV Retrospective Theses & Dissertations by an authorized administrator of Digital Scholarship@UNLV. For more information, please contact digitalscholarship@unlv.edu.
INFORMATION TO USERS

This manuscript has been reproduced from the microfilm master. UMI films the text directly from the original or copy submitted. Thus, some thesis and dissertation copies are in typewriter face, while others may be from any type of computer printer.

The quality of this reproduction is dependent upon the quality of the copy submitted. Broken or indistinct print, colored or poor quality illustrations and photographs, print bleedthrough, substandard margins, and improper alignment can adversely affect reproduction.

In the unlikely event that the author did not send UMI a complete manuscript and there are missing pages, these will be noted. Also, if unauthorized copyright material had to be removed, a note will indicate the deletion.

Oversize materials (e.g., maps, drawings, charts) are reproduced by sectioning the original, beginning at the upper left-hand corner and continuing from left to right in equal sections with small overlaps. Each original is also photographed in one exposure and is included in reduced form at the back of the book.

Photographs included in the original manuscript have been reproduced xerographically in this copy. Higher quality 6" x 9" black and white photographic prints are available for any photographs or illustrations appearing in this copy for an additional charge. Contact UMI directly to order.
FEAR ITSELF: ASSESSING THE RISKS OF TRANSPORTING

HIGH LEVEL NUCLEAR WASTE

by

Fred C. Dilger

Bachelor of Arts
Pennsylvania State University
1981

Master of Arts
University of London
1996

A thesis submitted in partial fulfillment of the requirements for the degree of

Master of Arts

in

Ethics and Policy Studies

Department of Political Science
University of Nevada, Las Vegas
August 1998
Thesis Approval
The Graduate College
University of Nevada, Las Vegas

July 7, 1998

The Thesis prepared by

Fred C. Dilger

Entitled

Fear Itself: Assessing the Risks of Transporting High Level Nuclear Waste

is approved in partial fulfillment of the requirements for the degree of

Master of Arts in Ethics and Policy Studies

Examination Committee Chair

Dean of the Graduate College

Examination Committee Member

Examination Committee Member

Graduate College Faculty Representative
ABSTRACT

Fear Itself: Assessing the Risks of Transporting High Level Nuclear Waste

by

Fred C. Dilger

Dr. Jerry Simich, Examination Committee Chair
Professor of Political Science
University of Nevada, Las Vegas

This thesis contrasts and compares two approaches to risk assessment as they apply to the problem of transporting high level radioactive waste to Yucca Mountain, NV. Risk assessment, a lineal descendant of cost-benefit analysis, is an increasingly popular tool for justifying policy or programmatic decisions that involve some potential for public harm. The study uses Frank Fischer's framework for policy analysis to examine the problem of transportation risk assessment and to propose a new process for risk assessment that has political legitimacy, rather than technical elegance, as its goal.
# TABLE OF CONTENTS

ABSTRACT ....................................................................................................................................................... iii

LIST OF FIGURES .................................................................................................................................................. vi

ACKNOWLEDGEMENTS .......................................................................................................................................... vii

CHAPTER 1 INTRODUCTION ................................................................................................................................ 1
  Background ........................................................................................................................................................... 2
  When will the waste be shipped? .......................................................................................................................... 7
  How Will the Waste get to Yucca Mountain? ..................................................................................................... 7
    Rail ................................................................................................................................................................. 8
    Highway ...................................................................................................................................................... 11
    Intermodal Transportation ............................................................................................................................ 13
  Regulatory and Legal Framework .................................................................................................................... 14
    The Regulatory Environment of Route Selection .......................................................................................... 14
    Hazardous Materials Transportation Act 1982 (HMTA) .............................................................................. 15
    Price-Anderson Act ..................................................................................................................................... 16
    Nuclear Waste Policy Act of 1982 ................................................................................................................. 18
    Nuclear Waste Policy Act and Amendments 1987 .................................................................................... 20
    The Legal Environment of Route Selection .................................................................................................. 20
  The Two Worlds of Risk Assessment .................................................................................................................. 23
  Perspectives on Risk ......................................................................................................................................... 24
    Expert Risk Assessment ................................................................................................................................ 24
    Democratic Risk Assessment ...................................................................................................................... 27
  Comparing the Worlds of Risk Assessment ...................................................................................................... 27
  Frank Fischer's Framework for Policy Analysis .............................................................................................. 29
    1. Program Verification .................................................................................................................................. 31
    2. Situational Validation .................................................................................................................................. 31
    3. Societal Vindication .................................................................................................................................. 32
    4. Social Choice .......................................................................................................................................... 32
  An Alternative Process ..................................................................................................................................... 33
  Why is it Important? ......................................................................................................................................... 34

CHAPTER 2 EXPERT RISK ASSESSMENT ........................................................................................................ 36
  The Development of Transportation Risk Assessment ..................................................................................... 37
  Route Selection with the Guidelines ................................................................................................................ 42
  The DOT Route Selection Process ............................................................................................................... 43
LIST OF FIGURES

Figure 1-1 Nuclear Fuel Rod Assembly .................................................................3
Figure 1-2 Yucca Mountain and US Nuclear Power Plants.................................7
Figure 1-3 Class I rail lines....................................................................................10
Figure 1-4 Interstate truck routes to Yucca Mountain .........................................12
Figure 2-1 The default preferred route through Clark County, Nevada ............45
Figure 2-2 State designated alternative routes A and B......................................46
Figure 2-3 Accident consequences .....................................................................50
Figure 2-4 Five and ten mile buffers around the default route .........................51
Figure 2-5 Five and ten mile buffers around the A and B routes.......................51
Figure 2-6 Land use multipliers ..........................................................................52
Figure 2-7 Unadjusted route selection results.....................................................53
ACKNOWLEDGEMENTS

The author wishes to express his appreciation to Dr. Simich and the other committee members, particularly Dr. Walton who provided insightful and necessary editorial advice and assistance. The author also wishes to sincerely thank Dawn Pomento of the Institute for Ethics and Policy Studies. Her thorough and fastidious assistance did much to bring this effort to its completion. Lastly, I want to thank my wife Nada for the steadfast assistance and unfailing encouragement that did so much to make this thesis a reality.
CHAPTER 1

INTRODUCTION

This study will compare and contrast two alternative approaches to risk analysis as they apply to transporting spent nuclear fuel from nuclear power plants in the US to a proposed repository at Yucca Mountain, Nevada. These two approaches are referred to as 'expert' and 'democratic.' Expert risk assessment defines risk by comparing the activity being assessed to the probability of death. This definition of risk has rendered expert risk largely ineffective as a policy tool. Democratic risk assessment argues that risk is actually a culturally constructed phenomenon and democratic risk assessors argue that the definition of risk used by expert risk assessors is too narrow. This study argues that both sides of the debate are incorrect and will propose a different approach. This approach relies on the public to both answer key methodological questions and to provide a more legitimate basis for making policy.

This chapter will provide information about the problem of transporting the waste from nuclear power plants across the country to the proposed storage site at Yucca Mountain, Nevada. It will also describe the legal and regulatory framework within which nuclear waste transportation takes place. The chapter will then introduce the competing
approaches to risk assessment and describe how these approaches will be analyzed using
the framework for policy analysis developed by Frank Fischer.¹

In Chapters 2 and 3 expert and democratic risk assessment will be examined by
applying each approach to the problem of comparing routes for high level waste. Chapter
2 will examine the expert view of risk. Chapter 3 will deal with democratic risk
assessment. Both chapters will conclude by applying Fischer's policy framework. This
framework highlights the shortcomings of both approaches to risk assessment. It will
also demonstrate that the competing frameworks miss a crucial aspect of risk.

In Chapter 4, the experience of transportation planners will be harnessed to serve
as the basis for a new process of risk assessment. This process relies on a combination of
political and deductive reasoning to define risk. This alternative method focuses on
public acceptability rather than on technical efficiency. The new process derives from the
central argument of this study which is that risk should be defined and presented in a way
that incorporates the concerns of the affected public and is useful to governmental
decision makers. The current approaches to risk assessment are tuned to the concerns of
experts.

Background

The U.S. produces 20% of its electricity using 119 nuclear power plants.

Commercial nuclear energy in the United States is generated primarily by light water
fission reactors. The reactors generate steam by using highly radioactive fuel rods

containing U-235 in a reactor pile. The fuel rods are "enriched" by processing mined uranium (which is typically about .07% U-235) to a level suitable for use in a reactor (about 3% U-235). See Figure 1-1 for a depiction of a fuel rod assembly.²

![Nuclear Fuel Assembly](image)

Figure 1-1 Nuclear Fuel Rod Assembly

Operation of the reactor depletes the amount of fissionable uranium in the fuel rod. A typical fuel rod will become depleted after three years, and an average reactor will generate approximately 30 tons of spent fuel rods each year. After the fuel rods are no longer usable, they are stored in pools of barium-treated water at the reactor sites. The resultant high-level radioactive waste may be the most lethal substance ever created. Upon removal from the reactor, the fuel rods must be isolated from the environment for at

least 2,500 years. This is due to the level of radiation still present in the spent fuel rod. A "spent" fuel rod still contains ninety percent of the radioactivity of the original rod.

The United States Department of Energy (DOE), Office of Civilian Radioactive Waste Management is currently studying deep geological disposal as the sole method of storing the nation's present and projected inventory of high level radioactive waste. The only location being studied for suitability as a disposal site is Yucca Mountain, Nevada, immediately adjacent to the Nevada Test Site (NTS) in southern Nevada. If Yucca Mountain is chosen, the waste will be transported from 119 civilian nuclear reactors and a number of defense facilities, ninety percent of these sites are east of the Mississippi River. If highway and rail routes were chosen under present regulation and practice, repository bound shipments could traverse 43 states.

Selecting acceptable transportation routes for radioactive waste is vitally important for the future of nuclear power. The present safe transport of approximately 500,000 hazardous materials shipments in the United States each day shows that the logistical difficulties of moving relatively low amounts of radioactive waste are not insurmountable. However, the problem facing the United States' high level radioactive waste disposal program is whether or not the public will allow the transportation to take place despite this excellent safety record.

---


At this point, DOE estimates that there will be a total of 63,000 metric tons of spent nuclear fuel from all the reactors that will need disposal by 2035.\(^5\) Disposing the waste has proven to be the most intractable problem ever faced by the nuclear industry, in part because of wide-ranging public opposition.\(^6\) While this was the least anticipated component of the problem, it has combined with DOE's inability to build a permanent repository to prevent any new nuclear power plant from being licensed in the United States since 1979. Figure 1-2 depicts the location of Yucca Mountain with respect to the nation's civilian nuclear power plants.

---


After decades of indecision by U.S. policy makers, President Carter decided in 1979 to pursue deep geologic storage as the only means of disposal for civilian spent nuclear fuel and high level waste from defense and research activities. Subsequently, responsibility for disposing of such waste was given to the DOE under the Nuclear Waste Policy Act of 1982. \(^7\)

**When will the waste be shipped?**

The current schedule calls for the repository to begin receiving spent fuel in 2015. However, frequent delays and schedule slippages have plagued the radioactive waste program and have caused the nuclear power utilities who currently own the waste to call for an immediate solution. The proposed answer has been to designate the Nevada Test Site (NTS) as an interim storage facility (ISF). This facility could be in operation as early as 2004. DOE estimates that the repository transportation program will last between 10 and 30 years, thus exposing corridors to risk for a long period of time. \(^8\)

**How Will the Waste get to Yucca Mountain?**

Transporting the radioactive waste to Yucca Mountain is one of the least studied aspects of the entire waste disposal program. Transportation problems were not included in the political calculus of selecting a site. The Yucca Mountain site is remote and is not served by any rail route. Constructing a new rail line is required if the rail transportation


\(^8\) Ibid. 54.
mode will be used to ship waste.

**Rail**

Ideally, most of the spent nuclear fuel would be transported by rail. This mode has numerous advantages from the DOE's point of view. For example, DOE's Multi-Purpose Canister program (MPC) proposed containers that could hold between 30-50 fuel assemblies on a single flatcar as compared to the two to three assemblies that may be held in the largest truck container. As a result, rail transportation would require fewer shipments. Fewer rail shipments would simplify the administrative problems of security and handling and be less costly than truck transportation.

Another important reason in favor of rail transportation is that there are fewer potential legal complications. Rail transportation routes are on private right of way. As a result, there are very few owners with whom the DOE will have to coordinate. Additionally, the railroads, as interstate carriers, are compelled to carry the waste or lose the ability to transport goods between states. The railroads have repeatedly sued the DOE to avoid carrying radioactive materials and have lost every case because of the implications for restraining interstate commerce.

---


potential rail routes used to ship the waste.\textsuperscript{11}

The limited number of rail routes available to transport the HLW is another reason rail transportation is the most attractive mode for the DOE. Fewer routes make route selection more difficult to interfere with because of the limited options, but easier to sabotage for the same reasons. Political considerations combine with geography to suggest that the preferred mode for radioactive waste transportation is rail.

There are, however, drawbacks associated with transporting HLW by rail. The lack of rail access to Yucca Mountain could cost in excess of one billion dollars to rectify. Constructing a rail line would also delay the commencement of storage by five years. Another drawback is that the US rail system is rapidly dwindling both in its quantity and quality.

The Staggers Rail Act of 1980 enabled railroad companies to discard unprofitable rail lines. As a result, the United States has decommissioned 50% of its top quality rail lines (Class 1) in the last 20 years. At the origin of the trip, rail access may not be available for many nuclear reactors, There is no rail access at the destination end of the trip. The Union Pacific Railroad owns the track between Los Angeles and Salt Lake City, and has recently discontinued passenger service and may soon abandon the line altogether. The DOE could be forced to subsidize the operation of several rail lines to

---


13 Wright, Transportation Engineering, 53.

keep them operational until the HLW shipments have been completed, a period of thirty years.

Highway

It is likely that the absence of rail lines to the Yucca Mountain and the Nevada Test Site will force most of the waste to be transported from reactors to the final disposal site by truck. Truck transportation is more flexible than rail transportation. That flexibility, however, creates additional problems. Administrative problems, such as security and control of the waste, are more difficult with truck transportation than with rail transportation. Truck shipping will be significantly more costly than rail.

Another difficulty is that transportation will take place on publicly-funded and maintained roads and the issues of liability, emergency response, and routing are more problematic than for rail with its private right of way. The following map depicts the possible interstate truck routes to Yucca Mountain and the nuclear power plants.
Figure 1-4 Interstate truck routes to Yucca Mountain

Truck transportation becomes most problematic and difficult to control in the area of route selection. The availability of alternative routes enables powerful, or more articulate interests to route HLW away from themselves and toward other groups. Route
selection decisions become equity decisions that will take place in a highly political and litigious atmosphere.

Intermodal Transportation

Combining rail and highway transportation is the most likely solution. This intermodal solution (or more precisely bimodal) provides some of the best of both modes. A nuclear power reactor that had no rail access would ship waste to an intermodal transfer facility where it would be placed on a rail car and shipped to another transfer facility near Yucca Mountain. The waste container would be loaded onto a heavy haul vehicle that would transport the waste to the disposal site at Yucca Mountain. This would avoid the requirement to build a railway to Yucca Mountain.

The use of container on flatcar (COFC) transportation is booming in the United States and provides a relatively simple and flexible alternative for the DOE's transportation program. However, despite the flexibility and ease of bimodal transportation, there is a significant drawback. The operational costs of an intermodal shipping campaign from a workable intermodal transfer site to another such site at Yucca Mountain is almost exactly the same as the cost of building and maintaining a rail route to the mountain. Any cost savings that have been projected as a result of an intermodal shipping program are also illusory since high maintenance costs of a heavy haul road would offset the difference in construction costs between an intermodal site and a rail

---

spur.

Regulatory and Legal Framework

The Regulatory Environment of Route Selection

Congress has recognized that transporting HLW is a serious national problem that requires considerable attention. The legislation that has been enacted, however, has raised as many questions as it has answered. The existing legal structure is an interlocking web of agencies, laws and procedures that regulate the transportation of radioactive waste. These regulations grew out of the more immediate problem of hazardous waste transportation.

Awareness of the problems posed by transporting hazardous materials is relatively recent. The need to regulate hazardous waste transportation was not urgent as long as the predominant mode of transportation was railway. Railroads own the land on which they transport materials and so responsibility for any accident is very clearly defined. Rail accidents are also enormously expensive and so railroad owners have much greater incentives to reduce accident rates than do truck shippers who bear only a portion of the cost of an accident (a railroad owns the track damaged in an accident while a trucking company pays only the cost of his truck). A free-market insurance system is sufficient to reimburse people affected by highway accidents.

The suburbanization of the U. S. population was facilitated by the increasing availability of truck transportation as an alternative to transporting freight by rail\textsuperscript{16} This

\textsuperscript{16} Institute of Traffic Engineers, \textit{Transportation Planning Handbook}, 32.
change of freight travel mode enabled hazardous materials to move unimpeded on highways that are publicly controlled. Areas once insulated from hazardous materials shipments were now vulnerable. The increasing trend toward truck transportation was not monitored by government agencies. A series of accidents focused attention on the issue. As a result of this trend, the U.S. Congress decided that there was a compelling public interest in regulating transportation of hazardous materials.

Hazardous Materials Transportation Act 1982 (HMTA)

Awareness of the problems posed by transporting hazardous materials is relatively recent. The need to regulate hazardous waste transportation was not urgent as long as the predominant mode of transportation was rail. The HMTA provided the first comprehensive treatment of the issue and was a positive step in the management of the nation's hazardous materials. The HMTA set the U.S. policy for selecting routes for hazardous materials, including HLW. The routing standards are especially vital because:

- The federal rules preempt state or local rules when the miles are not stringent as federal law.
- Route selection decisions were made without reference to the people affected.
- Route selections were made without a rational basis.
- Routing dangerous materials exposes certain portions of population to greater risk than others.
- Route selections create competing socioeconomic interests and raise questions of equity and efficiency.

The huge amount of hazardous wastes transported in the United States caused the Congress to attempt to create uniform standards for hazardous waste package labeling.

---

routing controls, and other standards. The importance of the HMTA is that the DOT is the responsible party for selecting routes for the transportation of HLW. It also established the framework for making decisions about selecting routes.

Price-Anderson Act

Congress established the Atomic Energy Commission (AEC) in 1946. The AEC was given authority over the development of nuclear weapons and commercial power. Convinced that nuclear power could be applied for peaceful purposes, Congress passed the Commercialization of Nuclear Power Act in 1954 to enable public utilities to develop the technology for commercial use of nuclear power.\footnote{Gerald Jacob, \textit{Site Unseen}, (Pittsburgh: University of Pittsburgh Press, 1990), 4-23.} Under this statute, the AEC was permitted to issue licenses to “transfer or receive in interstate commerce, manufacture, acquire (or) possess byproduct materials, source materials or special nuclear materials.”

The Price-Anderson Act established a unique system of private insurance and public indemnity for nuclear accidents.\footnote{Omar Brown, “Insurance and Indemnity Coverage for Public Liability Associated with Nuclear Materials in Transportation,” \textit{Forum} American Bar Association (Summer 1982): 1326-1334.} The system created by Price-Anderson provides coverage for public liability related to nuclear materials during storage, transportation and use. It purpose was to guarantee funds would be available in the event of a serious accident and to encourage private industry to participate in the development of nuclear energy by accepting some of the liability risk in the public arena.
Price-Anderson has been reenacted twice and amended several times. The governmental indemnity options of the Act were removed by the 1975 amendments. The government is indemnified only for shipments made by non-profit educational institutions, foreign reactors, and the Federal government and its contractors. The NRC has the responsibility for administering the financial protection system and the indemnity agreements. The Federal government self-insures nuclear materials risk. The indemnity for nuclear reactors is up to 500 million dollars for each nuclear incident occurring in the US and up to 100 million dollars for each occurrence outside the US.

Indemnity for transportation accidents is covered by the "omnibus" features of the Price-Anderson insurance indemnity system. The Price-Anderson protections were broadened in 1966 when Congress added provisions for an "extraordinary nuclear occurrence (ENO)." When it has been determined that an ENO has occurred, state laws are waived in order to consolidate cases in a single federal district court. This is intended to speed up compensation for victims.

Price-Anderson has never been tested in a transportation context in court. It is likely that the provisions in the act are adequate to provide limited indemnity protection for privately transported HLW. Price-Anderson was a vital piece of legislation for the nuclear industry because it removed the financial indemnity of the nuclear generators and left responsibility squarely on the shoulders of the public. The consequences of any

---

20 Ibid., 1329.

21 Ibid., 1331.
accident will be paid out of public funds.

Nuclear Waste Policy Act of 1982

Discontent with HLW transportation lead several states to enact laws prohibiting or restricting power plant construction or licensing. When some of these laws were upheld in Court, the Congress recognized the need to create a comprehensive program for HLW storage and disposal. When nuclear power was first adapted for commercial use, it was assumed that an appropriate technological solution would be found to dispose the waste. No agency or industry invested in waste disposal, not surprisingly no technology was forthcoming. In the 1970's the Federal Government incrementally provided monetary and regulatory assistance in an attempt to deal with the problem of nuclear waste.\(^{22}\) The 97th Congress passed the Nuclear Waste Policy Act (NWPA) in 1982 as an attempt to finally solve the problem. This Act selected five sites for consideration as a repository. None of the original five sites was located in or near optimal geology. Despite claims to the contrary, a process that relied on geological conditions for initial site selection was never implemented.\(^{23}\) In 1987, legislation removed other sites from consideration for disposal and settled on Yucca Mountain as the only site to be studied.

The decision to use Yucca Mountain resulted from a combination of

\(^{22}\) Jacob, Site Unseen, 4-23.

\(^{23}\) Ibid., 22.
bureaucratic and political pressures, as Seley indicated:²⁴

_Sometimes the location finally chosen for a new development or the site chosen for
the relocation of an existing facility, comes out to be the site around which the least
protest can be generated by those to be displaced. Rather than being an optimal, a
rational, or even a satisfactory location decision, the decision is perhaps more the
rejection by elements powerful enough to enforce their decision that another location
must not be used; alternatively, the location decision may result in a choice against
which no strong argument can be raised since such elements either inarticulate or
command too little power to render their argument effective._

There was also a powerful bureaucratic incentive to study only Yucca Mountain. For 40 years, the NTS, just 90 miles northwest of Las Vegas, was the only place where the United States tested nuclear weapons by detonating them. From 1951 to 1992, approximately 1000 nuclear warheads were detonated at the NTS. To support this testing, an uninhabited area the size of the State of Connecticut (1375 miles) was set aside for use as a testing ground.²⁵ Billions of dollars of improvements (e.g. roads, power lines, and buildings) were built and scrupulously maintained. By the end of the 1980s, however, public pressure to stop nuclear testing was growing. Simultaneously, computer modeling techniques were rendering full-scale tests unnecessary. It became obvious that the NTS would need a new mission.


The NWPA created a comprehensive plan to collect, transport, and dispose of HLW. The cornerstone of the bill was a provision for the construction of "away from reactor storage." A site for the facility to house this waste was to be proposed by the secretary of the DOE within one year of the bill's passage. and completion of the storage site was projected for the mid 1980s.26

Nuclear Waste Policy Act and Amendments 1987

By 1987, the multi-state repository site selection process had created severe political pressure on DOE. The comprehensive process for site selection had proven to be a failure. In January of 1987, the DOE announced that no repository could be completed before 2008 (the previously announced date was 1998).27 These pressures created an opportunity to amend NWPA.

The result was the NWPAA of 1987. This statute brought about several changes in the DOE program. Major changes in the process were that only a single site was to be characterized (Yucca Mountain), the State of Nevada was given funds for oversight, three new oversight organizations were created and the discretion of DOE managers was restricted.28

The Legal Environment of Route Selection


28 Dept. of Energy, Nuclear Waste Policy Act as Amended 44.
The HMTA gives the Department of Transportation (DOT) broad regulatory power. Any state, local or tribal transportation regulation, code or ordinance that is determined by DOT to be inconsistent with federal transportation law under provisions of 49 Code of Federal Regulations may be preempted. The Nuclear Regulatory Commission (NRC) advises DOT on packaging and safety standards. In 1979, to avoid redundancy, the NRC adopted some DOT regulations and currently assigns licenses to shippers if they comply with DOT transportation regulations.

Several states have passed legislation to control the public dangers presented by radioactive materials transportation. Some states have excluded certain types or quantities of these materials while others have adopted and supplemented the federal regulations. These state laws are evaluated in the context of federal regulations and determine consistency with the federal regulations. State regulations have not fared well in this process because courts have held that interstate commerce would be jeopardized had they not supported the federal regulations. An additional concern is that the state laws were specifically enacted to exclude nuclear materials. The courts did not want to establish a precedent for laws regulating other materials.

Courts have made it possible for localities to receive preemptive exceptions which


30 Ibid., 5.

will override a DOT inconsistency ruling. A State can appeal to the courts for a
preamption exception when all administrative remedies have failed. A state may receive
a preemption exception if it can show that its regulations are based upon concern for the
safety of its citizens as opposed to an attempt to merely prevent the transportation of
waste.

A carrier transporting highly radioactive materials must operate on a "preferred
route" which consists of: 32

an interstate system highway for which an alternative route is not
designated by a state routing agency, and a state designated route
selected by a state routing agency in accordance with the DOT
"Guidelines for Selecting Preferred highway Routes for Highway Route
Controlled Quantity Shipment of Radioactive Materials.

Shippers of radioactive materials must use preferred routes that reduce time in
transit. This is because the waste containers are not able to prevent the release of some
radiation. A route that minimizes time in transit diminishes the amount of radiation
released during routine transportation. If a state does not designate a preferred route, the
DOT regulations require carriers to use interstate highways because they reduce travel
time and guarantee an available transport route for the waste.

State selected routes are preempted by federal regulation if: 33

• it prohibits transportation between two points without providing an alternative;

32 Dept. of Transportation, Guidelines for Selecting Preferred Highway Route Controlled

33 Mattson, Michelle, "Transportation of Radioactive Materials in Our Backyards-A
State's Perspective," 52.
is not established by a state routing agency;
• there is no comparative radiological risk study;
• there is no consideration of risks to affected jurisdictions;
• there is no continuity of routes between jurisdictions.

The process of comparing routes for transportation is crucial for states concerned about radioactive waste transportation. These route comparisons are important to states because of the length of time the transportation will take place. The period of time the DOE estimates the entire shipping campaign will last for 30 years. The distance traveled is also significant. A single trip from the Peachbottom nuclear power plant in Pennsylvania to Yucca Mountain will be approximately 1750 miles. The waste will be transported through many of the most populous areas of the US.\textsuperscript{34} How to compare the risk of transporting the waste is the bone of contention.

The Two Worlds of Risk Assessment

Susan Jasanoff (past President of the Society for Risk Analysis), referred to the competing views of risk as the "Two worlds" of risk assessment (perhaps in reference to C.P Snow's description of two worlds of intellectual life).\textsuperscript{35} Jasanoff lauded the achievements of the two approaches and bemoaned the lack of cooperation between them. Her comments indicate how even experienced risk assessors misunderstand the fundamental distinction between these two worlds. In her comments, Jasanoff


distinguished between quantitative and qualitative risk. She indicated that quantitative risk assessment is performed by physical scientists while qualitative risk assessors use qualitative methods.\(^\text{36}\) Hers is an ironic, but common mistake. The Society for Risk Analysis was founded by Paul Slovic, a social scientist, who is renowned for his use of quantitative methods to measure public perception of risk.\(^\text{37}\) On the other hand, a physical scientist used qualitative methods to show that Canadian nuclear power was safe.\(^\text{38}\) The way to differentiate between the worlds of risk assessment is not methodological. The difference lay in how risk is defined.

**Perspectives on Risk**

Policy discussion about risk assessment is fairly new. Although the first modern writing about risk and policy was done by Frank Knight in the 1920s, it was not until a 1969 article by Chauncey Starr that the current debate over risk policy took shape.\(^\text{39}\) Starr established the most widely used measurement for risk assessment policy - risk of death. His definition of risk is the singular feature of expert risk assessment.

**Expert Risk Assessment**

Starr argued that society revealed its preferences for risk based on its willingness to accept the deaths caused by policies and natural phenomena. He calculated the

\(^{36}\) Jasanoff, "Bridging the Two Cultures of Risk Analysis," 125.


\(^{38}\) Shrader-Frechette, *Risk and Rationality*, 63-64.

probabilities of mortality in given situations, e.g., the Vietnam War, disease, automobile accidents and then compared them. Starr argued that this comparison revealed society's implicit acceptance of the alternative policies and hazards. The United States was willing to accept a given number of deaths caused by a policy or behavior in exchange for the benefits received. These "revealed preferences," he argued, should be the explicit basis for evaluating public policy. Starr's technique was typical of the ambitions of the scientific social science of the 1960's.

Starr's method of measuring risk was widely accepted and has been incorporated into legislation. The probability of death is the accepted measure of risk in areas as diverse as cancer research, air quality, and emergency management. Policy makers hoped that such comparisons would inform public opinion about policies that involved risk. Starr hoped to articulate a way to evaluate public policy that was value-free. The expert view of risk conforms to positivist philosophy in that they restrict their inquiry to observable phenomena that do not address problems of human perception, evaluation, and values.

Positivism in risk assessment is a commitment to obtaining factual knowledge about the risk under consideration. Fischer defines positivism as:

..a term used to refer to the legacy of a Philosophical movement

---


41 Frank Fischer, Evaluating Public Policy, 10.
called 'logical positivism.' Originally developed in reference to the natural and physical sciences. Positivism advances a theory of knowledge based on the rigorous testing of empirical propositions. Positivist social science, founded on specific normative and empirical assumptions, employs deductive methods to construct and empirically test hypotheses. It seeks to define the epistemological and methodological foundations of verifiable causal explanations and general laws.

In risk assessment, positivism manifests itself by defining risk in a way that is accessible to analytic techniques. Fischer states: 42 "Positivism is distinguished by developing causal models with predictive power." This is a clear characteristic of expert risk assessment which harnesses: cost benefit analysis, experimental research design, multiple regression analysis, survey research, and mathematical simulation models to make inferences about the risks posed by certain programs or policies.

In HLW transportation, the expert view of risk assessment hopes to generalize past experience (e.g. fatal accident rates) and predicted performance (e.g. the durability of waste containers in accidents) to the present. The hope of expert risk assessment in transporting HLW is to sidestep political influence in route selection. The ambition of the expert risk assessors is that their epistemology will make for successful public policy. The progenitor of the expert view, Chauncey Starr asserted that "the issue of public safety can be focused on a tangible, quantitative engineering design objective." 43

Shrader-Frechette dubbed Starr's view of risk as "naive-positivist" because of its

42 Fischer, Evaluating Public Policy. 11.

narrow definition of risk.\textsuperscript{44} Chapter 2 will examine expert risk assessment in greater detail through a case study. Starr's method was immediately attacked. His article had the effect of causing other theories about risk to form into a coherent criticism of his approach.

Democratic Risk Assessment

The alternative perspective on risk was most famously articulated by the anthropologist Mary Douglas and her colleague, the late political scientist, Aaron Wildavsky. They suggested that societies decide what they will and will not define as dangerous behavior.\textsuperscript{45} They argue that Starr's attempt to measure and manage risk is futile because cultural effects make it impossible to distinguish between competing risk assessments. The democratic world of risk assessment uses a broader definition of risk that encompasses more than the probability of death. Specifically, it defines risk in a way that acknowledges human motivation.

Various authors have used other measures and more sophisticated methods to define and measure risk. Such measures include potential danger to environmentally sensitive locations, threats to an area's economy, costs for Governmental services, among others. The inability to agree on a definition of risk has contributed to the policy stalemate. Chapter 3 will examine the democratic view of risk in greater detail.

Comparing the Worlds of Risk Assessment

\textsuperscript{44} Shrader-Frechette, \textit{Risk and Rationality}, 29-33.

\textsuperscript{45} Douglas and Wildavsky, \textit{Risk and Culture}, 3.
In what follows, the two worlds of risk assessment (expert and democratic) will be described by applying procedures contained in two documents to the problem of route selection. In Chapter 2, the expert view of risk will be studied by applying the risk assessment criteria contained in the *Guidelines for Selecting Preferred Highway Routes for Highway Route Controlled Quantity Shipments of Radioactive Materials* hereafter referred to as the "Guidelines." These are the criteria used by states to choose between alternate routes for transporting high level waste (HLW). The Guidelines will be applied to the problem of selecting a route through the State of Nevada. The results obtained by applying the Guidelines will be evaluated by using Frank Fischer's framework for policy analysis. This evaluation will highlight the limitations and embedded assumptions contained in the Guidelines.

In Chapter 3, the democratic view of risk will be explained by applying the criticisms of the DOE process contained in *Guidelines on the Scope, Content, and Use of Comprehensive Risk Assessment in the Management of High Level Nuclear Waste Transportation* by Dominic Golding and Allen White. The comments in this report will be applied to the same problem of selecting routes. This will demonstrate that the democratic view of risk fares no better than the expert view. By using Fischer's framework, this study will show that the democratic view of risk remains unable to

---


distinguish between risk and therefore, unable to shape policy. Fischer's framework reveals the shortcomings of both views of risk.

**Frank Fischer's Framework for Policy Analysis**

Fischer's framework asks whether or not a policy analysis actually works. It takes a broad view of what the goal of policy analysis should be and provides context for methodological and empirical debate about a particular policy. This framework is especially useful in the case of radioactive waste transportation because:

- There are two clearly identifiable perspectives in HLW transportation risk assessment, each with a strong coalition.
- Extensive research has been conducted by persons on both sides of the issue.
- There is confusion about why neither perspective has achieved widespread acceptance, with the affected public.
- Policy making has been stifled by the stalemate between the two worlds.

Discussion about the risks of transporting HLW takes place at what Fischer describes as "different levels of discourse." He believes that participants in many policy debates often argue at different levels. Fischer cites the example of the Head Start program. Supporters of the program focused on statistical measures of progress made by the policy. Opponents argued that the Head Start program was so flawed that no quantitative measure of progress was of any use. The program itself should be scrapped.

This example characterizes the current situation in selecting routes for HLW transportation. Proponents of the DOE program willingly accept the simplifying assumptions inherent in expert risk assessment. Opponents of the program seek to

---

broaden the definition risk so that transporting the waste becomes problematic. Fischer intends his framework to reconcile these normative and empirical dimensions of policy. He recognizes that empirical data and methods are routinely used by both sides of a policy debate, but that empirical data is unable to resolve policy controversy by itself. This incapacity lifts policy discussion to higher levels.

Fischer's model postulates four levels. It operates by posing questions to the policy being evaluated. These questions force policy discussion away from routine matters of methodology and empirical problems to deeper questions about equity and justice. Fischer's model categorizes the discussion that takes place about policy. It becomes possible to place the argument about risk into perspective. It is important to recognize that Fischer's typology places distinct boundaries around the levels of policy discussion where they may not be quite so distinct. This is done for convenience only. In practice, these boundaries are blurred. Fischer also recognizes that policy discussion is discursive. Discussion about policy involves all of the levels of discussion of policy at different times. These phases take place concurrently and some receive more or less attention at different times in the debate.

Competing sides in the risk debate talk around each other rather than address the substance of their issue. The Fischer framework analyses policy at levels beyond the empirical discussion that has left risk assessment stuck in the mire. It challenges competing viewpoints to display their political philosophies and ambitions for society. The framework consists of the levels described below.
1. Program Verification

The first level of policy discourse described by Fischer is called "program verification." In this level of discussion, programs that implement the policy must demonstrate how well or poorly they fulfill the stated policy goals. This level focuses on empirical data and methodology. At each level Fischer asks questions of the policy. The questions at this level are:

- Does the program empirically fulfill its stated objectives?
- Does the empirical analysis uncover secondary or unanticipated effects that offset the program objectives?
- Does the program fulfill the objectives more efficiently than alternative means available?

At this level of analysis, the facts of the policy are compiled and discussed at a very basic level. Discussion about how probabilities are measured, what data to use, and how the data should be manipulated take place at this level. This is a low level of analysis in that it does not seek to examine anything besides the immediate issues of implementing the policy in question.

2. Situational Validation

Situational validation moves policy debate to a higher level of analysis that asks normative rather than empirical or methodological questions. The three questions posed at this level are:

- Is the program objective(s) relevant to the problem situation?
- Are there circumstances in the situation that require an exception be made to the objective (s)?
- Are two or more objectives equally relevant to the problem situation?
At this level the policy must demonstrate that it is the best method to meet the objectives. In this case, if it assumed that the risks must be compared, then the methodology used to compare those risks must demonstrate that it is the best available alternative.

3. Societal Vindication

At this level of discussion, Fischer poses the following questions:

- *Does the policy goal have instrumental or contributive value for the society as a whole?*
- *Does the policy goal result in unanticipated problems with important societal consequences?*
- *Does a commitment to the policy goal lead to consequences (e.g. benefits and costs) that are judged to be equally distributed?*

These questions move the debate to a completely different level. Here, the discussion becomes familiar to a broader audience. Should the opinions of experts receive greater credence than the opinions of the affected public? In this level of policy discourse about HLW transportation, the role of expert judgment is the issue concealed behind all of the technical discussion about risk assessment. At this level, these concerns are applied to the problem of how decisions about technology are made.

4. Social Choice

At this level questions about the policy are applied to the society as a whole. The questions asked of expert assessors influence decisions where human values are intrinsically at stake, yet their answers are not incorporated into the assessment. Discussion about nuclear power, risk assessment and transporting radioactive waste is also about the kind of society we live in and what we value. Choosing routes for
transporting radioactive waste is really about how we make judgments which influence our lives in the future.

An underlying assumption made by many risk assessors is that their analyses are the result of a deductive process that is free of bias. The entire appeal of risk assessment is that it would provide an objective basis for comparing policies. In this sense, it is closely related to cost-benefit analysis. A growing body of work shows that risk assessors themselves are blind to the bias and error contained in their work. The problem multiplies because the managers and policy makers who are the consumers of risk analysis are lead to believe, falsely, that the assessments they use to manage policy are free of bias. As a result, the public may be forced to endure the guesses of risk assessors repackaged as objective truth. Fischer's model both illuminates and oversimplifies. But it does highlight those questions that are never discussed and seldom reflected upon.

An Alternative Process

In Chapter 4 the study will propose a new process for performing risk assessments that avoids the pitfalls of expert and democratic views of risk. The proposed process draws on the experience of transportation planners and their method of reconciling technical knowledge with political decision making. This new view of risk assessment subordinates the problems of deduction in risk assessment by seeking legitimacy as a crucial objective for any risk assessment. It is worthwhile to point out that risk assessments have different objectives. Some risk assessments have small technical audiences as their audience. The recommended alternative procedure is meant to apply only to those risk assessments that will affect the public at large.
The problem of assessing and communicating the risk of transporting radioactive waste is emblematic of the larger problem of managing technology. Often demonstrated man-made dangers have given rise to public concern about the development and deployment of technology. This concern is manifesting itself in several ways. The experience of transportation planners is especially useful in this case. This study will point to parallels between the seemingly technical practice of risk assessment and the field of transportation planning in local government. At first glance, they appear to have little in common. However, closer inspection will highlight the similarity of the problems faced by the two groups.

Why is it Important?

Public fear is eroding popular support for scientific projects. Citizens groups have effectively blocked or derailed many projects, ranging from the development of bacteria that prevent frost damage to crops to the licensing of nuclear power plants. This study is important because it points the way to a practical solution to the problem of selecting routes for transporting spent nuclear fuel and has broader applications. It examines why policy analysis in the field has failed to provide meaningful guidance to decision makers. The problem identified here is an example of how difficult it is to reconcile scientific understanding and democracy. The process for performing risk assessment developed in this study is explicitly intended for use outside the field of transporting radioactive waste. But the problem of achieving public acceptance of nuclear waste transportation is by no means negligible.
In April 1996, the French government transported a container of radioactive waste to a storage facility at Gorleben, Germany.\textsuperscript{49} Because of previous protests, the French government released misleading and false information about the time and location of the shipment. Despite this ruse, several thousand German protesters intercepted the shipment en route to the Gorleben waste site. The protesters ripped up rail lines and signal boxes and attempted to destroy the road leading to the storage facility. The protests resulted in a riot that injured 30. While the shipments were delivered to the Gorleben facility despite the protest, this was a serious demonstration of how public fears combined with opposition to nuclear power can create violent activism.

Advocates of risk assessment hope to persuade the public to accept risky technologies through the use of “value-free” calculations. They have not been successful. The expert view of risk assumes that objective, value-free assessments of risk are possible. Chapter Two will demonstrate that the numerous empirical assumptions made by expert risk assessors reflect support for the technocratic model of knowledge.

CHAPTER 2

EXPERT RISK ASSESSMENT

Fischer’s critique of positivist methods of policy analysis closely parallels critiques of the Guidelines. This chapter will: 1) provide a more detailed account of the development of expert risk assessment in the transportation field, 2) examine the expert view of risk by applying procedure for route comparison contained in the Guidelines to the State of Nevada, and 3) critique the Guidelines using Fisher’s policy framework.

In 1987, the Congress designated the interstate highway system as “preferred routes for shipping HLW.” This designation ensured that routes would be available to ship HLW. Congress also recognized that states may want waste transported on routes that do not belong to the interstate system and directed the DOT to develop a process to compare potential shipping routes. Although this chapter focuses on the Guidelines, it is important not to lose sight of Congress’ attitude toward risk as expressed by the designation of preferred routes. Congress’ stance suggests that they are willing to accept highway transportation of radioactive waste through major metropolitan areas in order to

---

facilitate the waste disposal program.

The Development of Transportation Risk Assessment

It is appropriate that the first studies of transportation risk were sponsored by agencies interested in measuring the safety of transporting radioactive materials. The problems posed by nuclear materials have always been reckoned susceptible to scientific analysis, and federal research grants opened the door to such analysis. Each of the advances in risk assessment cited below occurred with the patronage of the federal government in support of the nuclear industry.*

In 1958 F.F. Liemkuhler analyzed the frequency and severity of truck accidents. He used regression analysis to correlate accident frequency, cargo type, and season of the year. The study presented probability distributions for the impact of collisions between vehicles at different angles and stratified these results according to the type of roadway. Probabilities for four-lane roads, divided highways and high and low traffic volumes were calculated and the results extrapolated to apply to radioactive materials.52

While this study was the first to use probabilities to predict the consequences of accidents, it was severely limited because the only data available were for the cargo damage to new automobile transport. The study highlighted the difficulty of forecasting without reliable data. and indicated that the procedures used in the study could be applied to a range of problems beyond accident forensics. The study was the first attempt at


52 Ibid., 15.
prediction in the field of expert risk assessment. Past accidents revealed significant correlations that could be used to forecast future events.

Liemkuhler's work had no ambitions in the arena of public policy. His study was a narrowly focused attempt to tease out meaningful correlations that could be used by radioactive materials shippers to identify optimal transportation conditions. The study was not widely disseminated except to transportation professionals. This study paved the way for analyzing transportation accidents with the same process used in engineering safety analysis.

The next major step forward in transportation risk assessment occurred in the late 1960's when William Brobst, of the Atomic Energy Commission, developed a method for classifying rail and highway accident severity in terms of impact speed and fire characteristics. The crucial distinguishing feature of Brobst' work was that he included a conditional probability of container damage for accidents of various severity and used probabilities to forecast accident consequences. His work inaugurated "probabilistic risk assessment" as a subset of quantitative risk assessment in the transportation field.53

Another characteristic of the expert view of risk becomes clear from Brobst's work. Brobst' admits that a great deal of engineering judgment is included in his figures. The values in his study are based on "gross judgment and the very limited data available."54 Brobst's study occurred at an ironic time. Just as questions about the safety

53 Ibid., 16.
54 Ibid., 19.
of nuclear power became more common, the ambitions of expert risk assessors took them further from the empirical data they purport to rely on. When data are absent or too expensive to collect, expert judgment is introduced and often not rigorously documented. A common defense of expert risk assessment is that it is "logical," or "scientific." This claim is made despite the inevitable presence of expert judgment in even the most rigorous risk assessment.

In 1976, a third major innovation in expert risk assessment took place when Sandia National Laboratories released a study which reported probabilistic distributions for the magnitude of mechanical and thermal stress results from accident forces. In this study, engineering models were substituted for empirical data. This study is important because it marked the first use of computer simulation in the field. The debate over computer testing versus full-size cask testing continues to this day.

The study is significant because it marks the inauguration of computer simulation as a technique to compensate for missing data. In this case, the knowledge about the safety of the containers was inferred solely from the results of computer models without any empirical data. A model constructed without empirical data relies heavily on expert judgment. Indeed, the Sandia study was expert judgment codified as a computer program.

Computer models were immediately used by the DOE to examine risk and

---


routing. RADTRAN, STATEGEN, HIGHWAY, RAILLINE, and INTERLINE are all transportation risk assessment computer programs produced and maintained by the Department of Energy for the express purpose of assessing the risk of transporting HLW. The results of these computer models have been indifferent. On the one hand, they are used because "that's all we have." On the other hand, they are seldom effective in dealing with the public. When the Carolina Environmental Study Group sued Duke Power over plant safety, one of the issues in the lawsuit was that the RADTRAN model used by Duke Power assumed that no container would ever have a hole in it larger than one inch in diameter. Expert risk assessment often relies heavily on computer simulation without qualifying the results of the models as largely the product of expert judgment.

These studies all advanced the methods used to perform an analysis of the risk of transporting radioactive materials. They adapted quantitative tools and procedures from engineering to address a narrow technical audience comfortable with using expert judgment. None of these studies was originally intended as a public policy instrument. Some catalyst was necessary to bring expert risk assessment out of the cloisters of the national laboratories and into public view.

In 1969, Chauncey Starr wrote an influential article in Science magazine which


\[\text{\footnotesize 58 Duke Power v Carolina Environmental Study Group.} \]
advocated numerical comparison of risks as the basis for public policy. Quantitative revolutions were sweeping many disciplines at that time and quantitative methodologies held out the hope of "value-free" policy formation. Starr felt this was possible. He argued that implicit in every nonarbitrary national decision on the use of technology is a trade-off of societal benefits and societal costs. Starr made two assumptions in developing his ideas: 1) that historical national accident records are adequate for revealing consistent patterns of fatalities in the public use of technology and 2) that such historically revealed social preferences and costs are sufficiently enduring to permit their use for predictive purposes. These "revealed preferences" should be used, he argued, to guide policy makers.

His arguments framed the ideology of expert risk assessment. The characteristics of Starr's viewpoint are very clear: 1) The consequences of a policy or program can be understood only when they are reduced to the probability of death. 2) The influence of human behavior need not be considered because they are already contained in the fatality rates. 3) Considerations of equity or the distribution of risk is irrelevant in the face of quantifiable death rates. Despite numerous refinements, the process sketched out by Starr

[59] Starr, "Technological Risk versus Societal Benefit," 1232


[62] Ibid., 1232
remains standard practice in the field of risk assessment.\textsuperscript{63}

**Route Selection with the Guidelines**

The route comparison procedure contained in the Guidelines provides a mechanical method for distinguishing between routes that is entirely consistent with Chauncey Starr's ideal. The route selection process described in the Guidelines distinguishes between alternate routes by applying three criteria to each potential route. They are:

- *Normal Radiation Exposure*
- *Public Health Risk*
- *Economic Consequences*

The first criterion is the radiation exposure caused by the accident-free transportation of the waste containers on highways. None of the containers used to hold the waste can completely shield the truck driver or nearby motorists from some radiation exposure. The Guidelines argue that since the likelihood of an accident is small, normal radiation exposure is the most significant risk associated with the shipments. This criterion seeks the shortest path from the origin of the trip to the destination. The shortest path will minimize the time in transit and, therefore, the radiation exposure for people living adjacent to the route.

The second criterion is the public health risk from accidents. This benchmark measures the health effects of an accident which breeches the container holding the

waste. If a container breaks open, radioactive particles can spread in an airborne plume. The Guidelines assume that radioactivity will spread up to ten miles downwind from an accident and will contaminate an area of approximately 25 square miles. This criterion minimizes the population exposed to radiation by avoiding densely populated regions.

The last criterion used to select routes is the economic risk of transporting the waste. The economic risk is defined as the cost of decontaminating buildings adjacent to the route. The factor provides an estimate of the total cost to decontaminate areas affected by radiation. The Guidelines ignore any economic costs beyond decontamination costs. This criterion seeks the route with the lowest cost to decontaminate.

The chosen routes are evaluated for each criterion. The criteria are compared and if no route is significantly better than any other, the criterion are normalized to calculate an index of risk that combines the three factors. The Guidelines also designate three secondary factors that are evaluated optionally and are not used for this study.

**The DOT Route Selection Process**

The route selection process contained in the Guidelines is performed in the following steps:

- *Determine highway route that minimizes impacts*
- *Identify alternative highway routes available in consultation with affected jurisdictions*
- *Develop list of route comparison factors*
- *Evaluate route comparison factors for each alternative highway route*
• Select route that best minimizes impacts based on evaluation of route comparison factors
• Document entire routing analysis to serve as the basis for the routing decision

The Guidelines create a reliable process for comparing routes. This process is consistent with expert risk assessment because the criteria for evaluating routes is confined to measurable variables. The process is also objective in the sense that if the same numbers and formulae are used, different parties will obtain the same results regardless of their personal prejudices or opinions. The Guidelines reflect Chauncey Starr's hopes for policy analysis free from values.

The DOT Process Applied to Clark County

The process used to apply the Guidelines to Clark county is given below:

1. Identify the default Interstate route and State of Nevada designated alternatives
2. Arrange data to conform to the standards required for analysis
3. Calculate criteria for State designated alternatives and the default Interstate routes
4. Calculate risk indices for the default Interstate route and compare them to proposed State alternatives

Each step is described below.

1. Identify default Interstate route and State of Nevada designated alternatives

The default route through Clark County to the NTS is depicted in Figure 2-1. This route uses Interstate 15 traveling south from the Utah border to the US 95 interchange and then through the northwest part of Clark County to the NTS.
The State of Nevada has designated several alternatives to the default route. These routes were chosen to avoid the most densely populated regions of Clark County. They have never been evaluated using the criteria contained in the Guidelines. These alternative routes are in Figure 2-2.
Route A uses Interstate 40 to connect to Interstate 15 near Barstow California. The route travels north into Clark County up to State Route 160 and then out of Clark County and north to the Nevada Test Site. Route B passes north from Interstate 40 on US 95 and then over State Route 164 to Interstate 15 and then out of Clark County to the Nevada Test Site through California. Routes A and B share links on road segments. All of the segments on route A are on route B.

2. Arrange data to conform to standards required for analysis

After identifying the routes, it was necessary to segment the routes in a way that
conforms to the population data. This enables the population risk to be calculated. Each route was divided into links with nodes at the census tract boundaries created and maintained by the US Bureau of the Census. The census tract boundaries and the population data comes from a commercially available data base that uses the 1995 update to the 1990 census.

Each road segment was assigned a unique number and was used to organize and analyze the data. The Clark County road data is from the street centerline file maintained by Clark County. This is the most up to date record of the County’s road network. Road segments that could be used as routes from the Interstate 15 to the NTS are depicted. The next step of the data conversion was to add necessary data to each road segment. The following data were assigned to each road segment:

The following comments describe how the data was organized. Some segments were so long that there were multiple speed zones on a segment. In these cases, the mean average speeds were calculated and applied to the segment. Average annual daily traffic (AADT), which indicates the number of vehicles using the route during a 24 hour period averaged over a year, was added to the route segment. The road data used in the analysis are all current as of 1995, with the exception of the national accident averages. These averages are current as of 1992, when they were published in the Guidelines. In cases where there were multiple traffic counts on a segment, the number was averaged and applied to the sections.

Accident rates and accident information was obtained from the Nevada State Office of Public Safety which compiles information for inclusion into the US DOT’s Fatal Accident Reporting System (FARS). This data is for 1995 and is the most current information available. Distances between opposing lanes was obtained by personal survey of the alternate routes. Locations of segment endpoints were determined and the routes were examined to obtain first-hand knowledge of the distance and road conditions. The land use information was obtained from the Clark County Regional Transportation Commission’s land use data base. Land use polygons were merged according to the land use scheme mandated by the Guidelines.
- segment number
- segment endpoints
- segment length
- average speed
- distance between opposing lanes
- population count 0-5 Miles
- population count 5-10 Miles
- daily traffic count (Average Annual Daily Traffic)
- daily truck count
- annual number of deaths (Nevada figures)
- accident rate per million truck miles (Nevada figures)
- accident rate per thousand shipments (National averages)

3. Calculate criteria for State designated alternatives and the default Interstate routes

The route comparison factors were calculated for each of the route segments. The calculations are presented in Appendix 1. Several road segments were divided into multiple portions to enable more accurate representation of the roadway. The route with the lowest factor is the preferred route. The preferred route factors are marked in bold letters.

A. Normal Exposure Factor

The first criteria calculated was the normal exposure factor. The normal radiation exposure factor estimates the radiation exposure caused by the routine transportation of fuel. The factors considered in the equation are:

- Dose to people at truck stops (D4)
- Dose to truck crew (D3)
• Dose to passengers in other vehicles (D2)
• Dose to persons residing along route (D1)

The total risk is the sum of these factors: \( D_1 + D_2 + D_3 + D_4 \)

The equation used to calculate this factor is:

\[
D = \frac{P \cdot L}{v} + \frac{L \cdot T}{v_2} \cdot C_2 + \frac{L \cdot T}{v_3} \cdot C_3 + \frac{L}{v}
\]

where:

\( D \) = normal radiation exposure comparison factor
\( P \) = average population density along the route (people per square mile)
\( L \) = length of route (miles)
\( T \) = average annual daily traffic along the route
\( v \) = average speed of vehicles on the route (mph)
\( C_1 \) = Constant \( 6.7 \times 10^{-5} \) (Average distance between opposing lanes)
\( C_2 \) = Conversion factor (Average vehicle separation distance)
\( C_3 \) = Conversion factor from Table

The spreadsheets that contain the calculations are found in Appendix 1. The results of this calculation are:

Default interstate route: 7.06
Route A: .164
Route B: .853

The preferred route based on this criteria is Route A because it has the least radiation exposure.

B. Population Exposure Factor

The next step was to calculate the risk to the population living along each route.

Risks of accidental release depend on two factors: 1) The frequency of accidents that could result in a release and 2) the consequences of such an accident. The route
population risk factor is determined by multiplying the frequency by the consequences of an accident. To calculate the frequency, the accident rate in units of accidents per vehicle mile are multiplied by the route length. For this analysis the national truck accident rate was used. The other variable, accident consequences, is calculated by multiplying the population living within bands around the road segment by multipliers contained in the Guidelines. The multipliers are:

<table>
<thead>
<tr>
<th>Population Band Boundary</th>
<th>Health Consequences Multipliers</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-5 miles</td>
<td>.75</td>
</tr>
<tr>
<td>5-10 miles</td>
<td>.25</td>
</tr>
</tbody>
</table>

![Figure 2-3 Accident consequences](image)

These multipliers adjust accident consequences to reflect the decreased effect of radiation as distance from the accident increases. The result of this multiplication is then divided by the length of the route segment to identify the consequences of an accident. This number is then multiplied by the accident frequency to determine the population exposure factor. The maps in figures 2-4 and 2-5 depict the buffers surrounding the alternate routes.
Figure 2-4 Five and ten mile buffers around the default route

Figure 2-5 Five and ten mile buffers around the A and B routes
The population exposure factor for the considered routes is:

Default Route: 0.42674
Route A: 0.0325
Route B: 0.0335

Route A is the optimal route based on the population risk criteria.

C. Economic Consequence Factor

The release of radioactive materials will have economic impacts. These impacts are measured in the Guidelines by calculating the cost of decontaminating the irradiated land and buildings. The economic consequence measure multiplies the land use within bands along the road segment by multipliers to arrive at a cost of decontamination. The multipliers are:

<table>
<thead>
<tr>
<th>Land use type</th>
<th>0-5 mile Band</th>
<th>5-10 Mile Band</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rural (applies to vacant land also)</td>
<td>0.002</td>
<td>0.0002</td>
</tr>
<tr>
<td>Residential</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Single family</td>
<td>0.10</td>
<td>0.04</td>
</tr>
<tr>
<td>Multi-family</td>
<td>2.0</td>
<td>0.20</td>
</tr>
<tr>
<td>Commercial/Industrial</td>
<td>0.20</td>
<td>0.01</td>
</tr>
<tr>
<td>Parks</td>
<td>0.03</td>
<td>0.02</td>
</tr>
<tr>
<td>Public Areas</td>
<td>0.50</td>
<td>0.05</td>
</tr>
</tbody>
</table>

Figure 2-6 Land use multipliers

The land use areas are multiplied by the economic consequence measure and summed to obtain a total value for each road segment. This product is multiplied by the
accident rate to create the economic consequence measure. The spreadsheets used to calculate the economic consequence measure are presented in Appendix 1. The economic consequence measure for each route is:

Default route: \(0.0002\)

Route A: \(0.000048\)

Route B: \(0.00005\)

Based on the evaluation, Route A is the optimal route. The economic consequences factor is the most controversial of the three primary criteria. Theories about risk perception have focused much attention on the incompleteness of this measure. Problems of the distributional effects of the radiation, long term impacts on land value and public health are all ignored.

**DOT Route Selection Results**

The Department of Transportation methodology produces a reliable result that clearly differentiates one route from others. The results are presented below:

<table>
<thead>
<tr>
<th>Route</th>
<th>Normal Exposure</th>
<th>Population</th>
<th>Economic Consequence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Default Route</td>
<td>7.06</td>
<td>0.42674</td>
<td>0.0002</td>
</tr>
<tr>
<td>Route A</td>
<td>0.198</td>
<td>0.0761</td>
<td>0.000488</td>
</tr>
<tr>
<td>Route B</td>
<td>0.853</td>
<td>0.0335</td>
<td>0.00005</td>
</tr>
</tbody>
</table>

Figure 2-7 Unadjusted route selection results

The Guidelines effectively discriminate between rates. The expert risk assessor would argue that the analysis presented above is sufficient. Unfortunately, the issues in route
Evaluation of the Route Selection Process

Discussion about route selection remains mired in methodological swamps. Various parties examine the efficacy of individual parts of the Guidelines without placing discussion about risk assessment in its broader context. Fisher’s framework of policy discourse is useful for this purpose because it lifts the policy analysts’ attention away from the mundane problems presented by methodological discussion to fit risk assessment in its broader context. This section will look at the Guidelines with Fisher’s framework and examine the difficulties of expert risk assessment.

1. Program Verification

At the first level, the observed performance of the policy is evaluated. Fisher’s framework demands that the facts of the policy show they are relevant to the problem. Does the policy perform as advertised? At first glance, the Guidelines appear to provide a meaningful basis for comparing routes. The Guidelines, when applied to the state of Nevada, did distinguish between three routes. The numerical calculations are straightforward and the data are readily available. Fisher’s’ first question can be answered affirmatively, but not conclusively. There are two problems with the Guidelines that are common to any expert risk assessment.

Data Collection

The very act of collecting and organizing data excludes other information from being gathered and used. Any expert risk assessment can be assailed for the incompleteness or poor quality of data. In the nuclear field, only the acute affects of
radiation are considered. The long term health effects of low levels of radiation are poorly understood and cannot be included in an analysis of this type. The conclusions drawn by applying the Guidelines are eternally open to question because of incomplete data.

Another constraint on the data is created by constant changes in reality. The data we collect today may have no predictive value for the future. Slight changes in the DOE program can easily make data already collected invalid or obsolete. Formaini cites the case of Love Canal to illustrate how facts do not necessarily lead to sound conclusions. He cites how one firm did blood samples and found "chromosome damage." However, State investigators did not have the statistical evidence to support the claim.65

Sometimes the consumers of expert risk assessment do not understand the limitations imposed by data collected.

In the case of the Guidelines, each of the variables used to calculate risk are assumed to be meaningful when applied to a future shipping campaign. The average annual daily traffic (AADT) number is a case in point. Even if the averaging is accepted, the dramatic economic growth in the region manifests itself as increasing traffic. This increase in traffic is extremely variable. The numbers used for one year are not applicable for the next, the numbers for one route are not necessarily applicable to the future. These assumptions may be necessary, but they prevent any route comparison from being beyond question.

---

Another case where the data fails is in calculating populations. Population numbers can be challenged because they reflect nighttime population rather than daytime employment. The expert view of risk assessment wanders into a methodological hall of mirrors from which there is no escape. Critics are free to question and challenge the assumptions used by the expert risks assessor, while the risk assessor can only appeal to specific legislation or to the scientific method for support and legitimacy. But, in questions of public policy, neither is likely to be held universally meaningful by the affected parties. Uncertainty about data leads us to ask whether or not the objectives of the Guidelines could be more effective using a different method.

Methodological Concerns

Another set of problems at this level, is that the Guidelines do not necessarily provide the best method for comparing routes. The Guidelines themselves offer an array of alternatives. For example, the Guidelines do not specify which accident rate should be used to calculate the risk. There are five alternatives cited in the Guidelines:\footnote{\textit{\textsuperscript{60} Department of Transportation, Highway Routing of Hazardous Materials, Guidelines for Applying Criteria.} Wash DC Nov 1996. P 20.}

- Truck accident rate
- Hazardous materials truck accident rate
- Fatal accident rate
- Accidents with property damage in excess of $1,000
- National average accident rates

A risk assessment performed with one accident rate can always be criticized for failing to use one of the other rates. The selection of an accident rate is ultimately a subjective
decision. None of the accident rates is necessarily better than any of the others.

The result of these problems is that the Guidelines fail to guide. The empirical issues raised at this level of analysis are insoluble. The Guidelines, to be an effective policy tool, should resolve empirical questions. They should be able to produce the most persuasive answer to comparisons of risk. Instead, they raise more questions and direct critics to alternative answers that can be used to contradict the route selection. The failure of the Guidelines points to the next level of Fisher's analytical framework.

2. Situational Validation

The failure of the Guidelines to empirically demonstrate that one route is superior to another has dampened the ambitions of expert risk assessors. They now defend much less territory than Starr first described. At this level the questions asked are: Is the program relevant to the problem situation? The answer for the Guidelines is 'yes.' The examination of routes given in the Guidelines is appropriate. Comparing routes using the factors described is certainly important and useful. However, it may not be the best process. The quantitative measures developed by the risk assessors are all relevant. But they can never be sufficiently persuasive to justify adopting the policy based on the strength of their argument alone.

Critics of expert risk assessment have argued in favor of “comprehensive risk assessment” which would broaden the definition of the risks and consequences.67 Advocates of expert risk assessment counter that in order for any risk assessment to be

---


Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.
performed, the variables considered must be limited rather than expanded. The problem for advocates of the Guidelines is that the Guidelines are only one method of arriving at a route selection discussion. Whether or not the Guidelines provide the best method is an open question. Expert risk assessors themselves argue about the best measures of risk. There are numerous alternatives within the field of expert risk assessment.

The most serious problem with the methodology of expert risk assessment relates to the definitions used by the Guidelines. In this case the most fundamental question is the risk itself. The traditional measure of risk is the probability of death. The probability of death is expressed as the likelihood of an event ("hazard" in technical parlance) multiplied by the consequences of that event. The problem for the Guidelines is that most people use a broader definition of risk. Indeed, it is hard to come to agreement on a simple definition of risk. It demonstrates how the expert view of risk reduces the world to manageable dimensions. In doing so it must lose some of its credibility and much of its legitimacy.

Nowhere is the problem of definitions better illustrated than in the measure of


economic consequences. The Guidelines definition of economic consequences is open to question. Social scientists attacked Starr's definition of risk as inadequate. They felt that there were other factors to be considered. The field of risk perception grew out of dissatisfaction with the methodology used to analyze risk given its narrow definition.

The cost to decontaminate affected structures is a major indication of how far the Guidelines go in abstracting from reality. For example, the long-term impact of a radiation spill on families, homes, commerce, and communities is not nearly captured by that factor. Neither are the "social costs" incorporated into this measure. These costs, such as costs to local governments for emergency response preparations, are completely ignored by the Guidelines. This definition of risk has become a lightning-rod for criticism of expert risk assessment. Expert risk assessors are comfortable with the definition, but few others are.

Discussion about route selection seldom examines the basic methodological implications caused by the definition of risk. The desire of the technical experts to confine the discussion is more the result of their formal training than in a recognition of the practical needs of policy making. The Guidelines present problems because although they are intended to create exceptions to the default interstate route system, they do not allow for exceptions themselves. At this level of analysis there is no clear answer.

---

3. Societal Vindication

At this level of analysis the Guidelines must demonstrate that they have a value to society. In all of the transportation discussion about HLW, there is little mention of the fundamental question: Should HLW be transported to a storage facility at all? At this level of analysis, in order for the Guidelines to be valuable, they must show that they provide value to society. They do this only if it is assumed that society desires the waste to be transported. In the present case, this seems self-evident. The Congress, acting on behalf of the American people, voted to enact the program that would require shipments and created the Guidelines. But there are problems with this assumption. The first is the inequitable distribution of impacts. The Guidelines and indeed all of the technical risk literature is deaf and dumb on the inequitable distribution of risks. Freudenberg refers to this as "risk assignment."³

Inequitable distribution calls into question the legitimacy of the Guidelines as a policy-making instrument. They raise basic political questions about how routes should be designated. To be fair, the Guidelines are, in this respect, no different than the policies denominating default routes through the country. This blindness to the inequitable distribution of risks raised by the Guidelines is a serious problem that lingers in all of expert risk assessment.

The second problem created by the Guidelines is that of unintended consequences.

In order for the Guidelines to function, the people affected by the transportation of HLW must abandon themselves to the results of a study in which they had no influence. The Guidelines admit little public complaint and no challenge. In fact the public has no place in the discussion except as objects to be counted and tallied to generate results.

According to the Department of Transportation, which promulgated the Guidelines, the public was excluded because so little is known about HLW. But this logic seems inverted: because science cannot tell us much about the problem of shipping HLW, we must rely more heavily on the little science we have.

This is not the case in selecting routes for hazardous materials. In hazardous materials route selection, public agencies and local citizens groups are embedded into the process as key participants who shape and define relevant issues. It is ironic that the Guidelines for Applying to Criteria to Select Routes for Hazardous Materials are also published by the Department of Transportation. It seems odd that the public is involved when private industry shipping is concerned, but when the shipping program is performed by the Federal Government, the public is excluded.

The Guidelines are in fact anti-democratic and mildly subversive by their exclusion of public concerns. By demanding the affected public relinquish its standing in the route selection process, it denigrates both the public and the local officials elected by

---


Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.
that public. Policy discussion about risk assessment seldom addresses this problem. Instead, the affected public is treated to large doses of public relations.\textsuperscript{76}

4. Social Choice

At Fisher's highest level of analysis, the Guidelines are placed in their broader context. The Guidelines must demonstrate that they select routes in a way that is consistent with the accepted social order. Phrased another way: Will the Guidelines be regarded as legitimate by the people affected by transporting waste? The expert view of risk exemplified here by the Guidelines does not accomplish this most basic task.

Because the Guidelines may not be regarded by affected stakeholders as legitimate, they have succumbed to death by inanition. Instead of a credible policy tool, the Guidelines' failure to address the need for political legitimacy transforms it into a toy for engineers and technicians. Since 1987, 15 laws have been passed by Congress that relate to risk assessment.\textsuperscript{77} Many of these laws mandate the use and scope of risk assessment. Congress, which increasingly relies on assessments of this type, is progressively abandoning its role as a deliberative body by choosing to rely on technical experts in order to seek objective answers.

A distinctive feature of expert risk assessment manifests itself at this level. Expert risk assessment sacrifices the ability of the public to shape policy. Aaron


\textsuperscript{77} Aaron Wildavsky, "No Risk is the Highest Risk of All" \textit{American Scientist} vol. 67 No 1. (Jan-Feb 1979): 32-37.
Wildavsky has identified this as a cultural divide.\textsuperscript{78} The most important goal for the future of expert risk assessment to see this cultural dimension of its own thinking and to find a way to reconcile technical elegance with democratic concerns. The Guidelines require the public to abandon their standing in the policy arena and accept a society driven by the numerical calculations of technical elites who chose to ignore the disparate impacts of their decisions.

Summary

Fischers' model of policy analysis highlights the many failings of the Guidelines as a public policy instrument. The empirical questions raised are unanswerable. On expert assumptions, there are numerous alternatives to the Guidelines. The Guidelines themselves have no concern for the distributional effects they cause and finally the Guidelines require the public to become subservient to the technical world view. This last is the most important basis for dissent from the expert view of risk. The vague discomfort many have with expert risk assessment is focused here. The democratic view of risk has made many trenchant criticisms of the expert view of risk. But critics must demonstrate that they have a better explanation of risk. Chapter Three will provide the same examination of democratic risk that was performed for expert risk assessment in Chapter Two.

\textsuperscript{78} Ibid., 36.
CHAPTER 3

DEMOCRATIC RISK ASSESSMENT

Criticism of expert risk assessment has coalesced into a distinctive approach referred to here as democratic risk assessment. This chapter will: 1) describe democratic risk assessment; 2) apply the Comprehensive Risk Analysis (CRA) criticisms proposed by Golding and White to the problem of selecting routes through the State of Nevada and 3) analyze CRA with Fischer’s framework. This analysis will highlight the deeper problems with democratic risk assessment.

What is Democratic Risk Assessment?

It is an ironic characteristic of the democratic view of risk that democratic theories about risk lagged behind legal precedent. While Liemkuhler was laying the groundwork for expert risk assessment in transportation, the Supreme Court established the legal precedent for the democratic view of risk. In 1959, the Supreme Court awarded damages on the basis of the perceived loss of value of land due to the siting of power lines in TVA vs. Willesley. The court based its finding on perceived effects, not on any quantitative evaluation of risk. This finding established a measure of risk inconsistent with the expert

view even before the expert view was fully formed.

Democratic risk assessment treats risk as a social construct that is the result of complex interactions between societies, cultures, technology and the natural world. They argue that no thing possesses risk. Democratic risk assessors argue that risk is a "post-normal" concept that cannot be readily accessed by reason.®® Risk is a function of how it can be used by human beings—hence the ever-present subjectivity in all risk assessments.®¹ That is, societies pick and choose what is and is not defined as risk. They argue that the selection of risk is not based on any quantitative analysis, as in expert assessment. Rather, the identification and selection of risk is the result of complex interactions between culture and the natural world.®²

Mary Douglas through her collaboration with Aaron Wildavsky originally enunciated the theory. They cite several examples from other cultures to sustain their point of view. They take great pains to show that societies make mistakes in risk selection. The Lele people of Zaire, for example:®³

...suffered all the usual devastating tropical ills-fever, gastroenteritis, tuberculosis, leprosy, ulcers, barrenness, and pneumonia. In this world of disease, they focused mainly on being struck by lightning, the affliction of

---


®¹ Formaini, The Myth of Scientific Public Policy, 16.

®² Shrader-Frechette, Risk and Rationality, 31.

®³ Douglas and Widlavsky, Risk and Culture, 42.
barrenness, and one disease, bronchitis: they mainly attributed these troubles to specific types of immorality in which the victim would generally be seen as innocent and some powerful leader or village elder would be blamed.

Poor risk selection can even destroy entire societies. Douglas cites the nomadic Hima people who are convinced that women should be kept completely apart from cattle. The Hima are convinced that human reproduction is an explicit threat to cattle reproduction. The result of the Hima's complex pollution beliefs is that the tribe's population is shrinking rapidly, and the tribe is facing extinction.

Douglas and Wildavsky equate Hima society with our own societies and point out that our own theories about danger can take on a similar, unrealistic tinge under outside inspection. They cite poll results and other numerical measures as proof that modern technological societies are no different than the misguided Lele or the luckless Hima. This formulation of risk, referred to by Shrader-Frechette as "Cultural-relativism" argues that the selection of dangers and the choice of social organization run hand in hand. In the field of nuclear safety, the democratic view of risk might have remained an academic artifact had it not become an essential tool in the debate over risk policy.

---

81 Ibid. 40.
85 Ibid. 41
86 Ibid. 44.
87 Ibid. 44-48
88 Shrader-Frechette, Risk and Rationality, 38.
89 Douglas and Wildavsky, Risk and Culture, 186.
The Reactor Safety Study

In the field of nuclear power, the democratic view was used to respond to the Reactor Safety Study (RSS). This report was commissioned by the Nuclear Regulatory Commission (NRC) to demonstrate to the public that nuclear power was safe. The report was a watershed in expert risk analysis because it established the techniques used by future risk assessors and, most importantly, the study's objective was to influence public policy.

Unlike previous expert risk assessments, the RSS deliberately sought to sway public opinion in favor of nuclear power. This objective is completely consistent with Starr's goal of informing public policy by calculating the likelihood of harm. RSS is an interesting example of how expert risk assessors think they think. The study group expressed its results in quantitative terms and believes that this expression of risk will be satisfactory to everyone potentially affected by the program. The RSS ignored the role played by expert judgment in reaching final conclusions. The quantitative approach was, they thought, sufficient to sway public opinion in favor of nuclear power. The techniques used in the study set the standard for all future expert risk assessment. Fault trees, decision trees and other tools of the expert risk assessor were all introduced in that

---


91 Ibid.
Ironically, despite its technical elegance, the report was important more for the controversy it created than for its contribution to expert risk assessment.

When the executive summary of the report was released it caused immediate controversy for several reasons: 1) the use of expert judgment in preparing the report was neither mentioned nor documented. 2) long-term health effects of radiation (in both high and low doses) were not considered. 3) public input was never solicited, 4) it did not indicate uncertainties associated with probability estimates, and 5) it did not address accident initiating events such as sabotage and terrorism.93

The "disastrous" release of the executive summary of this report also excluded any social considerations in calculating the risks imposed by nuclear reactors.94 This exclusion, along with other faults in the study forced the NRC to establish a review group to look at the process of risk assessment generally. This sparked interest in studying the risks of nuclear power. New studies began in the early 1980's and were often underwritten by states who were potential nuclear waste repository sites. These studies were similar to the RSS in that they hoped to influence public policy as their goal. These studies differed from the RSS because they attempted to broaden the definition of risk in the hope that a new view of risk would give affected parties greater say in the program.

92 Ibid.


Like expert risk, democratic risk assessment has, as its goal, influence over public policy.

Democratic Risk Assessment

New studies of risk placed man at the center of the analysis and culminated in Paul Slovic's "psychometric model" of risk. This model of risk was developed using sophisticated survey and statistical techniques to measure how people felt about risk, as well as how they made comparisons between alternative risks. The studies found significant differences in the way people of different ages, races, and genders evaluate risk. Slovic and his associates (notably James Flynn) attempted to show how risks are perceived. The public evaluates and compares risk in a complex manner that could be identified using public opinion surveys. His views closely follow Douglas' and are recognizable as a more reasonable model of risk than the expert view. The expectation of democratic risk assessors is that if social scientists incorporated public sentiment into risk assessment then progress was possible.

Portions of the democratic view of risk have made important inroads in the policy debate. In the fifteen years since the original studies were performed, survey research and sampling have become mainstays in risk assessment. The relevance of the public has

---


96 Ibid., 687.

97 Hank Jenkins-Smith and Gilbert W. Bassett Jr. "Perceived risk and Uncertainty of
also found its way into risk assessment. A society to study risk has been formed and the theoreticians once outside the mainstream of risk assessment are now accepted members. Even the DOE has tacitly adopted the view of the democratic risk assessors by using public opinion surveys along waste transportation corridors.  

Risk assessment seems poised to make a huge leap forward in its functionality as a public policy tool by using social science to study both the physical world and the perceptions of the people. However, the introduction of opinion surveys has failed to make the public more receptive to the results of risk assessments. Retargeting quantitative measures to people as well as things has not improved the policy performance of risk assessment. The State of Nevada remains firm in its opposition to the proposed repository. Informal opposition groups have actually increased membership after these tools were used.

Despite hard-won acceptance, only portions of democratic risk assessment have found their way into the mainstream of discussion about transportation route selection. Issues of importance to democratic risk assessors such as: human factors analysis, sabotage and terrorism are seldom incorporated. Indeed, it can be argued that the use of democratic risk techniques are actually in decline. In 1984, the NRC promulgated

---


98 Hank Jenkins Smith, Transporting Radioactive Materials presentation to the DOE’s Transportation External Coordination Working Group. 19 January 1996.

regulations which incorporated the threats of terrorism and sabotage into the study of transporting HLW. In 1989 these regulations were withdrawn, because the "probability of that risk was negligible."\textsuperscript{100}

A major failing of the democratic view of risk has been that its proponents have stopped short of implementing their vision of risk in a way that can be used by policy makers. Unlike expert risk assessment, which was intentionally crafted to meet the needs of decision makers, democratic risk assessment does not have a methodology that can be implemented in a way that produces reliable results. The variables considered by one democratic risk assessor may not be used by another risk assessor working on a similar project. Risk perception remains a highly controversial subject. A simple definition that has observable results is not available. Numerous counter examples exist that seem to refute the idea of perceived risk.\textsuperscript{101} For example, more people are using the land near nuclear power plants for home sites.\textsuperscript{102} It is not yet clear how risk perception or low probability events can be integrated into any risk assessment. Essential things such as standard terminology, best practices, and common epistemology have never been developed for the democratic view of risk.


\textsuperscript{101} Metz, "Potential Negative Impacts of Nuclear Activities on Local Economies: Rethinking the Issue," 771-772.

\textsuperscript{102} Metz, "Potential Negative Impacts of Nuclear Activities on Local Economies: Rethinking the Issue" 765.
Proponents of democratic risk analysis remain too content to point out the failings of the expert risk assessment without providing a true alternative. This has enabled expert risk assessors to exert control over the field by pointing to their contributions to policymaking. The democratic view of risk creates problems for decision makers, rather than solving them. The expert risk assessors’ actuarial tables, mortality charts, and cost-benefit analyses reign supreme and enable expert risk assessors to dismiss the democratic view of risk as mere politics. The close association of prominent democratic risk assessors with opposition movements (notably nuclear waste) has leant credence to the view that democratic risk analysis is merely a device to oppose unpopular programs.

Comprehensive Risk Assessment

The single attempt to create an alternative to the Guidelines was funded by the State of Nevada. This report, *Guidelines on the Scope, Content, and Use of Comprehensive Risk Assessment in the Management of High-Level Nuclear Waste Transportation* (hereafter referred to as CRA) was prepared for Nevada’s Nuclear Waste Project Office by Dominic Golding and Allen White in December of 1990. The report expressed the state’s concerns about the relevance of sociological knowledge and is the nearest application of the democratic view of risk assessment developed in the transportation field. The state report is noteworthy because it provides a blueprint for applying the democratic view to risk assessment.

---


104 Ibid., 5-6
The authors begin by highlighting limitations in expert risk assessment. They believe that broadening the definitions of risk and examining special situations would successfully incorporate the concerns of democratic risk assessors and the public. However, a key component of their report is that "No new basic methodology is needed, but existing methods may have to be adapted or extended." They believe the epistemology of expert risk assessment is valid - it need only be expanded to include the social sciences.\textsuperscript{105}

The authors say that opening the process of risk assessment to input from the social sciences will encourage a comprehensive view of risk assessment by enlarging the definition of the causes and the consequences of transportation hazards. They claim their process will provide greater realism to risk estimates and yield results that are more coincident with public sensibilities. They look at 1) initiating events, 2) consequences, and 3) uncertainty as particularly fruitful areas for improvement.

By initiating events, the authors refer to events that cause accidents. They focus on human error as a primary cause of failure in complex technological systems. This is consistent with findings in other transportation accident analyses.\textsuperscript{106} The authors also denigrate expert risk analysis as a tool to understand low-probability, high-consequence events such as terrorism, sabotage, and natural disasters. The authors believe that the consequences of accidents chosen by expert risk assessment are also very clear. As

\textsuperscript{105} Ibid., 5.

alluded to above, the consequences of a HLW transportation accident are a very controversial subject. CRA would include: "economic losses; the costs of emergency planning and preparedness; the behavior of public officials and households under emergency conditions; declining property values; psychological stress; and so forth."  

Another area in which CRA provides guidance is by acknowledging the uncertainty that exists in transportation risk assessment. The authors say that this uncertainty arises because of:

- poor or inadequate data;
- the choice of models and assumptions;
- the use of expert judgment as a substitute for poor or missing data;
- the assumptions about human factors, and human and organizational errors; and,
- human error in estimation techniques

CRA is consistent with the ideal of democratic risk assessment because it demands that greater attention be paid to non-radiological impacts and economic consequences. The authors explicitly criticize the expert view of risk for using a narrow definition of risk. They say a comprehensive risk assessment needs to address the complete range of events and consequences, and be able to accommodate a broader view of risk that is more compatible with that of the public. They do not however, define that broader view or how it can be implemented.

**Application of Comprehensive Risk Assessment**

---

107 Golding and White, 10.

108 Ibid., 4.

109 Ibid., 4
Unlike expert risk assessment, the democratic view of risk is difficult to apply. The primary reason expert risk assessments have gained such a hold in policy making can partly be explained by the failure of the democratic view to produce a reliable alternative to the expert view. CRA, unlike the Guidelines, contains no procedure for comparing routes. The clear-cut numbers and equations of expert risk assessment are not available in the democratic view.

The authors highlight and discuss in detail what goes wrong with expert transportation risk assessments. They do not, however, show 1) how to measure the variables they recommend including in their analysis and 2) how to integrate these variables into a route comparison. This failure is a major handicap for democratic risk assessment and occurs because democratic risk assessment is partly hostage to its intellectual roots.

Douglas' comparison between our own society and that of aboriginal tribes is meant to demonstrate how difficult it is to argue that risk assessments are not derived partly by cultural factors. The fact that the Hima's and the Lele's risk beliefs are noteworthy is itself evidence of the cultural differences inherent in risk selection. This logic provides an argument against democratic risk assessment. If it is impossible to differentiate between risks because of cultural differences, then there is no basis for comparing any risk assessments.

Mary Midgley's analysis of cultural relativism (which she referred to as "moral isolationism") explains how it is possible to distinguish between policies despite the possibility of cultural bias. Her critique is relevant for the risk assessment because it
illustrates the weakness of the democratic argument. Midgley uses a non-controversial example to show how it is possible to distinguish between a good and bad policy despite the existence of cultural differences. The example she uses is the ancient Samurai custom of testing a new sword by killing a random passerby. Midgley argues that it is possible to criticize this custom on a moral basis despite cultural distinctions. She describes how it is difficult to do otherwise.\textsuperscript{110}

Midgley makes three pertinent criticisms of the cultural relativist viewpoint. First, she asks whether or not cultural bias should prevent praise as well as blame. The work done on perceived risk is almost completely negative, in the sense that it is a critique of positivist method rather than an attempt to construct an alternative argument. The proponents of democratic risk assessment showcase our fears and anxieties, but do not replace them with anything. If their theories were balanced, then there should be room for constructive effort rather than a wholly negative orientation.

Midgley's second question is: what is involved in judging? This is question democratic risk assessors have not been prone to address. Only Paul Slovic, has attempted to dissect and explain what variables constitute our fears.\textsuperscript{111} To date, no democratic risk assessor has shown how these variables work together to produce fear. This omission also fails to explain how counterexamples to the theory of democratic risk


occur and why they occur. The democratic position on risk ultimately "forbids us to form any opinions on these matters. Its ground for doing so is that we don't understand them." The democratic view of risk disarms any discussion of risk by rejecting the validity of any process used to understand it.

The final question posed of cultural relativism is: If we can't judge other cultures then how can we judge our own? The democratic view of risk suffers because it cannot explain itself to itself. If risks are perceived according to culture, then how can we know that. Perhaps there is no such thing as risk at all. Democratic risk assessment cannot argue on its own behalf. These problems with the theory lead democratic risk assessment into a "formless relativism" that ultimately kills any kind of risk assessment as a policy tool.

The problems raised by Midgley have not been addressed by either side of the debate. The expert risk assessors claim that any introduction of cultural factors will inevitably lead no where, while democratic risk assessors have not shown they have the stomach to do more than criticize the expert view of risk. Accepting the methods proposed by CRA can create problems.

In order to judge the efficacy of emergency measures, people living near two nuclear power plants were surveyed. The survey found that 40% of the people living near one nuclear power plant would evacuate based on an emergency message. The same message played to the audience of people living near a different power plant would cause 25% of residents to evacuate. There are clear differences between the two populations, however, democratic risk assessors have provided no insight as to how these differences
can be reconciled. Democratic risk assessors argue that social and cultural factors must be included in the discussion but do not say how.

The difficulty of measuring economic effects is an example of the difficulties with democratic risk assessment. Economic effects are measured in the Guidelines by the cost to decontaminate buildings. This cost is relatively easy to measure if standard costs are agreed upon. The definition of economic impacts used in the CRA is more problematic. CRA recommends that economic effects of transporting waste be measured by the following variables: 1) economic losses; 2) the costs of emergency planning and preparedness; 3) the behavior of public officials and households under emergency conditions; 4) declining property values; 5) psychological stress. The authors airily claim that these variables should be included but do not indicate how they should be measured or how competing interests can be reconciled. Unlike the Guidelines, there is no clear-cut definition of impacts.

The first variable, economic losses, is difficult to forecast without any previous accident experience for high level waste. Proponents of DOE's program argue that the absence of any accident history suggests that the economic effects will be slight. However, the centerpiece of the State of Nevada's argument in favor of selecting routes that avoid Las Vegas is that shipping waste through Las Vegas would cause economic losses. The State believes that the profitability of the Casinos would be affected by the fear caused by those shipments. There are others, however, who argue that there will be no long term effects caused by the perceived fear of the shipments. This contention is
supported by the experience of real estate appraisers. CRA provides no method for resolving this question and appears to assume that it would be simple to resolve.

The second variable, the cost of emergency preparedness also presents definitional problems. Emergency response capabilities must be tailored to an accident scenario. However, there will be legitimate dispute about what kind of accident the local responders will have to cope with. People with their eyes on the budget will favor historical accident rates which suggest that virtually no radiation will ever leak. The people living along the routes may demand a higher standard of training. Once more, CRA possesses no mechanism to resolve this dispute.

Preparing a forecast of the costs incurred by public behavior is also very difficult. The risk assessment profession is wrestling with the program of predicting low probability, high consequence accidents—such as a radiation spill from a transportation cask— the discipline has not developed to the extent that it is capable of an even more sophisticated appraisal of what would be the cost of the public’s response to such an accident.

The negative impact transporting waste may have on land values remains hotly contested. The likely costs of psychological stress are a similar challenge. Both problems are open to abuse. Expert risk assessors have chosen to exclude any consideration of these costs. There is little chance of obtaining agreement on these costs.

---

There are undoubtedly other variables that could be used in place of or in addition to those proposed in the CRA. CRA does not provide any insight into how to operationalize these variables. The democratic view of risk assessment is tied to the use of the social sciences as a means of integrating the facts and values. Fischer's framework highlights the deeper flaws in the democratic argument.

**Fischer's Framework Applied to Democratic Risk Assessment**

Fischer's framework illustrates both the shortcomings and benefits of CRA. It does so in a way that points the way to the new requirements for risk assessment.

1. Program Verification

   At the first level of Fischer's framework, the democratic view of risk (as exemplified by a comprehensive risk assessment) must answer these questions:

   a) Does the program fulfill the stated objectives?
   b) Does the analysis uncover secondary or unanticipated effects?
   c) Does the program fulfill the stated objectives better than another?

   CRA does not fulfill its objectives because it does not make clear how the recommendations contained in the report can be applied. The report itself is a series of recommendations for improving existing expert techniques. The democratic view of risk expands the scope of expert risk assessment to include the concerns of the public, however, in practical terms it also becomes incomprehensible and unmanageable. Another problem is that CRA admits it builds on the Guidelines; it embraces the procedures contained in the Guidelines and merely supplements by widening the definition of risk. As a result, it incorporates the problems of the Guidelines (and of
expert risk assessment) without resolving them.

CRA creates unanticipated consequences that make its practical implementation doubtful. The CRA process is highly ideographic in that the results of one route assessment are unlikely to be successfully applied to another route. The democratic view of risk relies heavily on survey research to reach its conclusions. Virtually all of the perceived risk literature is the reportage and interpretation of survey results. Public opinion surveys conducted along alternate routes will be unreliable and open to dispute.

Survey questions may be asked along a transportation route, but the respondents and conditions in the route can change, negating the persuasive ability of the analysis. Questions may be answered based on self-interest or ignorance. The data is also perishable and subject to manipulation. A well-funded agency could implement an advertising campaign prior to a survey that would skew the results of the survey. Proponents of DOE’s program routinely dismiss the result of surveys sponsored by the State of Nevada. The example cited above of the difference in response likelihood varied between locations near nuclear power plants. CRA contains no plan to integrate data developed by social sciences with the data developed by statisticians and

---

transportation engineers.

The survey method of measurement used by Slovic in his psychometric paradigm is open to question and assault. Relying on polls as the basis for selecting routes is a difficult endeavor. It presents ethical problems that are beyond solution. Foremost among these is the tyranny of the majority. By using the opinions of the majority of the respondents, the democratic risk assessor forecloses the rights of the minority respondents. Areas that are well informed about problems of nuclear waste may express greater indignation at shipping campaigns. They can arrange to avoid transportation of waste through their areas. Using polling data as a guide to understanding public perceptions about shipping HLW, as has been done by the DOE, \(^{115}\) raises the question not just of whether or not the public is informed but how uniformly the information is distributed among affected parties. Areas with access to better information about the issue will naturally be better at avoiding route selections that effect them. Nevada is an example of how a sophisticated policy infrastructure already exists that can compare and select between routes. Nevada's expertise poses problems for its neighbors who do not have the same degree of sophistication.

There is little evidence that CRA is a better empirical tool than the Guidelines. A major criticism of expert risk assessment is that its definition of risk is too narrow.

\(^{114}\) Metz, "Potential Negative Impacts of Nuclear Activities on Local Economies: Rethinking the Issue" 765.

Although CRA requires that the "full range of initiating events be evaluated" there is no indication of what the full range of events is or who will decide what are those events. The Guidelines suffer from too narrow a definition of risk. CRA suffers from no definition of risk. The consequence of this limitation is that necessary methodological assumptions are just as uncertain in CRA as they are for the Guidelines. People affected by high-level waste transportation can infinitely broaden the effects of transport. The proponents of shipping can argue equally forcefully that any definition is too narrow. Given the procedures in CRA, it will be impossible to arrive at consensus about even the most basic questions. CRA does not provide a viable alternative.

At this level of Fischer’s analysis, CRA cannot claim to make a better comparison than the Guidelines. CRA must provide a more persuasive and convincing analysis than the Guidelines for it to be used as a substitute. Proponents of comprehensive risk assessment have only suggested a process that confuses the issue. CRA merely enlarges the amount of data collected without improving the meaning of the data collected. CRA’s performance as a policy tool improves at the next level of evaluation

2. Situational Validation

At this level of analysis, CRA is subjected to three questions:

a. Is the program relevant to the problem situation?
b. Are there circumstances that require exceptions to be made?
c. Are two or more criteria better applied to the problem?

The first answer is that CRA is certainly relevant to the problem solution. However, the problem for CRA is that it is not more applicable to the problem of route selection than the Guidelines. Some of the limitations of the Guidelines are not present in CRA. The methodological reforms recommended in CRA make it a more relevant choice than the Guidelines. However, the limitation with CRA is that although it recognizes these problems it does not adequately address them. There is no clear cut description of how routes can be compared by CRA. There is no process for examining the routes. There is no way to distinguish or compare between routes. In terms of comparing routes, the Guidelines remain unscathed by CRA’s criticisms because CRA provides no alternative methodology.

In this case CRA fails because there are no rules by which exceptions to the route selection can be made. CRA’s guidance is so broad that it does not provide any basis for comparing routes, or treating routes differently from one route to another. This leads to the answer to the third question at this level. The CRA is internally inconsistent. This inconsistency appears because CRA has broadened the discussion to the point that, for example, any evaluation of risk is just as good as any other. The absence of any structural limits to the definition of risk means that is impossible to distinguish between competing risk claims of hazard.

CRA fails to provide risk assessors with any basis for comparing route selection criteria. An example of this occurs in the selection of accident rates. Even the Guidelines propose seven different accident rates. CRA does not provide an empirical rule that could be used to choose between accident rates. The accident rate finally chosen for a
route selection could be calibrated to any one of several statistics. CRA provides no help in choosing between the competing claims and any set of criteria may be as sufficient.

At the second level of evaluation, the CRA contains grand ideas and sentiments but does not provide any method of operationalizing them. The advocates of perceived risk have leveled telling criticisms but provided nothing new. The second level of policy evaluation supports the assertion that CRA is more a collection of opinions than a true alternative to the Guidelines.

3. Societal Vindication

The third level of Fischer's framework moves from the "concrete situational context to the societal system as a whole." At this level the CRA begins to perform better than the Guidelines. It demonstrates a sensitivity to the full implications of shipping high-level waste. At this level the questions asked are:

a) Does the policy contribute to society as a whole?
b) Does the policy goal result in unanticipated problems with important societal consequences?
c) Does a commitment to the policy goal lead to consequences that are inequitably distributed?

CRA answers these questions better than the Guidelines because it allows the analysis to incorporate concern for the problems faced by affected parties. A CRA conducted as described in the document would be more attentive to society's needs than the Guidelines. The parties affected would have a greater chance to have their voices heard and an examination of the full impacts of the decision would be performed. But
problems for CRA arise at this level.

CRA introduces social science into the problems of risk assessment. The psychometric profile used to define perceived risk is an example of how social science can speak to problems of risk policy. However, the failure of CRA is the same as for the expert view risk. it fails to see that differences in the measurement of risk will become be manifested as political rather than technical issues. Even though the tools of social science may be incorporated into risk assessment, the same drawback exists-- these tools do not bring political legitimacy. The technocratic model of decision making is as inadequate when done by social scientific technocrats as when it is done by engineers.

The consequences of using CRA are also impossible to distribute equitably. Poll results, survey tools and qualitative methods cannot yield a uniformly equitable answer. In selecting routes one route must be chosen and someone must lose. There are mechanisms for compensating the losers in these discussions, however, these mechanisms only manifest themselves in a political atmosphere rather than through social science.

4. Social Choice

At first glance, democratic risk assessment appears to be a sufficient remedy for the drawbacks of expert risk assessment. As it is applied, however, it is insufficient for the same reasons. At the highest level of Fischer’s analysis, the following questions are relevant:

a) Do the fundamental ideals (or ideology) that organize the accepted social order provide a basis for legitimate resolution of conflicting judgments?
b) If the social order is unable to resolve basic value conflicts, do other social orders equally prescribe for the relevant interests and needs that the conflicts reflect?

c) Do normative reflection and empirical evidence support the justification and adoption of alternative ideology and the social order it prescribes?

Democratic risk assessors clearly see the problems with the expert view of risk assessment and still fall prey to them in practice. If risk assessment will deserve to play a role in public policy, it must be successful in winning public support. The fundamental ideals of the democratic risk assessors are sound. Aaron Wildavsky prominently argued that risk is political and can only be accessed by political understanding. However, that insight has not been incorporated into the everyday practice of risk assessment.

The democratic view of risk is closer to providing a legitimate basis for resolving policy conflicts than the expert view. The use of sophisticated statistical techniques and carefully worded polls has failed to reconcile Nevadans to a nuclear waste repository. The results of polls and focus groups have not enabled DOE to move radioactive wastes without controversy. These tools have been useful in understanding the character and depth of concern, but they have not proven to be a successful substitute. In practice, democratic risk assessors appear to know that risk is political, but choose to behave as though public opinion polls can substitute for political engagement. Democratic risk assessment can claim that its heart is in the right place. However, its brain has yet to follow.

The evidence from other activities continues to support the argument that slightly modified procedures can improve risk assessment so that technical analysis conforms more closely to the objectives of the people affected by the hazards posed. As currently
articulated by the CRA. democratic risk assessment is unable to resolve value conflicts. Instead, the public is treated to more of the same and the application of expert knowledge threatens the political system. However, as was to be expected, the response to technological uncertainty has spawned a number of new approaches to the problem of empowering the public to make decisions about technological risk.

Summary

In this chapter, democratic risk assessment was described. This view sees risk as a more complex phenomenon than the expert view of risk. Risk is impossible to understand outside some cultural context. This context shapes the technical analysis— and the risk chosen to analyze. A major drawback of the democratic view of risk is that it has adopted the epistemology of the expert view. As it is implemented in CRA, it accepts the problems of expert risk assessment while merely broadening the definition of risk. Fisher's framework shows that the problem as to who chooses the risks studied and how they are studied are political problems that cannot be addressed with the procedures and tools currently in place. In Chapter 4 a new process for performing risk assessments will be described. This process empowers the public to affect the technical program. It is built on the successful efforts of other disciplines and derives its strength not from technical merit but from political legitimacy.
CHAPTER 4
A New Process for Risk Assessment

Neither of the current approaches to risk assessment is adequate to provide guidance on comparing and selecting routes because both worlds of risk assessment create abstract models that are unconnected to the people affected by the risk. Easily recognized methodological problems conceal the anti-democratic world view of expert risk assessment. The democratic view of risk musters the same methods of expert risk assessors to identify the fears of affected populations but does not empower affected parties. In the context of selecting routes for transporting HLW, the two approaches to risk assessment are primarily distinguished by the undergraduate training of the risk assessors. This chapter summarizes the fundamental dilemma of risk assessment, provides a brief critique of risk communication, describes how the profession of transportation planning has handled similar problems, and provides a new route comparison process emphasizes a legitimate process as an important goal.

Risk Assessment’s Dilemma

The National Research Council’s committee on risk described the essential problem of risk assessment when it said: “detailed scientific and technical information is essential for understanding risks and making wise decisions about them, yet the people
responsible for understanding risk and the people affected by the decisions and who may therefore also take part in them are not themselves expert in the relevant science and technology."

This dilemma suggests that route comparison guidelines for high level waste transport must serve audiences usually excluded from risk assessments. The members of the public affected by risk are seldom able to influence the study design or interpret the results of risk assessments. This points to effective reforms of risk assessment. Any reform must meet two conditions: reliability and validity.

The problem of reliability is significant. Transporting high level waste will inevitably cause iniquities due to the spatial distribution of routes and the methodological uncertainties caused by limitations on our ability to collect and manipulate knowledge about the world. Affected cities have vested interests in the methodological assumptions embedded in risk assessments. Any new process will have to cope with methodological uncertainty while still producing routes that are not arbitrary. The route selection must be the necessary conclusion of some deductive process in order for it to be other than the result of arbitrary political power. It must also be perceived that way by affected parties.

Any route comparison must apply the same criterion to alternate routes in the same way. The criterion used in the analysis cannot solve the methodological uncertainties inherent in risk assessment. Instead a reliable process seeks to achieve a uniform evaluation of each route. Cost benefit analysis has had a similar experience.

The initial claims for cost benefit analysis were similar to those made by expert risk assessors. Cost-benefit analysis could "prove" one alternate was better than another. After numerous failures, cost-benefit analysts beat a hasty retreat to the current practice that merely attempts to apply their techniques in a uniform way.

Absolute proof is not the standard for route comparison. Instead mere uniformity is the goal. One methodological reform suggested is that data used in route selections be calibrated to observed data. Shrader-Frechette recommends calibrating expert opinion. Rather than calibrate risk assessors, it would be more productive to calibrate input data. This is not to suggest that past accident rates (for example) would be perfect predictors. Comparing past accident rates to averages would provide a basis for choosing which accident rate is most appropriate. The problem of reliability is important but it is not the central question. The challenge is not in how to apply criteria uniformly. The challenge is what criteria are relevant to legitimacy of the route selection?

Legitimacy

The other condition the selection process must meet is that affected parties perceive it to be legitimate. Research into risk perception suggests that actual estimates

---


119 Ibid.
of probability do not vary much between experts and laymen, however, the philosophical position behind interpreting the results varies greatly.\footnote{Karl Dake, and Aaron Wildavsky. “Individual Differences in Risk Perception and Risk-Taking Preferences.” \textit{The Analysis, Communication and Perception of Risk} ed. B.J. Garrick and W. C. Gekler, (New York: Plenum Press 1991) 76.}

The affected public considers human motivation in its risk assessment while technical risk assessors excluded human motivation. Social values play a part in risk assessment. Slovic cites the importance of trust.\footnote{Slovic, “Perceived Risk, Trust, and Democracy,” 679-682.} He points to the lack of trust as a cause of the decline in public confidence in the management of technological hazards. Despite the adoption of risk assessment techniques as a regulatory tool, there is little evidence those technical information changes public opinion.

Creating trust is difficult to do and easy to lose. In policy making there is a bias in favor of distrust because: trust-destroying events are more visible, they carry more weight, and sources of bad news are more credible than sources of good news. Distrust lingers by inhibiting contacts that would encourage trust. Risk has a component that is philosophical. The people affected by any risk perceive it differently based on its voluntariness or on the kind of risk.

The major flaw in Chauncey Starr’s 1969 article is that he failed to distinguish between individual and group risks. He equated the risks accepted by individuals (for example, mountain climbing) with risks that are borne or imposed by society as a whole.
Research has shown that people perceive differences in risks based on their voluntariness and scale. An individual who chooses mountain climbing as a hobby has accepted a risk qualitatively different from the person who lives near a route designated to carry high level waste by the Federal government.

The difference between these risks demands higher standards for trust on the part of the agency implementing the program imposing the risks. For route selection to be legitimate, it must possess three characteristics:

1. The affected parties must be fully informed of the route selection proposed and the process used to compare the routes.
2. The affected parties must have the ability to participate in the route selection process. That is the route selection must not be finalized without input from affected parties.
3. How the input from the public will be used to shape decisions must also be decided upon.
4. Affected parties must be compensated for losses based on the damage inflicted by the shipping campaign.

Incorporating legitimacy into risk assessment drastically changes how risk assessments are performed. In performing other duties, the DOE has strictly hewn to the letter of their governing regulations rather than making a genuine attempt to solicit information from the affected parties. The DOE has been accused of adopting a “Decide Announce Defend” strategy that excludes the public. The DOE makes decisions.

---

announces its program and desperately fights criticism of their program in an attempt to retain its credibility in the face of glaring errors or omissions. The process contained in the Guidelines is consistent with Decide Announce Defend because it gives artificially significant status to the mandatory factors whose value is open to dispute. A new process is needed to address this problem.

DOE officials have dismissed public involvement as a meaningless distraction. They argue that because public meetings are often acrimonious and few members of the public participate, there is little relevance in the process. The DOE officials have a point. Too often meetings decay into meandering discussions of trivial issues. The DOE appears to suffer from an inability to effectively obtain and efficiently use public input. There is also a poor attitude evinced by many senior DOE managers, which suggests that they arrive at public meetings unwilling to receive any meaningful input. Another reason the DOE derives little benefit from its public meetings is because it has fallen prey to the distraction created by the field of risk communication. Risk communication is important because it has not only failed, but also it has caused its clients to think they were succeeding when just the opposite was the case.

The Risk Communication Failure

The study of risk communication was inaugurated by comments made by the first

---

administrator of the Environmental Protection Agency. William Ruckelshaus.\textsuperscript{126} In 1985 he gave a speech that indicated that the procedures contained in the National Environmental Policy Act had failed to provide the desired results. He argued that the public did not understand the technical aspects of environmental assessments and that a new discipline was required to successfully transfer technical knowledge to laypeople.

Sadly, his proposal has been institutionalized by the creation of the field of risk communication. Risk communication imparts technical information about risk assessments to lay people. The typical risk communication project consists of a bulk presentation of technical knowledge to steering committees, panels and the public. Risk communication is used as an intermediate step between the calculation of the risk and the determination of whether or not the risk was acceptable. The basis for risk communication studies is that the public is rational about using technical information and that technical information will be used the in same way by both the public and risk assessors use it. Risk communication expects to repackage the technical data and present it to the public.\textsuperscript{127} Providing more information (even interpreted information) misses the point.

Risk communication shares with expert risk assessment the idea that increasing rationality on the part of the public will increase their willingness to accept the risk, that


“if only the public would understand this stuff isn’t so bad.” It does not admit that there may be a different kind of reasoning invoked when problems of public safety are concerned.

Risk communication was specifically developed to act as the servant of the agency funding the assessment rather than the people affected by the program being assessed. As a result, it is often little more than a public affairs activity struggling in the shadow of the assessors. Risk communication has results akin to guerrilla war. After appointing countless steering committees and advisory boards, the risk communicators win battles by converting the members of the boards but lose wars because their battlefield victories do not persuade the affected public.128

The Public and Risk

Although it is valid to inform the public about risk assessment, it is fatally flawed because it does not have legitimacy as a major goal. This is a substantial weakness in its approach. Studies have shown that opponents of technical programs are seldom convinced by additional technical information.129 Instead, opponents of programs use the information obtained from risk assessors to attack the assessment itself. Additional information is used to identify weaknesses in assumptions, data and models, all at the


129 Johnson, “‘Improving’ Risk Communication and Risk Management: Legislated Solutions or Legislated Disasters?,” 905.
The vocabulary of risk assessment is itself inarticulate as to how risk assessment is finally a political judgement.

Although the political nature of risk was understood by Douglas and Wildavsky when they first described the cultural aspect of risk, subsequent study of the cultural dimensions of risk has failed to recognize risk assessment as a discipline rooted in politics. In practice, both expert and democratic risk assessors have fallen into frenzy of academic activity that does not help craft public policy because it is not connected to political requirements.

Risk communication cannot make any meaningful inroads in swaying popular opinion because it begins with the premise of the public as audience instead of the public as policy maker. The technicians calculate some "risk" which is distributed in some way. The technicians assume they are correct and that their view of risk is shared by the people affected by their calculations. Fischer’s framework points out that larger questions about our society play a role in policy making. For example, what kind of society do we want to live in? Research into risk assessment shows that the general public is very aware of the larger implications of technical programs. Research supports the argument that the public examines policy from a perspective analogous to Fischer’s third and fourth levels rather than at the lower levels. The public is aware of its technical limitations and seldom steps over these boundaries. However, the public is acutely aware of its place in the hierarchy of institutions that effect it.

\[130\] Stern, Understanding Risk, P 32.
People make decisions about personal risks similar to the empirical reasoning found at the base of Fischer's typology, but they base decisions about group risks using the political reasoning found at the higher levels of Fischer's typology. Empirical reasoning is sufficient to explain an individual's perceptions of the world, but when asked to reason for the group, he uses a different set of rules. The new set of rules establish personal standards of legitimacy for a given program. How can the problem be resolved? Little previous research on risk has attempted to draw on analogous experience. One field in particular — transportation planning — provides an invaluable model of how to build a successful route selection process.

**Transportation Planning**

The dilemma posed by risk assessment is familiar to transportation planners. The transportation professionals that advise local government leaders (e.g. transportation engineers, and planners) share epistemology with the positivist risk assessors. However, experience has taught them to make their technical reasoning subservient to their political masters. The need to somehow incorporate political reasoning into technical discussion highlights the sterility of the competing views of risk assessment. The uninflected views of expert risk assessors make them simple targets for democratic risk assessors. But democratic risk assessors stopped short of creating a meaningful multi-dimensional approach and settled for a bigger version of expert risk assessment.

In attempting to make public policy, risk assessors have either attempted to exclude the public (the expert view) or to reduce the public to a guinea pig (the democratic view). Neither attempts to embrace the political arrangements and institutions.
that are part and parcel of making policy. The approaches to risk assessment more closely reflect the sectarian views of their proponents than the people who will be affected by the risk.

A more fruitful approach may be found in the practice of transportation planning. There are numerous similarities between transporting hazardous materials and transportation planning. Transportation planning grew out of the field of civil engineering. The engineering studies that began in the 1930's were sufficient to design roads and bridges, but were not sufficient to choose the locations where roads should be built. As a result, the separate discipline of transportation planning evolved in the 1950's. This was strongly supported by the Federal Interstate Highway Act of 1954 which opened the doors for vast construction projects.

These projects were frequently destructive. They ruined neighborhoods and intruded into cherished and vulnerable places. Over time, initially hesitant public protest grew into a fury. The Long Beach Freeway is a classic case in point. The freeway was first proposed in 1949. The project was necessary to accommodate booming Los Angeles and was suitable from a technical viewpoint. However, to make the freeway a reality, the demolition of an historic area was necessary. Public protest about the proposal ensued, and as of 1998 the freeway had still not been completed.\textsuperscript{131}

Proficient transportation planning practitioners now understand the need for an extensive public involvement process. They understand the need to bring the issue before

the public in order to get their approval and support. An advantage possessed by local transportation planners is that the lines of authority and accountability are very clear; the DOE does not currently possess this advantage. The author personally witnessed a senior DOE official attempt to draw a flowchart describing the process used by DOE to select routes for low level waste transportation. After numerous attempts, he was unable to explain how, where and by whom a decision was made.\footnote{Frank diSanza, "DOE's Decision Making Chain of Command," interview by the author, Las Vegas, NV, 2 May, 1997.}

Local elected officials are unable to dodge their responsibility. They, in turn, hold transportation planners accountable for the responsible exercise of their authority. This perspective is consistent with the ideals espoused by democracy and is incompatible with the way risk assessment is currently practiced. Changes in the practice of transportation planning were institutionalized by the Federal Highway Act of 1970 which mandated certain public involvement techniques and formalized the need to incorporate public concern.\footnote{Department of Transportation, Public Involvement Techniques for Transportation Decision Making (Wash DC: US Dept. of Transportation 1996) XI.} These institutional changes are embodied in the DOT's \textit{Public Involvement Techniques for Transportation Decision Making}.\footnote{Ibid., 11.} Regularly produced by DOT, the manual establishes nationwide standards on how to involve the public in the most effective way. The manual does not mention "effective communication." Instead the emphasis is on meaningful intentions. The five Guidelines in the forward of the manual

\begin{itemize}
\item \textit{Public Involvement Techniques for Transportation Decision Making.}
\item Regularly produced by DOT.
\item The manual establishes nationwide standards.
\item The emphasis is on meaningful intentions.
\end{itemize}
sum up the difference between the role of the public in risk assessment and transportation planning.  

- Acting in accord with basic democratic principles
- Continuous contact between agency and non-agency people throughout transportation decision-making
- Use a variety of public involvement techniques
- Active outreach to the public
- Focus participation on decisions.

The way the Department of Transportation defines democratic decision making is especially useful in the context of risk assessment:

Acting in accord with democratic principles means that public involvement is more than simply following legislation and regulations. In a democratic society, people have opportunities to debate issues, frame alternative solutions, and affect final decisions in ways that respect the roles of decision makers. Knowledge is the basis of such participation. The public needs to know details about a plan or project to evaluate its importance or anticipated costs and benefits. Agency goals reflect community goals. Through continued interaction with the entire community, agencies build community support and, more importantly, assure that the public has the opportunity to help shape the substance of plans and projects. In summary the public agencies act as public servants.

The incorporation of these beliefs into transportation planning suggests that the positivist training of transportation planners and engineers has not survived contact with the realities imposed by the public. Unlike risk assessment, however, which has gone underground, transportation planners were forced to change their behavior in a way that

135 Ibid., 3-4.
136 Ibid., 1-2.
would more effectively capture public concerns. This philosophy represents an effective blend of technical political understanding.

Another indication of how important public involvement is to transportation planners can be found in the budgeting for large projects. Large transportation studies typically budget 10% of their funds to ensure the public is fully aware of the implications of an impending project. For multimillion dollar projects, public involvement is a huge portion of the budget. Engineering firms keep specialists on staff whose whole job is to assist engineers and planners in receiving public input. Most importantly, the public is recognized as a key assistant in making decisions about technical matters. A new risk assessment process will incorporate the public in an intimate way.

**The Recommended Process**

This section will describe a new process for performing a risk assessment for comparing radioactive waste routes. This process operates within the constraints imposed by the NWPAA. It assumes that the waste will be stored in a single facility. The current national disposal program imposes greater challenges on the route selection process. The recommended risk assessment process is performed in the following steps:

1. Use public involvement techniques to define the risk and choose criteria to measure the risk created by transporting radioactive waste.
2. Calculate the probability and the consequences of the hazards that are of concern to the public
3. Identify mitigating measures and costs
4. Present the results to the public and make programmatic adjustments as needed.
The process is implemented in the following steps:

1. Use public involvement techniques to define the risk and choose criteria to measure the risk created by transporting radioactive waste. The alternative routes must also be identified. This makes it possible to identify affected parties and to collect data necessary to characterize the route. Once this is complete, focus groups, polls, citizens juries and other tools can be used to define the risk and select criteria.

This step requires extensive public meetings and consultation to make it possible to arrive at some agreement. It is important to point out that this is performed before the data collection begins.

This ensures that the data collected is correct. The National Research Council calls this "getting the science right." One problem in this stage is which experts are suitable. A trend in the nuclear waste industry appears to be the over-use of nuclear physicists. This may not be appropriate, depending on what are the public concerns. Experts study the things in which they are expert. The public concerns must be connected with the right experts.

In transportation planning the solution to this problem is to provide the public with the universe of possible alternatives and to study only those alternatives found to be publicly acceptable. A key feature of this step is the need to restrict the variables considered by the risk assessment. Failure to do so will doom the assessment to irrelevance. Too much data cannot be processed or understood by the public or even the

---

experts themselves. Even an arbitrary limit, perhaps 10 data items may be sufficient to compete this step. For example, a committee formed from affected parties could select three transportation-related variables (e.g. annual average daily traffic, fatal truck accident rate and speed) as discriminating variables. Another committee could select public health variables (e.g. daytime population, special populations, environmentally sensitive areas). A third committee could choose variables related to emergency response (e.g. the location of emergency response crews, the time required to reach an accident scene, and the likely type of accident). A final group could choose an economic variable (such as the contribution of the MSA to the general fund of the relevant state). Once these variables were identified, methodological problems can be resolved prior to using them in route selection. The intent is to establish the rules of the game before the play begins.

Risk assessment must focus not on the results of the assessment, but rather on the process used to arrive at the final assessment. An additional consideration is the need to identify how affected parties get that way. A long-standing dispute in nuclear waste transportation is whether or not people living adjacent to the routes will lose property value due to the fear created by the transportation campaign. The process of identifying these issues must be far reaching and detailed enough to provide a good representation of public concern as well as a convincing mechanism for the compensation and indemnification of affected parties.

---

This process must be undertaken by an agency completely and visibly accountable to elected officials. A clear chain of command is necessary in order for the project to have the needed credibility. It is likely that new data will have to be collected. Public concerns are unlikely to fit into existing frameworks for collecting data. For example, sensitive populations are currently defined as nursing home residents, school children and hospital patients. The public may wish to broaden or narrow that definition. If so, current data may not be sufficient to describe the corridor.

2. Calculate the probability and the consequences of the hazards that are of concern to the public. This step conforms to what the National Research Council has called "getting the science right." Once affected parties have agreed to how routes will be evaluated, then technicians can move on to calculate the most effective way to measure the probabilities and hazards. At this step the technical expert makes meaningful contributions.

The author has had personal experience with a similar study in which an arrangement of this kind was used successfully. In comparing routes for low level radioactive waste transportation, affected parties were assembled and persuaded to agree to the process that would be used to study the routes. Three criteria were chosen and the methodological problems of measuring and collecting data about the routes were resolved

---


140 Department of Energy. *Nevada Test Site Intermodal Transportation Facility Site and Routing Evaluation Study.* (Las Vegas: DOE, 1997).
by obtaining agreement from the affected parties. In this way, the study was able to proceed unaffected by empirical concerns.

The situation was akin to a game. Desperate enemies were persuaded to play the game by certain rules that were understood to be flawed. However, by agreeing to participate in the study they risked having to accept results they did not want. The same procedure should be used in transporting HLW. This is the best way to obtain both methodical agreement and legitimacy imparted by public participation.

3. Identify Mitigation Measures and Costs. Once the severity of the impacts has been measured, it is possible to make the systems affected by the transportation more responsive and resilient in the face of risks. This was the cornerstone of Mary Douglas' conclusions. She argued that avoiding risk was impossible and therefore it is more productive to develop systems that can recover from accidents than it is to chop logic about risk measurements.

In HLW transportation, this means developing an assessment of the impacts and then deciding whether to mitigate them through improving system performance (e.g., emergency management) or paying compensation for unavoidable impacts. This is a step that DOE is hesitant to take because of the potential price tag. However, facing the consequences early in the program is more realistic than pretending the costs will not be worsened by delaying decisions about impacts.

4. Present the results to the public and make adjustments to the program. Once the assessment has been prepared it must be presented to the public. This should not be done
through a formal risk communication process. Rather, it should be done through existing political structures and aggressive public involvement. It is likely that aggressive public involvement coupled with changes to the program based on public comment will be sufficient to allay most public criticism.

Even the most aggressive public involvement process will fail to allay all criticism. There will inevitably be inequities in selecting routes for HLW transportation. It is inevitable that not all of the people affected by the transportation will be satisfied. The process described above does not purport to disarm all criticism. It does, however, aim to achieve legitimacy by informing the people affected by the program and by offering compensation to those inevitably affected by the program.

Comments on the Proposed Process

The process suggested above relies on a political model of reasonableness that is adapted from both the democratic and the expert views of risk. Fischer's framework describes how political reasoning is introduced into policy making. The model proposed in this chapter has advantages because it avoids methodological disputes by obtaining prior agreement to the study. It confers legitimacy by placing the public firmly in charge of the assessment. Ultimately it enables the courts to be the final arbiter of the route selection. In the case of nuclear waste, the issue is abstruse and the implications are unlikely to appear urgent to a distracted public. As a result, participation in nuclear waste forums will undoubtedly remain sparse.

A weakness of the above process is that risk assessments may be unduly influenced by the activities of small groups concerned about the issue. However, this may
not be as great a problem because as Michael Kraft learned, the public is more concerned about the way decisions are made than they are about the end result.\textsuperscript{141} This process fits with that insight. This involvement process is aggressive in that it does not rely on the public to make some effort to attend public meetings or to express concerns. The goal is to make it as simple as possible for the public to bring its concerns to the fore. The techniques include: newsletters, television advertisements, radio messages, billboard advertisements, public meetings and the Internet. The tool used is less important than the message. The field of risk communication is useful in this context.

Specialists in organizing, presenting, and developing the message perform vital service in placing the problem before the public. The primary way in which transportation professionals are able to mesh the two objectives is by presenting alternatives to the public and allowing them to choose the most acceptable alternatives. In this way, the public guides and shapes the technical program in a way that suits its interest. The vast majority of people who do not care about road building issues are left alone. The people most affected by the program are able to have an effect on the problem.

The approach taken by transportation planners is that the public must be persuaded that: 1). The problem requires attention and 2). the problem can be addressed by one of the alternatives prepared for the public’s consideration by the technicians.

There are cases where these techniques have failed. There is no guarantee that either of the conditions described above will be met in each case. However, the chances of a successful transportation program implementation is greatly increased by adopting the mindset that places the public in a leadership role.

The inability of risk assessors to make the connection between obtaining public tolerance and technical models of understanding is the reason neither world of risk will work as a policy tool. In the case of transportation planning, controversial projects typically create interest groups hell-bent to stop the project. When the public has been convinced that the project is necessary and that the affected parties have had a say in shaping the program, programs become possible. It is neither possible to persuade everyone nor to equitably provide for all affected parties. However, by ensuring that the public has not been victimized by high-handed technocrats it sustains the social order and gives political leaders confidence. One of the primary concerns of the technocratically inclined observer is that political leaders do not have the courage to make difficult decisions. In transportation projects, the opposite is usually true. When the political leaders can see that the public has been approached without condescension, they often take tough, difficult positions.

A further aspect of the process is that it is recursive. Multiple analyses are done for the same origin and destination. The analysis is repeated for different origins at different times. This means that new information learned from one analysis can be applied to others. A flexible process is open to improvement and learning. This process can cope with changes and new situations better than the process contained in the
Guidelines which has remained fixed for several years.

Another aspect of the proposed process is timing. One of the continual problems of waste disposal is how long fuel rods will sit in fuel pools at reactors prior to disposal. This is called “burn-up credit.”\textsuperscript{142} The problem is that fuel rods lose radioactivity prior to final storage. It would be optimal for the program if nuclear power plants could be decommissioned and the fuel rods shipped at the same time. Those rods still needing burnup credit could be kept in above ground storage prior to final disposal. A waste delivery schedule that enabled a plant to be completely cleared of HLW is preferable to one in which the same route is used for an extended period.

The shift from results to process is significant because it admits our inability to “prove” one risk superior to another. One of the main reasons expert risk assessment has failed is that it excludes the public from the process of making decisions. Indeed the comments of expert risk assessors and bureaucrats who are consumers of risk assessments actually denigrate the wisdom of making decisions by political leaders instead of technical experts.

The shear scale of the shipping campaign presents problems for the process described above. Both in terms of time and distance, the challenge of nuclear waste transportation presents daunting obstacles. The length of the route from the origin to the destination is one example. Risk will not be evenly distributed and the jurisdictional boundaries in which risk is allocated will not necessarily conform to the administrative

boundaries established. The other problem is the problem of time. The time frame in which the transportation plan is scheduled stretches over 30 years. A public involvement process that extends through the thirty year life span of a shipping campaign will undoubtedly be costly and frustrating. Without it, however, the project will continue to alienate citizens living along potential routes and incite controversy.

**Fischer’s Framework Applied to the Proposed Process**

The proposed process copes with Fischer’s framework better than either expert or democratic risk assessment. It does this by incorporating political discussion into the process of risk assessment rather than by pretending it does not exist.

1. Program Verification

At the first level, the proposed process must show that it answers the following questions differently than the other models of risk assessment:

a. Does the program empirically fulfill its stated objectives?
b. Does the empirical analysis uncover secondary or unanticipated effects that offset the program objectives?
c. Does the program fulfill the objectives more effectively than alternative means available?

The proposed method of risk assessment will be criticized by technicians who claim that the suggested process is unimplementable. This is not true. Techniques of this sort have been used throughout Europe and the United States in similar situations and have effectively resolved similar problems. The method defines risk (albeit with the

---


The proposed process successfully answers the first question.

Public risk assessment has an unanticipated secondary effect in that it will be more expensive and time consuming to implement. To receive and coordinate meaningful public input across the wide range of routes, for the length of the shipping campaign, and for the number of jurisdictions will be a huge challenge. Nonetheless, the expense must be incurred and the processes must be developed to respond to the challenge. The methods used by the French Government to outwit and the German Government to repress opposition serve as models for the United States to avoid at all costs.

The proposed process uses public input to define the variables for consideration in broad terms; then the correct technicians are used to perform technical analysis. This serves to defuse insoluble methodological arguments by taking the unanswerable position that the public wants it that way. Public risk assessment (the proposed process) offers a better answer to the third question than either the Guidelines or CRA because it cuts through the webs of methodology.

2. Situational Validation

At this level, the proposed process must respond to three questions. They are:

a. Is the program relevant to the problem situation?
b. Are there circumstances in the situation that require an exception to be made to the objectives?
c. Are two or more criteria equally applicable to the situation?
Using the public in the process of risk assessment is relevant to the problem situation. The connection between the public and risk taking behavior comprises the major part of the published literature on risk. Implementing risk assessment practices that rely on the public is certainly relevant.

The proposed process would admit exceptional circumstances in the case of route selection. The mechanics of resolving pleas for exception present a thorny political problem of a highly idiosyncratic kind. There should be no exceptions from the proposed process. But, the process will contain exceptions based on the discretion contained within the variables.

Other criteria are certainly relevant to the problem of selecting routes for transporting HLW. However, the fundamental measurement when expressed through public input is irrefutable in a democratic society such as ours. The process requires that the public be a part of and aware of how the criteria were selected and applied. The result of the process will necessarily yield fewer criteria than some think advisable, however, the process of choosing and applying the criteria are probably more important than the criteria themselves.

3. Societal Vindication

At this level, the questions that must be answered are:

---

a. Does the policy have instrumental or contributive value for society as a whole?
b. Does the policy goal result in unanticipated problems with important societal consequences?
c. Does a commitment to the policy goal lead to consequences that are judged to be equitably distributed?

Public risk assessment provides more value for society than either the Guidelines or CRA. It does this by developing policy that requires the public's active participation in a meaningful way. Rather than as a mute spectator, the public must add its voice to selecting hazards that affect it. Society benefits from public risk assessment because routing decisions are fundamentally made by the people affected by those decisions rather than by anonymous technocrats. Further, these decisions can be defended based on how they were made. Policy makers can point to a legitimate process that relies on a conception of how our government should work rather than on a model of technical understanding that excludes or denigrates the central role of the public.

The policy goal in question here, the comparison and selection of routes for transporting HLW is so intimately bound up with the program of geological disposal of HLW that they are difficult to address separately. The negative consequences caused by the proposed process come about because that disposal will be facilitated by an improved process of risk assessment. However, it is my opinion that the greatest potential effect of the disposal program (in terms of health and public safety consequences) will probably arise out of transporting HLW, rather than disposing it.

In a case with limited numbers of route choices available and the need to designate some route, it is inevitable that some inequities will arise. The proposed
process fails in that it is not without inequities. However, neither the expert nor the
democratic view avoids inequities. This process attempts to reduce inequities by
implementing a process that is more fair and just than the current available alternatives.
To be fair to the democratic view of risk, it has always known that there is a political
dimension to risk assessment that must be considered. This will not persuade die-hard
opponents. What it will do is force them to provide a more legitimate and persuasive
explanation for their view -- one that will enable them to win elections and thus change
policy rather than simply remain professional opponents.

4. Social Choice

At the fourth level of Fischer's model, the relevant questions he asks are:

a. Do the fundamental ideals (or ideology) that organize the accepted social order provide
a basis for a legitimate resolution of conflicting value judgments?
b. Do normative reflection and empirical evidence support the justification and adoption
of an alternative ideology and the social order it prescribes?

The proposed process for risk assessment has the potential (if implemented
correctly) to provide a better basis for resolving conflicts than other alternatives. By
enabling affected parties to have input into route selection and by ensuring their input has
programmatic effects, the proposed process will not resolve conflicts, but it does throw
the process into the political arena where the decision should be made rather than
attempting to hide the process.

At this level, the proposed process creates a method of treating the public with
necessary deference as well as coping with intractable problems of methodology and

146 Douglas and Wildavsky, Risk and Culture, 192.
inequity. Among the tools used to resolve problems like this is a citizen jury. The analogy with the legal system is very appropriate. We use juries to decide life and death matters of crime and punishment on a routine basis. A citizen's jury or a similar technique serves to enhance the legitimacy of the policy as well as reconcile the disaffected.

The proposed process is consistent with Midgley's argument in favor of moral reasoning. She sees that the exercise of critical judgement is essential to distinguishing between various cultural practices. She argues that moral reasoning can cut through cultural differences to make plausible arguments about policy. The proposed process embraces the standard of plausibility by incorporating the public affected by route selection into the process of selecting the route. This, in turn forces expert risk assessors to engage the public in a dialogue using language comprehensible to both parties. The proposed process uses expert risk assessors properly. No longer are they the samurai of technical enlightenment. rather they are trained technicians whose valuable insights are harnessed to resolving the task at hand. The proposed process puts a brake on the expert risk assessor.

The same is true for the democratic risk assessor. The proposed process uses reasonable techniques to make the affected public a part of the process. By doing so, the concerns of democratic risk assessors are addressed. No longer will the route selection

---

be the arbitrary judgement of some remote authority. At the same time, democratic risk assessors are challenged. They must present make a plausible case that their concerns are justified. The assertions of the democratic risk assessors cannot be theoretical criticisms of the expert view. Instead they must present plausible arguments supporting their position. By reconciling the two views of risk, it is possible to make risk assessment a useful tool for decision makers, experts, and the public.

**Summary**

In previous chapters this thesis has shown that the competing paradigms used to assess the risk of transporting HLW are ineffective. They are vulnerable to criticism on a basis that cannot be refuted using expert judgment and technical analysis. This chapter proposed an assessment strategy that incorporates the public into an open process for risk assessment. Attending to public concerns promotes legitimacy of the policy by demonstrating to the public that their concerns are receiving consideration. Neither of the proposed worlds of risk assessment achieves this. The expert technique fails because it relies on arbitrary expert judgment that is always open to question. The democratic technique has not developed into a reliable process. Yet it suffers from the same problems as the expert technique in that it relies on the same assumptions and methodologies that fatally handicap expert risk assessment. The proposed process uses the public as a crucial component of the risk assessment process and admits that there will be political issues that must be dealt with that are inherent to any risk analysis.
How we make decisions about technology is fundamental to the nation's future. To attempt to remove public concerns and judgments about technology (as advocates of expert risk assessment would argue is irresponsible and dangerous). However, to deny that we must accept risk is to retreat away from the many benefits of technology and to stifle the nation's future. Technology is often portrayed as the demon. In the case of nuclear power, the problem is more complex. Opposition to nuclear power has largely gained provenance not because of the dangers of radioactivity but because of the failure of managers to make good decisions about technology.
CHAPTER 5

CONCLUSION

In the modern world, the most dangerous form of determinism is the technological phenomenon. It is not a question of getting rid of it, but by an act of freedom, of transcending it.\textsuperscript{148}

This study argues that the central controversy in risk assessment has more to do with political legitimacy than it does with either the technical methodology of the physical or social sciences. Legitimacy is a necessary ingredient in the route selection process for comparing the routes used to transport high level radioactive waste.

This study has shown that the two prevailing schools of thought on risk assessment fail to create a legitimate basis on which to make public policy. The competing schools are different mainly in the way they define risk. The expert risk assessment school defines risk in a way that excludes human values and their potential responses to a hazard. The democratic school defines risk in a manner that is so broad that no risk assessment can hope to be implemented.

Fundamentally the two worlds of risk assessment share a common characteristic. They both exclude the political content of any route comparison. As a result, neither

\textsuperscript{148} Jacques Ellul, quoted in Susan Cutter, \textit{Living with Risk}, 1.
school of though is a useful public policy tool because the needs of legitimacy are not met. This was shown by evaluating each of the two worlds of risk assessment using Fischer’s framework for policy analysis.

Fischer’s framework is extremely useful in this context because it shows how different sides of the risk controversy argue from different levels of his framework. The two sides are arguing around each other rather than addressing the issues that are of fundamental importance if risk assessment is to be a successful tool.

Expert risk assessment is incapable of “proving” one route is safer than another. Democratic risk assessment as articulated in CRA has no mechanism that can show one assessment to be more sound than another. Each individual risk assessment is as good as any other. Because of this, risk assessment has consistently failed to deliver on its promise of informing the public and policymakers as to optimal strategies to cope with uncertain programs.

This study defined a new method of making policy in the face of this kind of uncertainty. This process relies on public input as a critical component of the decision making process. The example of transportation planning is instructive for risk assessment because planners were faced with the challenge of reconciling technical and political understanding. After decades of struggle, the transportation planning field has responded by institutionalizing public involvement and developing sophisticated techniques for obtaining public input.
The importance of this input is less because of its technical merit than because of its merit as a means to create legitimacy. The public demands to know that their concerns are foremost in the minds of decision makers. Mistakes made by risk assessors in the past have been to equate private with public risk and voluntary risk with involuntary risk. Fischer's framework suggests that policy about risk must meet different benchmarks when it applies to public risks and when risk is willingly accepted by individuals rather than imposed on groups.

In order for risk policy to be successful a context must be established for the affected parties. This context must possess several characteristics. These characteristics are:

1) There must be clear lines of authority within the organization implementing the risky policy. Typically no single agency has authority for overseeing all of the dimensions of the hazard. This is a major weakness in the DOE's program and should be corrected prior to any shipping campaign. We suggest a special task force to manage a routing decision should be considered by DOE.

2) The full implications of the risky project should be considered. In this case, for example, compensation for affected parties should be defined prior to beginning the shipping. Additional complications arise when even simple questions are asked: who is affected by the program? In what way are they affected? How can those effects be compensated or mitigated? None of these questions can be answered in the current context of nuclear waste transportation. The recognition of these potential complications is just now becoming clear to the DOE and its supporters. None of the fundamental
questions about the transportation portion of the program have been answered (or scarcely even asked).

3) The program must be malleable. The public must also be able to see its influence on the DOE’s program. This does not mean a foolish decision should be made in order to appease public opinion. Instead it means that the public must see that their are concerns incorporated in meaningful ways. The DOE cannot afford to use “Decide, Announce, Defend” as their leitmotif. A way to enhance malleability is to adopt a gradual programmatic implementations strategy. Gradual programs that enable calibration of assessments will also enable the public to have greater confidence in the larger program. These will have enormous advantage to the larger program.

The challenge posed by the transportation of High Level Waste is a serious one by itself. Seen in the broader context of a technological society, the problems of risk assessment are important. The problem of nuclear fuel disposal is real and cannot be dismissed. Something must be done with it. Fuel rods must either be transported to a storage facility or left where they are. But something must be done. The same thing will prove to be true for other evolving technologies. There is a consensus growing among scientists and technicians that a backlash against science is currently in full swing. The fear expressed by Carl Sagan is that we will return to a “demon-haunted world” in which technology and science are viewed as evil.149

---

This diagnosis misses the point. The story of technological failure reveals less about technology than it does about the wise management of technology. The Bhopal, India disaster would not have occurred had it not been assumed that the a plant designed in Texas could be duplicated in its entirety in India.\(^{150}\) The management of technology is the most pressing problem facing industrialized nations. As technology becomes more difficult for laymen to comprehend and as the pace of change increases, it is not likely technology will cease to be developed. It is more likely that institutional and political arrangements must evolve that can successfully cope with these changes. The application of technology is not an ethically neutral endeavor. The dream of the expert risk assessors was that it would be.

Risk assessment was proposed as the best way to reconcile the public to the problem of dangerous technologies and programs. This dream may yet prove possible, but only if reforms to the practice of risk assessment are undertaken. The case of choosing routes for high level waste transportation points the way.

The existing procedures leave numerous methodological questions unanswered. These unanswered questions will cause methodological argument when route selection begins and the Guidelines are actually implemented. The Guidelines are also a part of a very incomplete policy architecture. The inability to answer basic questions about the potential impacts of the program means that there will be confusion about how the program is ultimately implemented.

\(^{150}\) Susan Cutter, \textit{Living with Risk}, 101.
Once more, the specter of horribly mismanaged technology comes into view. The fuel rods themselves will not be the culprit in causing an accident. In expert terms they are simply the “hazard.” Instead harm will be done because people have failed to wisely manage dangerous technology. The key challenge for democratic societies is how to manage the technology so that the process of technological management conforms to our collective aspirations of what our society should be. It is up to risk assessors to develop methods that enable them to find out what those aspirations are and build systems that can are consistent with those goals.

---


Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.
APPENDIX: ROUTE ANALYSIS WORKSHEETS
<table>
<thead>
<tr>
<th>Seg. No.</th>
<th>Seg. Desc.</th>
<th>Lengt h</th>
<th>Speed</th>
<th>Dist be twee n opposi ng lanes</th>
<th>Pop Count 0-5 Miles</th>
<th>Pop Count 5-10 Miles</th>
<th>Daily Traf Count</th>
<th>Daily Truck Count</th>
<th>Yrly Death s</th>
<th>Acc. Per million mi.</th>
<th>Acc. Per 1000 shipments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>I 15</td>
<td>26.61</td>
<td>65</td>
<td>60</td>
<td>102</td>
<td>125</td>
<td>15870</td>
<td>1746</td>
<td>0</td>
<td>0</td>
<td>0.00001</td>
</tr>
<tr>
<td>1</td>
<td>I 15</td>
<td>33.12</td>
<td>65</td>
<td>60</td>
<td>458</td>
<td>699</td>
<td>15990</td>
<td>1759</td>
<td>0</td>
<td>0</td>
<td>0.00001</td>
</tr>
<tr>
<td>2</td>
<td>I 15</td>
<td>9.56</td>
<td>65</td>
<td>60</td>
<td>534</td>
<td>879</td>
<td>15405</td>
<td>1695</td>
<td>0</td>
<td>0</td>
<td>0.00001</td>
</tr>
<tr>
<td>3</td>
<td>I 15</td>
<td>1.77</td>
<td>55</td>
<td>60</td>
<td>6789</td>
<td>12390</td>
<td>60375</td>
<td>3019</td>
<td>0</td>
<td>0</td>
<td>0.003</td>
</tr>
<tr>
<td>4</td>
<td>I 15</td>
<td>2.00</td>
<td>55</td>
<td>45</td>
<td>8779</td>
<td>21000</td>
<td>93900</td>
<td>4695</td>
<td>2</td>
<td>0</td>
<td>0.001</td>
</tr>
<tr>
<td>5</td>
<td>I 15</td>
<td>3.56</td>
<td>55</td>
<td>45</td>
<td>23456</td>
<td>27811</td>
<td>102405</td>
<td>5120</td>
<td>3</td>
<td>0</td>
<td>0.002</td>
</tr>
<tr>
<td>6</td>
<td>US 95</td>
<td>.89</td>
<td>55</td>
<td>10</td>
<td>4567</td>
<td>6199</td>
<td>102405</td>
<td>5120</td>
<td>0</td>
<td>0</td>
<td>0.001</td>
</tr>
<tr>
<td>10</td>
<td>US 95</td>
<td>.94</td>
<td>55</td>
<td>10</td>
<td>37777</td>
<td>34401</td>
<td>102405</td>
<td>5120</td>
<td>1</td>
<td>0</td>
<td>0.002</td>
</tr>
<tr>
<td>11</td>
<td>US 95</td>
<td>.56</td>
<td>55</td>
<td>10</td>
<td>54670</td>
<td>65501</td>
<td>165265</td>
<td>8263</td>
<td>0</td>
<td>0</td>
<td>0.0003</td>
</tr>
<tr>
<td>12</td>
<td>US 95</td>
<td>.72</td>
<td>55</td>
<td>10</td>
<td>10346</td>
<td>23222</td>
<td>165265</td>
<td>8263</td>
<td>5</td>
<td>0</td>
<td>0.001</td>
</tr>
<tr>
<td>13</td>
<td>US 95</td>
<td>.59</td>
<td>55</td>
<td>10</td>
<td>32491</td>
<td>42221</td>
<td>147350</td>
<td>7368</td>
<td>2</td>
<td>0</td>
<td>0.003</td>
</tr>
<tr>
<td>14</td>
<td>US 95</td>
<td>.76</td>
<td>55</td>
<td>10</td>
<td>27810</td>
<td>32680</td>
<td>147489</td>
<td>7374</td>
<td>3</td>
<td>0</td>
<td>0.0005</td>
</tr>
<tr>
<td>15</td>
<td>US 95</td>
<td>.65</td>
<td>55</td>
<td>10</td>
<td>19001</td>
<td>28741</td>
<td>128005</td>
<td>6400</td>
<td>0</td>
<td>0</td>
<td>0.0001</td>
</tr>
<tr>
<td>16</td>
<td>US 95</td>
<td>.84</td>
<td>55</td>
<td>10</td>
<td>21001</td>
<td>38088</td>
<td>128005</td>
<td>5120</td>
<td>1</td>
<td>1E-08</td>
<td>0.001</td>
</tr>
<tr>
<td>17</td>
<td>US 95</td>
<td>1.06</td>
<td>55</td>
<td>10</td>
<td>54059</td>
<td>69214</td>
<td>128005</td>
<td>5120</td>
<td>1</td>
<td>1E-08</td>
<td>0.001</td>
</tr>
<tr>
<td>18</td>
<td>US 95</td>
<td>1.08</td>
<td>55</td>
<td>10</td>
<td>63499</td>
<td>39004</td>
<td>128005</td>
<td>5120</td>
<td>.001</td>
<td>1E-08</td>
<td>0.0025</td>
</tr>
<tr>
<td>19</td>
<td>US 95</td>
<td>1.51</td>
<td>55</td>
<td>10</td>
<td>34752</td>
<td>46420</td>
<td>84430</td>
<td>3377</td>
<td>.002</td>
<td>1E-08</td>
<td>0.00034</td>
</tr>
<tr>
<td>20</td>
<td>US 95</td>
<td>1.75</td>
<td>55</td>
<td>45</td>
<td>12832</td>
<td>18555</td>
<td>84430</td>
<td>3377</td>
<td>.001</td>
<td>1E-08</td>
<td>0.00001</td>
</tr>
<tr>
<td>21</td>
<td>US 95</td>
<td>3.36</td>
<td>55</td>
<td>45</td>
<td>23111</td>
<td>32135</td>
<td>84430</td>
<td>3377</td>
<td>.001</td>
<td>1E-08</td>
<td>0.0002</td>
</tr>
<tr>
<td>22</td>
<td>US 95</td>
<td>3.99</td>
<td>55</td>
<td>45</td>
<td>14401</td>
<td>23423</td>
<td>64580</td>
<td>2583</td>
<td>.001</td>
<td>1E-08</td>
<td>0.00001</td>
</tr>
<tr>
<td>23</td>
<td>US 95</td>
<td>8.26</td>
<td>55</td>
<td>45</td>
<td>11913</td>
<td>15870</td>
<td>64580</td>
<td>2583</td>
<td>.001</td>
<td>1E-08</td>
<td>0.00001</td>
</tr>
<tr>
<td>23</td>
<td>US 95</td>
<td>4.52</td>
<td>55</td>
<td>45</td>
<td>5666</td>
<td>6321</td>
<td>29390</td>
<td>1175</td>
<td>.001</td>
<td>1E-08</td>
<td>0.00001</td>
</tr>
<tr>
<td>23</td>
<td>US 95</td>
<td>4.52</td>
<td>55</td>
<td>45</td>
<td>8790</td>
<td>10870</td>
<td>10690</td>
<td>427</td>
<td>.2</td>
<td>1E-08</td>
<td>0.00001</td>
</tr>
<tr>
<td>23</td>
<td>US 95</td>
<td>25.24</td>
<td>55</td>
<td>45</td>
<td>2354</td>
<td>3363</td>
<td>8350</td>
<td>334</td>
<td>1</td>
<td>1E-08</td>
<td>0.00001</td>
</tr>
</tbody>
</table>
### Routine Exposure Criteria

**D1** Dose to persons residing along route

<table>
<thead>
<tr>
<th>Seg. No.</th>
<th>p*(t/v)</th>
<th>C1</th>
<th>D1</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1.15</td>
<td>26.61</td>
<td>65</td>
</tr>
<tr>
<td>1</td>
<td>1.15</td>
<td>33.12</td>
<td>65</td>
</tr>
<tr>
<td>2</td>
<td>1.15</td>
<td>9.56</td>
<td>65</td>
</tr>
<tr>
<td>3</td>
<td>1.15</td>
<td>1.77</td>
<td>55</td>
</tr>
<tr>
<td>4</td>
<td>1.15</td>
<td>2.00</td>
<td>55</td>
</tr>
<tr>
<td>5</td>
<td>1.15</td>
<td>3.56</td>
<td>55</td>
</tr>
<tr>
<td>6</td>
<td>US 95</td>
<td>.89</td>
<td>55</td>
</tr>
<tr>
<td>10</td>
<td>US 95</td>
<td>.94</td>
<td>55</td>
</tr>
<tr>
<td>11</td>
<td>US 95</td>
<td>.56</td>
<td>55</td>
</tr>
<tr>
<td>12</td>
<td>US 95</td>
<td>.72</td>
<td>55</td>
</tr>
<tr>
<td>13</td>
<td>US 95</td>
<td>.59</td>
<td>55</td>
</tr>
<tr>
<td>14</td>
<td>US 95</td>
<td>.76</td>
<td>55</td>
</tr>
<tr>
<td>15</td>
<td>US 95</td>
<td>.65</td>
<td>55</td>
</tr>
<tr>
<td>16</td>
<td>US 95</td>
<td>.84</td>
<td>55</td>
</tr>
<tr>
<td>17</td>
<td>US 95</td>
<td>1.06</td>
<td>55</td>
</tr>
<tr>
<td>18</td>
<td>US 95</td>
<td>1.08</td>
<td>55</td>
</tr>
<tr>
<td>19</td>
<td>US 95</td>
<td>1.51</td>
<td>55</td>
</tr>
<tr>
<td>20</td>
<td>US 95</td>
<td>1.75</td>
<td>55</td>
</tr>
<tr>
<td>21</td>
<td>US 95</td>
<td>3.36</td>
<td>55</td>
</tr>
<tr>
<td>22</td>
<td>US 95</td>
<td>3.99</td>
<td>55</td>
</tr>
<tr>
<td>23</td>
<td>US 95</td>
<td>8.26</td>
<td>55</td>
</tr>
<tr>
<td>23</td>
<td>US 95</td>
<td>4.52</td>
<td>55</td>
</tr>
<tr>
<td>23</td>
<td>US 95</td>
<td>4.52</td>
<td>55</td>
</tr>
<tr>
<td>23</td>
<td>US 95</td>
<td>25.24</td>
<td>55</td>
</tr>
</tbody>
</table>

**D2** Dose to passengers in other vehicles

<table>
<thead>
<tr>
<th>L*t</th>
<th>v2</th>
<th>(l*v^2)</th>
<th>Conversion Factor</th>
<th>D2</th>
</tr>
</thead>
<tbody>
<tr>
<td>17594.76</td>
<td>65</td>
<td>270.68</td>
<td>.000077</td>
<td>.0208</td>
</tr>
<tr>
<td>2206.07</td>
<td>65</td>
<td>339.44</td>
<td>.000077</td>
<td>.0261</td>
</tr>
<tr>
<td>6139.24</td>
<td>65</td>
<td>94.44</td>
<td>.000077</td>
<td>.0077</td>
</tr>
<tr>
<td>4441.51</td>
<td>55</td>
<td>80.75</td>
<td>.000077</td>
<td>.0062</td>
</tr>
<tr>
<td>7840.14</td>
<td>55</td>
<td>142.54</td>
<td>.00011</td>
<td>.0156</td>
</tr>
<tr>
<td>15186.96</td>
<td>55</td>
<td>276.12</td>
<td>.00011</td>
<td>.0303</td>
</tr>
<tr>
<td>3797.51</td>
<td>55</td>
<td>69.04</td>
<td>.00049</td>
<td>.0338</td>
</tr>
<tr>
<td>4010.86</td>
<td>55</td>
<td>72.92</td>
<td>.00049</td>
<td>.0357</td>
</tr>
<tr>
<td>3856.18</td>
<td>55</td>
<td>70.11</td>
<td>.00049</td>
<td>.0343</td>
</tr>
<tr>
<td>4957.95</td>
<td>55</td>
<td>90.14</td>
<td>.00049</td>
<td>.0441</td>
</tr>
<tr>
<td>3622.35</td>
<td>55</td>
<td>65.86</td>
<td>.00049</td>
<td>.0322</td>
</tr>
<tr>
<td>4670.48</td>
<td>55</td>
<td>84.91</td>
<td>.00049</td>
<td>.0416</td>
</tr>
<tr>
<td>3466.80</td>
<td>55</td>
<td>63.03</td>
<td>.00049</td>
<td>.0308</td>
</tr>
<tr>
<td>4480.17</td>
<td>55</td>
<td>81.45</td>
<td>.00049</td>
<td>.0399</td>
</tr>
<tr>
<td>5653.55</td>
<td>55</td>
<td>102.79</td>
<td>.00049</td>
<td>.0503</td>
</tr>
<tr>
<td>5760.22</td>
<td>55</td>
<td>104.73</td>
<td>.00049</td>
<td>.0513</td>
</tr>
<tr>
<td>5299.51</td>
<td>55</td>
<td>96.35</td>
<td>.00049</td>
<td>.0472</td>
</tr>
<tr>
<td>6147.94</td>
<td>40</td>
<td>153.69</td>
<td>.00011</td>
<td>.0169</td>
</tr>
<tr>
<td>11824.03</td>
<td>40</td>
<td>295.60</td>
<td>.00011</td>
<td>.0325</td>
</tr>
<tr>
<td>10735.59</td>
<td>40</td>
<td>268.38</td>
<td>.00011</td>
<td>.0295</td>
</tr>
<tr>
<td>22227.78</td>
<td>50</td>
<td>444.55</td>
<td>.00011</td>
<td>.0480</td>
</tr>
<tr>
<td>5536.94</td>
<td>65</td>
<td>85.18</td>
<td>.00011</td>
<td>.0093</td>
</tr>
<tr>
<td>2014.70</td>
<td>65</td>
<td>30.99</td>
<td>.00011</td>
<td>.0034</td>
</tr>
<tr>
<td>8782.92</td>
<td>65</td>
<td>135.12</td>
<td>.00011</td>
<td>.0148</td>
</tr>
</tbody>
</table>
## D3 Dose to Truck Crew

<table>
<thead>
<tr>
<th>Seg. No.</th>
<th>t^t</th>
<th>v3</th>
<th>L*tz/v^3</th>
<th>Vehicle Separation</th>
<th>D3</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>437751.56</td>
<td>11634539.73</td>
<td>274625</td>
<td>42.365</td>
<td>.000016</td>
</tr>
<tr>
<td>1</td>
<td>443889.06</td>
<td>14700189.72</td>
<td>274625</td>
<td>53.528</td>
<td>.000016</td>
</tr>
<tr>
<td>2</td>
<td>412003.51</td>
<td>3940624.92</td>
<td>274625</td>
<td>14.349</td>
<td>.000018</td>
</tr>
<tr>
<td>3</td>
<td>6328369.14</td>
<td>11173189.91</td>
<td>166375</td>
<td>67.156</td>
<td>.000018</td>
</tr>
<tr>
<td>4</td>
<td>153076.53</td>
<td>30674558.44</td>
<td>166375</td>
<td>184.36</td>
<td>.000016</td>
</tr>
<tr>
<td>5</td>
<td>18206222.27</td>
<td>64800862.82</td>
<td>166375</td>
<td>389.48</td>
<td>.0000086</td>
</tr>
<tr>
<td>9</td>
<td>18206222.27</td>
<td>16203537.82</td>
<td>166375</td>
<td>97.39</td>
<td>.000015</td>
</tr>
<tr>
<td>10</td>
<td>18206222.27</td>
<td>17113747.93</td>
<td>166375</td>
<td>102.86</td>
<td>.000015</td>
</tr>
<tr>
<td>11</td>
<td>47417569.84</td>
<td>26553839.11</td>
<td>166375</td>
<td>159.60</td>
<td>.000013</td>
</tr>
<tr>
<td>12</td>
<td>47417569.84</td>
<td>34140630.28</td>
<td>166375</td>
<td>205.20</td>
<td>.000013</td>
</tr>
<tr>
<td>13</td>
<td>37694483.51</td>
<td>22239745.27</td>
<td>166375</td>
<td>133.67</td>
<td>.000015</td>
</tr>
<tr>
<td>14</td>
<td>37765633.89</td>
<td>28791881.76</td>
<td>166375</td>
<td>172.51</td>
<td>.000013</td>
</tr>
<tr>
<td>15</td>
<td>28446666.71</td>
<td>18490333.36</td>
<td>166375</td>
<td>111.13</td>
<td>.000015</td>
</tr>
<tr>
<td>16</td>
<td>28446666.71</td>
<td>23895200.04</td>
<td>166375</td>
<td>143.62</td>
<td>.000015</td>
</tr>
<tr>
<td>17</td>
<td>28446666.71</td>
<td>30153466.71</td>
<td>166375</td>
<td>181.23</td>
<td>.000013</td>
</tr>
<tr>
<td>18</td>
<td>28446666.71</td>
<td>30722400.05</td>
<td>166375</td>
<td>184.65</td>
<td>.000013</td>
</tr>
<tr>
<td>19</td>
<td>12375737.67</td>
<td>18643249.61</td>
<td>166375</td>
<td>112.05</td>
<td>.000015</td>
</tr>
<tr>
<td>20</td>
<td>12375737.67</td>
<td>21627952.42</td>
<td>64000</td>
<td>337.93</td>
<td>.00001</td>
</tr>
<tr>
<td>21</td>
<td>12375737.67</td>
<td>41595961.37</td>
<td>64000</td>
<td>649.93</td>
<td>.000006</td>
</tr>
<tr>
<td>22</td>
<td>7240584.02</td>
<td>28887708.94</td>
<td>64000</td>
<td>451.37</td>
<td>.000005</td>
</tr>
<tr>
<td>23</td>
<td>7240584.02</td>
<td>39811278.15</td>
<td>125000</td>
<td>478.49</td>
<td>.0000078</td>
</tr>
<tr>
<td>23</td>
<td>1499694.34</td>
<td>6780450.25</td>
<td>274625</td>
<td>24.68</td>
<td>.000018</td>
</tr>
<tr>
<td>23</td>
<td>198396.00</td>
<td>897383.67</td>
<td>274625</td>
<td>3.26</td>
<td>.000018</td>
</tr>
<tr>
<td>23</td>
<td>121046.00</td>
<td>3055725.80</td>
<td>274625</td>
<td>11.12</td>
<td>.000018</td>
</tr>
<tr>
<td>Dose to People at Truck Stops</td>
<td>Routine Exposure Criteria</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-------------------------------</td>
<td>---------------------------</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Seg.</strong></td>
<td><strong>L/v</strong></td>
<td><strong>Seg.</strong></td>
<td><strong>D1+D2+D3+D4</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>.409</td>
<td>1</td>
<td>.430</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>.509</td>
<td>1</td>
<td>.536</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>.147</td>
<td>2</td>
<td>.154</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>.032</td>
<td>3</td>
<td>.0054</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>.036</td>
<td>4</td>
<td>.069</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>.064</td>
<td>5</td>
<td>.111</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>.016</td>
<td>9</td>
<td>.090</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>.017</td>
<td>10</td>
<td>.345</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>.010</td>
<td>11</td>
<td>1.232</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>.013</td>
<td>12</td>
<td>.195</td>
<td></td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>.010</td>
<td>13</td>
<td>.679</td>
<td></td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>.013</td>
<td>14</td>
<td>.385</td>
<td></td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>.011</td>
<td>15</td>
<td>.350</td>
<td></td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>.015</td>
<td>16</td>
<td>.268</td>
<td></td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>.019</td>
<td>17</td>
<td>.399</td>
<td></td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>.019</td>
<td>18</td>
<td>.443</td>
<td></td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>.027</td>
<td>19</td>
<td>.180</td>
<td></td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>.043</td>
<td>20</td>
<td>.092</td>
<td></td>
<td></td>
</tr>
<tr>
<td>21</td>
<td>.084</td>
<td>21</td>
<td>.130</td>
<td></td>
<td></td>
</tr>
<tr>
<td>22</td>
<td>.099</td>
<td>22</td>
<td>.135</td>
<td></td>
<td></td>
</tr>
<tr>
<td>23</td>
<td>.163</td>
<td>23</td>
<td>.215</td>
<td></td>
<td></td>
</tr>
<tr>
<td>23</td>
<td>.069</td>
<td>23</td>
<td>.081</td>
<td></td>
<td></td>
</tr>
<tr>
<td>23</td>
<td>.069</td>
<td>23</td>
<td>.075</td>
<td></td>
<td></td>
</tr>
<tr>
<td>23</td>
<td>.388</td>
<td>23</td>
<td>.040</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Seg. No.</td>
<td>Length</td>
<td>Economic Sum/Length</td>
<td>Accident Rate / Million Miles</td>
<td>Consequences * Frequency</td>
<td>Economic Consequences Factor</td>
</tr>
<tr>
<td>---------</td>
<td>--------</td>
<td>---------------------</td>
<td>-------------------------------</td>
<td>--------------------------</td>
<td>-----------------------------</td>
</tr>
<tr>
<td>1</td>
<td>26.61</td>
<td>9.028</td>
<td>9.02E-08</td>
<td></td>
<td>9.02E08</td>
</tr>
<tr>
<td>1</td>
<td>33.12</td>
<td>7.25</td>
<td>7.25E08</td>
<td></td>
<td>7.25E08</td>
</tr>
<tr>
<td>2</td>
<td>9.56</td>
<td>25.11</td>
<td>2.51E07</td>
<td></td>
<td>2.51E07</td>
</tr>
<tr>
<td>3</td>
<td>1.77</td>
<td>136.06</td>
<td>1.36E06</td>
<td></td>
<td>1.36E06</td>
</tr>
<tr>
<td>4</td>
<td>2.00</td>
<td>119.88</td>
<td>2.39E06</td>
<td></td>
<td>2.39E06</td>
</tr>
<tr>
<td>5</td>
<td>3.56</td>
<td>67.49</td>
<td>3.37E06</td>
<td></td>
<td>3.37E06</td>
</tr>
<tr>
<td>9</td>
<td>0.89</td>
<td>269.923</td>
<td>2.96E05</td>
<td></td>
<td>2.96E05</td>
</tr>
<tr>
<td>10</td>
<td>0.94</td>
<td>255.56</td>
<td>2.55E05</td>
<td></td>
<td>2.55E05</td>
</tr>
<tr>
<td>11</td>
<td>0.56</td>
<td>428.98</td>
<td>4.28E05</td>
<td></td>
<td>4.28E05</td>
</tr>
<tr>
<td>12</td>
<td>0.72</td>
<td>333.65</td>
<td>4.00E05</td>
<td></td>
<td>4.00E05</td>
</tr>
<tr>
<td>13</td>
<td>0.59</td>
<td>407.17</td>
<td>1.62E05</td>
<td></td>
<td>1.62E05</td>
</tr>
<tr>
<td>14</td>
<td>0.76</td>
<td>316.09</td>
<td>9.48E06</td>
<td></td>
<td>9.48E06</td>
</tr>
<tr>
<td>15</td>
<td>0.65</td>
<td>369.58</td>
<td>7.39E06</td>
<td></td>
<td>7.39E06</td>
</tr>
<tr>
<td>16</td>
<td>0.84</td>
<td>285.99</td>
<td>7.14E06</td>
<td></td>
<td>7.14E06</td>
</tr>
<tr>
<td>17</td>
<td>1.06</td>
<td>226.63</td>
<td>2.26E06</td>
<td></td>
<td>2.26E06</td>
</tr>
<tr>
<td>18</td>
<td>1.08</td>
<td>222.43</td>
<td>2.22E06</td>
<td></td>
<td>2.22E06</td>
</tr>
<tr>
<td>19</td>
<td>1.51</td>
<td>159.47</td>
<td>1.59E06</td>
<td></td>
<td>1.59E06</td>
</tr>
<tr>
<td>20</td>
<td>1.75</td>
<td>137.46</td>
<td>1.37E06</td>
<td></td>
<td>1.37E06</td>
</tr>
<tr>
<td>21</td>
<td>3.36</td>
<td>71.47</td>
<td>7.14E07</td>
<td></td>
<td>7.14E07</td>
</tr>
<tr>
<td>22</td>
<td>3.99</td>
<td>60.21</td>
<td>6.02E07</td>
<td></td>
<td>6.02E07</td>
</tr>
<tr>
<td>23</td>
<td>8.26</td>
<td>20.08</td>
<td>2.98E07</td>
<td></td>
<td>2.98E07</td>
</tr>
<tr>
<td>23</td>
<td>4.52</td>
<td>53.13</td>
<td>5.31E07</td>
<td></td>
<td>5.31E07</td>
</tr>
<tr>
<td>23</td>
<td>4.52</td>
<td>53.11</td>
<td>5.33E07</td>
<td></td>
<td>5.33E07</td>
</tr>
<tr>
<td>23</td>
<td>25.24</td>
<td>9.51</td>
<td>5.13E07</td>
<td></td>
<td>5.13E07</td>
</tr>
</tbody>
</table>
### Route A Worksheet

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>I 15</td>
<td>27.64</td>
<td>65</td>
<td>0.0011</td>
<td>16.09</td>
<td>1377.5</td>
<td>10.38</td>
<td>.0000018</td>
</tr>
<tr>
<td>2</td>
<td>I 15</td>
<td>5.94</td>
<td>55</td>
<td>0.0011</td>
<td>1295.5</td>
<td>1364.16</td>
<td>8.86</td>
<td>.0000018</td>
</tr>
<tr>
<td>3</td>
<td>SR160</td>
<td>3.91</td>
<td>50</td>
<td>0.0025</td>
<td>177.80</td>
<td>218.75</td>
<td>40.22</td>
<td>.000008</td>
</tr>
<tr>
<td>4</td>
<td>SR160</td>
<td>2.24</td>
<td>45</td>
<td>0.0025</td>
<td>1572.5</td>
<td>514.58</td>
<td>19.23</td>
<td>.000008</td>
</tr>
<tr>
<td>5</td>
<td>SR160</td>
<td>13.99</td>
<td>45</td>
<td>0.0025</td>
<td>9.059</td>
<td>514.58</td>
<td>19.23</td>
<td>.000008</td>
</tr>
</tbody>
</table>

### Routine Exposure Criteria

#### D1 Dose to Persons along Route

<table>
<thead>
<tr>
<th>Segment</th>
<th>P*l/v</th>
<th>C1</th>
<th>D1</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>6.84</td>
<td>.0000068</td>
<td>4.66E04</td>
</tr>
<tr>
<td>2</td>
<td>140.01</td>
<td>.0000068</td>
<td>9.52E03</td>
</tr>
<tr>
<td>3</td>
<td>36.94</td>
<td>.0000068</td>
<td>2.5E03</td>
</tr>
<tr>
<td>4</td>
<td>78.32</td>
<td>.0000068</td>
<td>5.33E03</td>
</tr>
<tr>
<td>5</td>
<td>5.27</td>
<td>.0000068</td>
<td>3.59E04</td>
</tr>
<tr>
<td>5</td>
<td>4.078</td>
<td>.0000068</td>
<td>2.77E04</td>
</tr>
</tbody>
</table>

#### D2 Dose to Passengers in other Vehicles

<table>
<thead>
<tr>
<th>L*t</th>
<th>V2</th>
<th>L*t/v2</th>
<th>D2</th>
</tr>
</thead>
<tbody>
<tr>
<td>38077.17</td>
<td>4225</td>
<td>9.01</td>
<td>.00099</td>
</tr>
<tr>
<td>8108.18</td>
<td>3025</td>
<td>2.68</td>
<td>.00029</td>
</tr>
<tr>
<td>855.61</td>
<td>1600</td>
<td>.53</td>
<td>.00013</td>
</tr>
<tr>
<td>1153.29</td>
<td>2025</td>
<td>.56</td>
<td>.00014</td>
</tr>
<tr>
<td>13481.44</td>
<td>2025</td>
<td>6.65</td>
<td>.0016</td>
</tr>
<tr>
<td>7200.45</td>
<td>2025</td>
<td>3.55</td>
<td>.00088</td>
</tr>
</tbody>
</table>
### D3 Dose to Truck Crew

<table>
<thead>
<tr>
<th>Segment</th>
<th>t⁺t</th>
<th>l⁺t²</th>
<th>V3</th>
<th>(l⁺t²)/v3</th>
<th>D3</th>
<th>L/v</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>189750.625</td>
<td>52451307.09</td>
<td>274625</td>
<td>190.99</td>
<td>.003</td>
<td>43</td>
</tr>
<tr>
<td>2</td>
<td>186095.69</td>
<td>11060916.85</td>
<td>166375</td>
<td>66.48</td>
<td>.000</td>
<td>11</td>
</tr>
<tr>
<td>3</td>
<td>47851.187165</td>
<td>187165.2</td>
<td>64000</td>
<td>2.92</td>
<td>.000</td>
<td>23</td>
</tr>
<tr>
<td>4</td>
<td>264796 .0</td>
<td>593463.9 3</td>
<td>91125</td>
<td>6.51</td>
<td>.005</td>
<td>2</td>
</tr>
<tr>
<td>5</td>
<td>264796 .0</td>
<td>6937326.19</td>
<td>91125</td>
<td>76.12</td>
<td>.006</td>
<td>0</td>
</tr>
<tr>
<td>5</td>
<td>264796 .0</td>
<td>3705232.36</td>
<td>91125</td>
<td>40.66</td>
<td>.000</td>
<td>3</td>
</tr>
</tbody>
</table>

### Routine Exposure Criteria

<table>
<thead>
<tr>
<th>Segment</th>
<th>D1+D2+D3+D4</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2.50E02</td>
</tr>
<tr>
<td>2</td>
<td>1.54E02</td>
</tr>
<tr>
<td>3</td>
<td>2.08E02</td>
</tr>
<tr>
<td>4</td>
<td>1.50E02</td>
</tr>
<tr>
<td>5</td>
<td>5.90E02</td>
</tr>
<tr>
<td>5</td>
<td>2.87E02</td>
</tr>
</tbody>
</table>
### Route B Worksheet

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>SR164</td>
<td>18.64</td>
<td>45</td>
<td>.00049</td>
<td>.339</td>
<td>30.83</td>
<td>321.08</td>
<td>.000001</td>
</tr>
<tr>
<td>1</td>
<td>US95</td>
<td>19.23</td>
<td>50</td>
<td>.00049</td>
<td>.56</td>
<td>230.65</td>
<td>47.69</td>
<td>.0000008</td>
</tr>
<tr>
<td>2</td>
<td>115</td>
<td>27.64</td>
<td>65</td>
<td>.00011</td>
<td>16.09</td>
<td>1377.5</td>
<td>10.38</td>
<td>.0000018</td>
</tr>
<tr>
<td>3</td>
<td>115</td>
<td>5.94</td>
<td>55</td>
<td>.00011</td>
<td>1295.5</td>
<td>1364.16</td>
<td>8.86</td>
<td>.0000018</td>
</tr>
<tr>
<td>4</td>
<td>SR160</td>
<td>3.91</td>
<td>40</td>
<td>.00025</td>
<td>377.80</td>
<td>218.75</td>
<td>40.22</td>
<td>.000008</td>
</tr>
<tr>
<td>5</td>
<td>SR160</td>
<td>2.24</td>
<td>45</td>
<td>.00025</td>
<td>1572.5</td>
<td>514.58</td>
<td>19.23</td>
<td>.000008</td>
</tr>
</tbody>
</table>

### Routine Exposure Criteria

#### D1: Dose to Persons along Route

<table>
<thead>
<tr>
<th>Segment</th>
<th>P*1/v</th>
<th>C1</th>
<th>D1</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>.14</td>
<td>.0000068</td>
<td>9.56E06</td>
</tr>
<tr>
<td>1</td>
<td>.21</td>
<td>.0000068</td>
<td>1.48E05</td>
</tr>
<tr>
<td>2</td>
<td>6.84</td>
<td>.0000068</td>
<td>4.66E04</td>
</tr>
<tr>
<td>3</td>
<td>140.01</td>
<td>.0000068</td>
<td>9.52E03</td>
</tr>
<tr>
<td>4</td>
<td>36.94</td>
<td>.0000068</td>
<td>2.50E03</td>
</tr>
<tr>
<td>5</td>
<td>78.32</td>
<td>.0000068</td>
<td>5.33E03</td>
</tr>
<tr>
<td>6</td>
<td>5.27</td>
<td>.0000068</td>
<td>3.59E04</td>
</tr>
<tr>
<td>6</td>
<td>4.078</td>
<td>.0000068</td>
<td>2.77E04</td>
</tr>
</tbody>
</table>

#### D2: Dose to Passengers in other Vehicles

<table>
<thead>
<tr>
<th>L*t</th>
<th>V2</th>
<th>L*t/v2</th>
<th>D2</th>
</tr>
</thead>
<tbody>
<tr>
<td>574.93</td>
<td>2025</td>
<td>.283</td>
<td>.00018</td>
</tr>
<tr>
<td>4436.56</td>
<td>2500</td>
<td>1.77</td>
<td>.000008</td>
</tr>
<tr>
<td>38077.17</td>
<td>4225</td>
<td>9.01</td>
<td>.00099</td>
</tr>
<tr>
<td>8108.18</td>
<td>3025</td>
<td>2.68</td>
<td>.00029</td>
</tr>
<tr>
<td>855.61</td>
<td>1600</td>
<td>.53</td>
<td>.00013</td>
</tr>
<tr>
<td>1153.29</td>
<td>2025</td>
<td>.56</td>
<td>.00014</td>
</tr>
<tr>
<td>13481.44</td>
<td>2025</td>
<td>6.65</td>
<td>.0016</td>
</tr>
<tr>
<td>7200.45</td>
<td>2025</td>
<td>3.55</td>
<td>.00088</td>
</tr>
</tbody>
</table>
### D3 Dose to Truck Crew

<table>
<thead>
<tr>
<th>Segment</th>
<th>t*t</th>
<th>l*t2</th>
<th>V3</th>
<th>(l*t2)/v3</th>
<th>D3</th>
<th>L/v</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>189750</td>
<td>52451307</td>
<td>274625</td>
<td>190.99</td>
<td>.00343</td>
<td>.002</td>
</tr>
<tr>
<td></td>
<td>6.25</td>
<td>.09</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>186095</td>
<td>11060916</td>
<td>166375</td>
<td>66.48</td>
<td>.00011</td>
<td>.004</td>
</tr>
<tr>
<td></td>
<td>0.69</td>
<td>.85</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>47851</td>
<td>187165.2</td>
<td>64000</td>
<td>2.92</td>
<td>.00023</td>
<td>.0017</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>264796</td>
<td>593463.9</td>
<td>91125</td>
<td>6.51</td>
<td>.0052</td>
<td>.004</td>
</tr>
<tr>
<td></td>
<td>.0</td>
<td>3</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>264796</td>
<td>6937326.19</td>
<td>91125</td>
<td>76.12</td>
<td>.0060</td>
<td>.05</td>
</tr>
<tr>
<td></td>
<td>.0</td>
<td>19</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>264796</td>
<td>3705232.36</td>
<td>91125</td>
<td>40.66</td>
<td>.0003</td>
<td>.02</td>
</tr>
</tbody>
</table>

### Routine Exposure Criteria

<table>
<thead>
<tr>
<th>Segment</th>
<th>D1+D2+D3+D4</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2.50E02</td>
</tr>
<tr>
<td>2</td>
<td>1.54E02</td>
</tr>
<tr>
<td>3</td>
<td>2.08E02</td>
</tr>
<tr>
<td>4</td>
<td>1.50E02</td>
</tr>
<tr>
<td>5</td>
<td>5.90E02</td>
</tr>
<tr>
<td>5</td>
<td>2.87E02</td>
</tr>
</tbody>
</table>
BIBLIOGRAPHY


Golding, Dominic and Allen White. *Guidelines on the Scope, Content, and use of*


Keeney, Ralph L. and Detlof von Winterfeldt. “Managing Nuclear Waste from Power

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.


VITA

Graduate College
University of Nevada, Las Vegas

Fred C. Dilger III

Local Address:
4505 Maryland Parkway
Las Vegas, NV 89154

Home Address:
1869 Desert Forest Way
Henderson, NV 89012

Degrees:
Bachelor of Arts, Economics, 1981
Pennsylvania State University

Master of Arts, Geography, 1996
University of London

Publications:

Dissertation/Thesis Title: Fear Itself: Assessing the Risks of High Level Radioactive Waste Transportation

Dissertation/Thesis Examination Committee:
Chairperson, Dr. Jerry Simich, Ph.D.
Committee Member Dr. Jay Coughtry
Committee Member Dr. Todd Kunioka
Committee Member, Dr. Craig Walton