UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

In the Matter	:	
of	:	PR-50, 51 (44 F.R. 61372)
Proposed Rulemaking on Storage and Disposal of Nuclear Waste, 10 CFR Parts 50 and 51 (Waste Confidence Rulemaking)	:	

STATEMENT OF POSITION OF ROBERT ABRAMS, ATTORNEY GENERAL OF THE STATE OF NEW YORK

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20. G. de Marsily, et al., "Nuclear Waste Disposal: Can the Geologist Guarantee Isolation?", Science, Vol. 197, No. 4303 at p. 519 (August 5, 1977).

21. President Carter's Message to Congress dated February 12, 1980, also printed at 126 Cong. Rec. H 811 (Feb. 12, 1980).

22. White House Fact Sheet on the President's Program on Radioactive Waste Management dated February 12, 1980.

23. Environmental Survey of the Reprocessing and Waste Management Portions of the LWR Fuel Cycle, NUREG-0116, NRC Task Force Report (1976).

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SUMMARY

It is the position of Attorney General Robert Abrams that there is no factual basis today for confidence either that nuclear waste will be safely disposed of by any given date or that it will be safely stored indefinitely until it is disposed of safely. We urge the Commission to make a finding of no confidence on both disposal and storage, and, as a consequence, to discontinue the licensing of new nuclear plants until the waste problem has been resolved.

In order to make a finding of confidence at this time, the Commission, among other things, would have to conclude, from facts existing today, that all technical

and political-social ("institutional") problems will be resolved. However, there is no basis for reaching that conclusion with respect to either type of problem.

Waste disposal would involve a multi-step process, requiring many separate technologies, none of which is available. In fact, in most if not all of the technical areas, there are either serious deficiencies in information or known obstacles -- or both -- which, unless resolved in the future, will preclude safe disposal. Further, there is no geologic medium which has been determined to be capable of assuring safe isolation.

The Department of Energy ("DOE") says erroneously that because research is planned or in process we can be confident today that safe disposal will be achieved. However, we do not know today whether or not the research will remove all obstacles; instead, it may fail to do so, or even uncover new uncertainties or problems making the task still more difficult to achieve. Confidence cannot be predicated on hope or blind technological optimism. Until the research has been completed -- and it can be stated (rather than guessed) that all difficulties have been resolved successfully -- we cannot begin to talk about confidence.

In addition, there are many technical criteria for repository site selection, each of which rules out geographic areas under consideration. There is no basis for con-

fidence that any proposed site which meets all of these criteria can be located.

Moreover, much of the information necessary for waste disposal can be obtained only by testing at specific sites, and cannot even be addressed until candidate sites have been selected. But no site will be selected until at least several years from now, and the results of in situ testing will not be known for some years thereafter. Therefore, it will be many years before we will know enough to express an opinion on confidence. Indeed, at the present time we do not even have a proven method for testing specific sites without fracturing them and destroying their structural integrity during the testing process. Until such a method exists, and until we have generic and in situ test results that appear to resolve all questions, a finding of confidence in safe disposal cannot be made.

Further, it will not be enough to find just one repository site; many sites, perhaps a dozen or more, will be needed for the increasing quantities of waste requiring disposal. This, in turn, means that dozens of candidate sites must be found meeting all criteria for in situ testing and evaluation. In view of the uncertainty that any site will be found meeting all the criteria, the need for many sites underscores the lack of a basis for confidence in safe disposal.

Similarly, there is no basis for confidence that institutional problems can be resolved. As DOE itself acknowledges, the public is very concerned about the consequences of building repositories, and many State and local governments, through legislation or otherwise, have expressed opposition to accepting repositories. Indeed, every Government effort to date to select particular sites has been opposed. Since many repositories will be needed, and thus dozens of candidate sites must be selected for testing and evaluation, the factor of public opposition creates a state of uncertainty that precludes confidence.

Moreover, beyond the specific technical and institutional doubts looms an even greater problem -- the impossibility of predicting events so far in the future. The challenge of nuclear waste disposal is truly unprecedented and unique, because nuclear waste will remain highly toxic for about a million years, and must be isolated for that long. Yet this period is many times longer than the entire span of recorded human history. No society has ever attempted to plan that far into the future, or even for a thousand years. Our ability to predict geologic events far into the future does not exist. And, we cannot rely on the

continued existence of social institutions as we know them today for even a period of centuries. Similarly, we cannot prevent human intrusions into the repository even in the near future. Therefore, even if all technical and institutional problems are eventually resolved and our disposal method seems to be foolproof, still there would be serious doubts that nuclear waste would be safely isolated for the necessary period.

DOE and others will urge the Commission to declare confidence in waste disposal, but the facts militate against their position. Confidence at this time could be based only on hope, not facts. Government officials over the past two decades have repeatedly expressed their hope that the solution was at hand, but the facts have never supported that conclusion and still do not today. DOE's current position is not grounded in facts any more than were past pronouncements.

Moreover, DOE employs distorted definitions of some of the key terms in this rulemaking -- "safety", "isolation", and "confidence" -- and thus seeks to becloud the issue before the Commission. Indeed, DOE projects its watered-down version of safety for only ten thousand years, a mere 1% of the million-year period during which isolation is necessary. DOE also admits that many data

gaps exist, that in situ testing will be needed after selection of candidate sites, that long term predictions are virtually impossible, and that public acceptance of repositories is low. Thus, even DOE's own statements show that its expression of confidence is unsupported by the facts and is unrealistic.

Long term storage, for the indefinite period until and if safe disposal becomes available, is no answer. It could be decades, or even centuries or more, before safe disposal has been achieved, and there is no basis for confidence that nuclear waste can be safely stored for that period of time. To the contrary, serious safety problems are known to exist even for short-term storage, and many accidents have occurred. Furthermore, there is no basis for confidence that safe away-from-reactor ("AFR") storage sites will be found, or would gain public acceptance.

Throughout this rulemaking the Commission must distinguish between wastes which exist today and wastes which will be produced in the future if new nuclear plants are licensed. It is generally accepted that existing wastes will have to be managed in the safest feasible manner, and we certainly hope that a truly safe disposal method will be available when needed. The Commission's action in this rulemaking will have little impact on these wastes, because the policy options are very restricted.

However, the Commission's finding in this proceeding will have a substantial impact on waste from new plants, as to which a full range of options is available. Presumably a finding of confidence will be seen by the Commission and licensing boards as a green light to approve new nuclear plants, and allow them to generate additional waste which will have to be managed. A finding of no confidence, however, must lead to a different result, if this rulemaking is to have any meaning.

We are now at a point of planning and controlling what nuclear wastes can be produced by new nuclear reactors, and in what quantities. Since these choices are available, and the danger of radioactivity is so great, the viewpoint that the best we can do is good enough has no place. While unfortunately it may become necessary at some point to adjust our safety standard for existing wastes -- because there is literally no alternative but to manage them as best we can -- there is no excuse for lowering our standard when deciding whether or not to permit additional plants in the future. By the same token, it is incumbent on the Government to commit itself to do the necessary research to design a system that will be as safe as possible for disposing of the existing wastes. But that hardly means that any method it ultimately adopts should be regarded as safe enough to warrant licensing new plants to generate more and more waste.

Because we have concluded that there is no basis for confidence today in safe disposal or indefinite storage, even for the existing waste, we urge the Commission to implement its statutory duty of protecting public health and safety by halting the licensing of new plants until the problem of safe disposal has been solved. It is bad enough that there is no disposal method for the existing inventory of waste. To license new plants to generate new waste under the circumstances would be grossly irresponsible.

This Statement opens with a discussion of the Government's history of false optimism on safe disposal over the past several decades, which parallels the hollow optimism voiced by DOE in this proceeding (Point I, p. 9). It then defines the issue before the Commission (Point II, p. 15), and explains how DOE has distorted the issue (Point III, p. 28). We then set forth our basis for saying there is no factual basis at this time for confidence in either safe disposal (Point IV, p. 42), or long-term storage for an indefinite period (Point V, p. 102). Finally, we explain why the Commission should order a moratorium on licensing new nuclear plants (Point VI, p. 111). Throughout this Statement, we rely predominantly on materials issued by or prepared for Government agencies.*

* In the first prehearing conference order, dated February 1, 1980, the Presiding Officer limited this rulemaking to a consideration of spent fuel, to the exclusion of reprocessing waste (p. 9). This limitation, of course, could make a final rule in favor of confidence of doubtful validity if the Government decides to proceed with reprocessing. Without waiving any right to challenge the Presiding Officer's ruling, we have limited our discussion below to spent fuel, and use the term nuclear waste in that sense.

I. THE DEPARTMENT OF ENERGY'S EXPRESSION OF CONFIDENCE IN SAFE DISPOSAL MUST BE VIEWED WITH DOUBT IN LIGHT OF THE GOVERNMENT'S LONG HISTORY OF FALSE PROMISES AND FAILURES.

Our national Government has been attempting to develop safe, permanent radioactive waste disposal for more than 30 years. In assessing its confidence today in safe disposal and evaluating DOE's optimistic statements, the Commission must consider the long history of Government optimism and promises which, so far, have failed to produce a solution to the growing waste disposal dilemma.

In 1957 the National Academy of Sciences ("NAS") issued a major report on the subject of nuclear waste disposal. Identifying geologic disposal in salt deposits as the most promising method for the near future, the Report's Study Committee stated that it was "convinced that radioactive waste can be disposed of safely in a variety of ways and at a large number of sites in the United States." The report added: "It may require several years of research and pilot testing before the first such disposal system can be put into operation."

In its Annual Report to Congress in 1959, the Atomic Energy Commission ("AEC") stated that "waste problems have proved completely manageable." That year, researchers at the Oak Ridge National Laboratory began to study the storage of wastes in salt. Beginning in 1963, field studies and laboratory

tests were initiated by the AEC at two salt mines in Kansas, one at Hutchinson and one at Lyons. After two more years of tests and preparations, a two-year experiment known as "Project Salt Vault" was conducted at the Lyons site. The experiment was concluded in late 1967. After analyzing the results of the experiment, the Government published a report in June 1970, declaring that:

> The feasibility of disposing of solidified waste in natural salt formation has been demonstrated in a salt mine in Kansas using spent reactor fuel...

On June 17, 1970, at "the culmination of a research and development program spanning more than 10 years," the AEC announced the tentative selection of the Lyons mine as "the nation's first underground radioactive waste repository." The Commission said that only one facility would be necessary to handle all of the commercial waste produced by the nation's nuclear reactors through the end of this century, and that it would be ready to start receiving wastes by about 1975. In its Annual Report to Congress in January, 1971, the AEC made its choice of Lyons "definite."

But several months later, the Lyons Project was aborted following the discovery of two major underground problems which cast doubt on the long-term safety and integrity of the site. One was a series of abandoned gas and oil drill

holes in the area; the other was an adjacent salt mine's extensive use of water to dissolve out salt. It was concluded that both of these problems made it possible that water might penetrate the area and allow radioactive wastes to escape. These problems, however, had gone undetected during the prior decade of research and optimistic pronouncements by the Government.

As a result of a study conducted by the United States Geological Survey ("USGS"), attention was then focused on a salt bed near Carlsbad, New Mexico. That site ultimately was designated as the "Waste Isolation Pilot Plant" (WIPP). John Deutch, head of energy research at DOE, stated as late as 1978 that he was "very confident" about WIPP, and predicted that it would be available by 1985.

In 1976, a report of the Energy Resources Council, representing several federal agencies, reaffirmed the feasibility of the safe management of radioactive wastes from nuclear production. Shortly after this report was issued, the assistant administrator of ERDA,* testifying before the Joint Committee on Atomic Energy of the United States Congress, outlined a timetable that would result in permanent storage of nuclear wastes in salt by 1985. The first storage location

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* Energy Research and Development Administration.

was to be the site near Carlsbad, New Mexico. Commerce Secretary Elliot Richardson observed that although mistakes had been made in dealing with nuclear waste, health and safety problems had not resulted, and "we should do even better in the future."

By the end of 1976, ERDA had announced plans to start deep drilling in the Spring of 1977 in "at least several of a list of 13 states." The selection of the first two repository sites was promised for 1978.

But no repository site was chosen in 1978. Instead, the last several years have witnessed an increasing articulation of the gathering doubts about the technical feasibility of geologic disposal. During the same period, public opposition to establishment of repositories at a variety of locations has crystallized.

On the technical side, in 1978 the USGS published Circular 779, which concluded:

> Key geologic questions are unanswered, and answers are needed before the risk associated with geologic containment can be confidently evaluated.

By 1978, ERDA had pushed back the date for selecting the nation's first repository to late 1979 at the earliest. In March 1979, the President's Interagency Review Group on Nuclear Waste Management ("IRG") concluded that "the scientific

feasibility of the mined repository concept remains to be established." A month later, a draft generic environmental impact statement on waste management was written by DOE. While professing hope in the ultimate feasibility of waste disposal in salt or other rock formations, DOE acknowledged numerous shortcomings in the data and the technology needed for permanent waste isolation. And in February 1980, the President declared that "past government efforts to manage radioactive wastes have not been technically adequate." Over DOE's objection, he cancelled the proposed WIPP Project, saying that further investigation of geologic sites was necessary before any media or sites could be selected.

Meanwhile, on the political side, the Government's efforts to choose candidate sites for repositories encountered public opposition in a number of States, including Michigan, Louisiana, South Dakota, Georgia, Vermont, South Carolina, and even New Mexico, which the Government had long viewed as friendly territory for a repository.

Today, after more than 30 years of scientific research and experimentation, no high-level waste repository exists, and the solution to the waste disposal problem continues to elude us. There are more questions than ever, and there is no factual basis for optimism. Indeed, the possible dates for a repository's being available have become more and more distant. While DOE and its predecessors have repeatedly and

confidently predicted during the past 20 years that disposal facilities would be operating within several years, DOE now concedes that final disposal might not be available until 26 years from now.

Meanwhile, more than half of the nation's nuclear reactors have now used up the spent fuel storage capacities which they were initially designed to accommodate. These reactors have obtained, and others will seek, permission to store additional spent fuel on-site; but these reprieves will only delay for several years the pressing need to solve the permanent waste disposal problem. In the apt words of the Court of Appeals for the District of Columbia:

> No one disputes that solutions to the commercial waste dilemma are not currently available. The critical issue is the likelihood (or probability) that solutions, either ultimate or interim, will be reached in time.

State of Minnesota v. NRC, 602 F.2d 412, 416 (D.C. Cir. 1979).

II. THE ISSUE BEFORE THE COMMISSION

The principal issue in this proceeding is whether the Commission is now confident, on the basis of existing facts, that nuclear waste will be safely disposed of by a given date.

A potential source of great confusion in this rulemaking is that different participants will define the issue and its key elements in different ways. For example, there will be different opinions as to what type of assurance is needed to create a basis for "confidence," or as to what degree of "isolation" is necessary, and for how many years, to provide for "safety." It will thus be necessary for the Commission to analyze each filing to determine what definitions and assumptions, stated or implied, are made which might affect the validity of the conclusions drawn.

For the purposes of clarity, then, the task before the Commission may be viewed as embracing several distinct elements. In order for the Commission to reach a determination in favor of confidence:

A. The Commission must be confident that nuclear waste will be safely disposed of by a given date. This requires making 3 separate determinations:

1) There must be confidence that disposal will be actually accomplished, not merely that it is technically feasible;

2) There must be confidence that the disposal will be safe; and

3) There must be confidence that the disposal will be available by a given date.

B. The Commission must decide that it has the necessary confidence today, based on facts which exist today.

C. The Commission must have the highest degree of confidence.

In this section, each of these essential elements of the issue of confidence is amplified. Section III will demonstrate that DOE distorts the issue, and fails in its Statement to satisfy the elements necessary to any finding of confidence.

A. The Commission Must Be Confident That Nuclear Waste Will Be Safely Disposed of By a Given Date.

1. There Must Be Confidence That Disposal Will Be Actually Accomplished, Not Merely That It Is Technically Feasible.

The issue before the Commission is not only whether it is confident that nuclear waste can, from a technical point of view, be disposed of. The issue, as stated in its notice of proposed rulemaking, is the Commission's present confidence

"that radioactive wastes produced by nuclear facilities will be safely disposed of." 44 Fed. Reg. 61372-3 (emphasis added). Thus, President Carter has urged the Commission to provide its judgment on whether or not radioactive wastes "can and will be disposed of safely." (Ref. 21, p. 5). Echoing the President's statement, his Council on Environmental Quality said, in its April 15, 1980 letter to the Commission with respect to this rulemaking:

> Nor should the NRC focus simply on the question of whether it is technically possible to provide safe, ultimate disposal; it is important for the public, the Congress and the Executive Branch to have the NRC's assessment of whether safe ultimate disposal will be provided as well as its assessment of whether it can be provided. (Emphasis in original).

DOE's National Waste Terminal Storage Program has recognized as well that "the resolution of the waste disposal problem requires a political consensus, a technical consensus, and a social consensus." (Ref. 15, p. 5). Some of the non-technical, institutional factors which in and of themselves should lead this Commission to determine that it lacks confidence that safe disposal will be achieved are discussed at pp. 68-76 of this Statement. The technical factors precluding confidence are discussed at pp. 58-67, 77-101.

Moreover, disposal of wastes means disposal of all wastes, not just some wastes. Thus, the Commission must be confident not merely that one safe repository can and will be available, but rather that many safe repositories can and will be available -- a sufficient number for all of the presently existing commercial and defense waste, for all the waste that may be produced by existing nuclear plants and ongoing defense activities, and for all the waste which any new plants would produce. This could require a large number of repositories. Indeed, since USGS suggests reducing the thermal load of each repository to avoid some technical problems produced by heat (Preliminary Statement, dated April 15, 1980, p. 10), it may be necessary to have a larger number of repositories, each containing less waste and less heat, than initially envisioned by DOE. In short, it may be that a dozen or more repositories will be needed just to handle the existing wastes plus those to be produced by existing plants and defense programs.*

* DOE's Statement of Position (hereinafter cited as "DOE Statement" or "Statement") assumes that 8 repositories would be needed in salt or granite. Statement, p. II-289. There must also be additional repositories available to handle wastes which have to be retrieved from other repositories. Thus, in 1976 ERDA planned to establish 6 repositories even though only one and a half repositories were then thought to be needed to house the anticipated waste inventory; the extra space was provided so that "waste could be transferred in case of problems at other repositories." New York Times, Dec. 3, 1976, IV, p. 7, col. 1. DOE has also recognized the need to be able to re-route wastes to other repositories if necessary. See pp. 62, 97, below, and DOE Statement, p. I-25. Applying even a factor of 2, rather than the factor of 4 used by ERDA, the need for backup facilities would require 16 or more repositories to be established.

In addition, as explained below at pp. 59-65, no potential site can be finally approved for repository construction until actual testing has been performed at the site. This means that a far greater number of potentially eligible sites would have to be identified, approved, and explored.

The question then is whether the Commission is confident today that the necessary number of safe repositories can and will be established.

In short, both technical and institutional difficulties must be considered in deciding whether or not <u>any</u> repositories will be established. The Commission then must decide if it is confident that many repositories will be found which meet all the siting and technical requirements and which also gain public acceptance. As the IRG said of the institutional difficulties, in a statement that could be applicable as well to the siting and technical constraints:

> The level of difficulty of all these problems could increase with the size of the nuclear waste inventory and its rate of growth. Institutions that can cope on a small scale may fail as the demands placed on them multiply.

(Ref. 10, p. 88).

2. There Must Be Confidence That The Disposal Will Be Safe.

The hazards associated with nuclear waste are well known and need not be belabored here. As one court has noted:

> Plutonium is generally accepted as among the most toxic substances known; inhalation of a single microscopic particle is thought to be sufficient to cause cancer.

> Moreover, with a half-life of 25,000 years, plutonium must be isolated from the environment for 250,000 years before it becomes harmless.

Natural Resources Defense Council v. U.S. Nuclear Regulatory Commission ("NRDC v. NRC"), 547 F.2d 633, 638-9, rev'd and rem on other grounds sub. nom. Vermont Yankee Nuclear Power Corp. v. NRDC, 435 U.S. 519 (1978) (footnotes omitted) (emphasis added).

And, beyond being carcinogenic, plutonium also causes changes in the genes (Ref. 14 , p. 247). Thus, each affected individual could transmit unpredictable genetic defects for generations to come. It is no exaggeration to say that exposure of a significant number of people to the plutonium from a waste repository could threaten the genetic integrity of the human race.

Other components of high level waste have half-lives much longer than plutonium, and may require isolation for millions of years. The Commission noted in its Table S-3 decision, for example, that Technetium-99 has a half-life of 213,000 years. 44 Fed. Reg. 45370, n.33 (August 2, 1979). Also having very long half-lives are Beryllium-10, Calcium-41, Rubidium-87, Zirconium-93, Palladium-107, Iodine-129, Cesium-135, Uranium-233, 234, 235, and 236, Neptunium-237, Plutonium-242 and 244, and Curium-247. Because nuclear waste contains such long-lived substances, DOE has acknowledged the need to isolate nuclear wastes for up to one million years. (Ref. 1, p. 1.9).

A method of disposal can be called safe only if it gives assurance of total isolation from the environment for the million years or more that isolation is required. As the NAS explained 23 years ago in a report prepared at the request of the AEC:

> Unlike the disposal of any other type of waste, the hazard related to radioactive waste is so great that no element of doubt should be allowed to exist regarding safety... Safe disposal means that the waste shall not come in contact with any living thing.

(Ref. 6, p. 3). (first emphasis supplied). EPA recently affirmed the goal of complete isolation during the hazardous lifetime of the waste. 43 F.R. 53265 (Nov. 15, 1978).

The need to isolate plutonium and other radioactive wastes from the environment for about a million years is most troublesome. No society has ever attempted to plan that far into the future, and no governmental institution has endured so long. See pp. 43-50, below. One writer has commented that the entire recorded history of mankind is only a fraction of the necessary storage time of plutonium, observing that Neanderthal man appeared only about 75,000 years ago. D. Farney, "Ominous Problem: What To Do With Radioactive Waste," 5 Smithsonian Mag. 20 (1974), cited by the court in NRDC v. NRC, 547 F.2d 633 at 652, n.54 (D.C. Cir. 1976). It is therefore necessary to develop a methodology that appears fool-proof, i.e., that has no detectable risks or flaws.

Of course, even such a methodology will carry with it very grave risks and be subject to unanticipated accidents. It will be subject to the uncertainty posed by our inability to predict geologic or human events even thousands of years from now. But to compromise our standard at the outset, to accept a methodology already known to have gaps and deficiencies, is to invite disaster. Such a weak methodology is more than likely to fail during the very long period under consideration.

President Carter has committed the Administration to work toward achieving a truly safe methodology. In his February 1980 message to Congress, he said: "My paramount objective in managing nuclear wastes is to protect the health and safety of all Americans, both now and in the future." (Ref. 21, p. 1). The President added: "We will act surely and without delay, but we will not compromise our technical or scientific standards out of haste." Id. at 5.

3. There Must Be Confidence That The Disposal Will Be Available By A Given Date.

The Commission must decide that it either does or does not have confidence today that nuclear waste will be safely disposed of by some specific date. The relevant date should be the time by which disposal facilities "are needed."

44 Fed. Reg. at 61372-3. As an outside limit, the Court of Appeals identified the year 2007 because one of the two power plants whose license amendments were before the Court happened to have an operating license which will expire in that year. However, there are a number of power plants in the United States whose operating licenses expire prior to 2007; for example, the license for Dresden-1 expires in the year 1996 (Facility Operating License # DPR-2); for Yankee Rowe in 1997 (License # DPR-3); and for Big Rock Point and Humbolt Bay in the year 2000 (License ## DPR-6, DPR-7). Had any of these specific plants been before the Court in State of Minnesota, it is clear that such earlier dates would have been identified as relevant.

More fundamentally, it is clear from the record below that the Commission itself, in using the phrase "when needed," was not referring to a date so far into the future. Thus, in its 1977 policy statement, the Commission clearly contemplated a repository license application in 1980 and facility operation soon thereafter. 42 F.R. 34393. The Appeal Board below interpreted the phrase "when needed" to mean "well before the termination of either the Prairie Island or Vermont Yankee operating licenses," 602 F.2d at 416, and explained:

> It is highly improbable that, by its reference to "when needed", the Commission had in mind a date even approaching the years 2007-

2009 (when the Prairie Island and Vermont Yankee operating licenses are due to expire).

7 NRC at 51 n. 10. Thus the Commission should not mechanically and arbitrarily assume for the purposes of this proceeding that the waste disposal facilities are not "needed" until 2007. Rather, at the outside, the Commission should choose 1996 as the deadline since reactor operating licenses begin to expire in that year. It then should decide whether or not it is confident that disposal will be available by 1996.

B. The Commission Must Decide That It Has The Necessary Confidence Today, Based On Facts That Exist Today.

It is insufficient for the Commission to decide that a basis for confidence may come into being sometime in the future. The issue is whether the Commission is confident today, based on the facts that exist today. Confidence cannot be based on hope, wishful thinking, an optimistic frame of mind, or absolute belief that science will overcome all technical problems and that institutional problems will evaporate. It must be based on facts that exist today. The long search for disposal methods and facilities described above amply demonstrates the unreliability of wishful thinking and the havoc it wreaks upon attempts at rational planning.

The requirement of a factual standard marks a departure from the Commission's prior basis for formulating nuclear waste policy. In 1977 the Commission, without a factual record, expressed confidence in ultimate waste disposal based solely on the ground that the Federal Government was then working on the problem, just as DOE is working on it now. The Commission cited ERDA's "dramatically expanded" program for repository development, and its "programmatic EIS" on waste management then in preparation. On the basis of a stepped-up program for site selection, ERDA was "expected to apply to the NRC for a license for such a facility in early 1980 or before." The Commission concluded:

> Thus, there is now a coordinated Federal program to develop an actual disposal facility.

42 F.R. 34393 (July 5, 1977). The decisions of the licensing appeal boards which were reviewed in State of Minnesota relied heavily on the above-quoted language in refusing to develop a formal fact-finding record on the issue of waste disposal. 7 NRC at 49-51. By remanding and directing the Commission to hold this rulemaking proceeding, the Court of Appeals made it clear that the bare existence of a "dramatically expanded" and "coordinated Federal program to develop an actual disposal facility," combined with NRC's ongoing development of licensing regulations, did not by itself constitute a factual basis for confidence.

Thus, the Commission may not find confidence merely because DOE is working on the problem and presents a plan of action with hopes for technical progress. Rather, the Commission must look behind and beyond the plan to ascertain whether facts exist today which justify a conclusion of confidence. In the words of Jude Tamm, concurring in NRDC v. NRC, 547 F.2d at 658:

> [NEPA] forbids reckless decisions to mortgage the future for the present, glibly assuring critics that technological advancement can be counted on to save us from the consequences of our decisions.

C. The Commission Must Have The Highest Degree of Confidence.

Defining "confidence" for this proceeding requires an analysis of the implications of the rulemaking. If the Commission makes a finding of confidence, presumably the result will be a green light for licensing new nuclear plants and permitting amendments to waste storage licenses. As we have seen, the growing inventory of nuclear waste includes highly toxic plutonium and many other radionuclides which are dangerous for a million years. The challenge of providing for safety over such a long period is unprecedented, and the consequences of unsafe disposal could be staggering. See above, pp. 19-21 Because of the recognized hazards, we submit that the highest degree of confidence is called for.

At a minimum, in the words of the IRG, "a high degree of assurance" of safe disposal would be required (Ref. 10, p. 42).

This Commission's prior declarations of confidence in safe disposal are not entitled to any weight in this proceeding. The Court of Appeals for the District of Columbia found such confidence to be unsupported in both the NRDC v. NRC (Table S-3) decision in 1976 and, as already observed, in the later State of Minnesota ruling, in 1979. Moreover, in July 1979 two members of the Commission, in separate opinions in the Table S-3 proceeding, questioned the policy of confidence. Commissioner Bradford expressly disassociated himself from it, and noted "the past record of the Commission's obsessive need not to know about the uncertainties regarding its waste disposal assumptions." 44 Fed. Reg. 45373 (Aug. 2, 1979). Commissioner Gilinsky also rejected the optimistic view on safe disposal of nuclear waste, saying:

> No such [waste] repository has yet operated. The prospective constructors of such a repository have not yet agreed on a design or even chosen a geologic medium. It seems anomalous, at this stage, for the regulators to express more confidence on this score than the repository designers and builders themselves have expressed.

Id. at 45374.

III. DOE DISTORTS THE ISSUE BEFORE THE COMMISSION.

The Department of Energy here expresses a kind of "confidence" in safe disposal that is totally different from the confidence that the Commission must have. This is because DOE's presentation of the issue to be decided fails to meet each of the essential elements set forth above (Section II).

A. DOE Has Not Shown That Nuclear Waste Will Be Safely Disposed Of By A Given Date.

1. DOE Has Not Shown That Safe Disposal Will Actually Be Accomplished.

At the very outset, DOE seeks to shift the issue away from whether or not wastes will be disposed of. It purports to define the objective instead as whether its program will result in "licensed waste disposal systems." DOE Statement, p. II-1. This in turn is defined as a finding

> that the Department is able (i) to understand and address the technical, social, political and institutional aspects of waste management; and (ii) to use the results from its program to develop licensed systems for the disposal of spent fuel in a time frame which is responsive to national needs.

(Id., emphasis supplied).

The issue in this proceeding, however, is whether the waste will in fact be disposed of, not whether DOE will obtain a license. Even if a license were ultimately obtained, DOE could fail to establish the needed number of permanent repositories because of technical problems or in situ tests which subsequently reveal the unsuitability of the sites. Technical problems aside, DOE could be unable to utilize any license it might receive because of public opposition or other institutional obstacles. To frame the issue solely in terms of whether or not DOE will get a license, therefore, misses the point. Even so, the license question at this time is too speculative to address intelligently -- not only because there are data gaps and no sites have been selected, but also because the NRC regulations are in preliminary form and the underlying EPA regulations have not been issued. The question as posed by DOE, therefore, is not only the wrong question, but is also impossible to answer in any meaningful way.*

* The quoted material from DOE's Statement is an example of the DOE doubletalk intended to obscure the weakness of its case. DOE must prove that it will overcome and resolve all technical, social, political and institutional problems. But the Department makes no claim that it will, hiding behind the empty phrase "understand and address".

2. DOE Has Not Shown, And Does Not Even Claim, That Disposal Will Be Safe For The Necessary Period.

In its draft impact statement, DOE said that nuclear waste has to be isolated for up to one million years. (Ref. 1, p. 1.9). This is because plutonium and other components of waste have half-lives of tens of thousands to hundreds of thousands of years. See above, pp. 19-20 . Yet its Statement of Position fails to demonstrate, or even to claim, that such isolation can be accomplished.

DOE now takes the absurd position that, for the purpose of finding confidence, isolation for only 10,000 years is sufficient -- and indeed DOE predicts isolation for only that long. (Statement, pp. I-14, 20). That period, however, is a mere 1% of the time for which isolation is needed for safety, by DOE's own reckoning. There is simply no rational basis for accepting an isolation period of only 10,000 years for finding confidence in safety when the scientific community knows the necessary period for safety is in truth 100 times longer. The fact that DOE does not even predict isolation for the necessary period is an admission of lack of confidence in safe isolation.*

* In any case, DOE fails to demonstrate a factual basis for confidence even for the inadequate 10,000 year period.

Moreover, DOE does not deny that releases of radiation from repositories will occur, but rather asserts that any releases will be small and comparable to releases experienced by members of the public in the course of engaging in common activities. The basis for this assertion is apparently that the repositories will have to meet NRC and EPA regulations, which will require that the repositories be constructed to insure safety.

The essential flaw in this circular argument, of course, is that there is absolutely no reason to assume, as DOE does, that regulations can prevent breaches in the future or guarantee that any breaches will be small. On the contrary, if the repository is breached, then, regardless of what the regulations say, common sense indicates that the releases are likely to be large. First, among the most serious and likely causes of a repository breach are human intrusion and groundwater entry. (See pp.49, 83, below.) If future generations drill into the repository at all, they are likely to breach it quite dramatically, leading to a substantial release of radioactivity. Similarly, once water establishes an escape route from the repository to the biosphere, there is more reason to think the migration of wastes will continue and indeed grow than that it will mysteriously subside. In short, when a closed system springs a leak, everything inside

can get out. And the likelihood of significant releases is compounded by the fact that during the course of a million years not just one but many, many breaches can occur, each one capable of releasing significant radiation -- either abruptly or gradually. Viewed in this light, DOE's claim that any release which occurs will be de minimus is pure fantasy and must be rejected.

But even if we assume for the sake of argument that releases from the repository would not exceed NRC and EPA regulations, this too would not assure safety. For one thing, the regulations have not even been issued, so there can hardly be confidence today that an as yet non-existent repository will some day meet some as yet non-existent standards. Moreover, regulations and policies are often found inadequate in light of experience. The Commission had to confront that situation after the accident at Three Mile Island, with the result that safety regulations have been revised in light of the Lessons Learned Reports. In addition, the Commission has decided to hold hearings aimed at reducing the risks of occupational radiation doses in NRC-licensed activities; EPA will conduct similar hearings. 44 F.R. 10388 (Feb. 20, 1979); 44 F.R. 53785 (Sept. 17, 1979). Thus, even if a proposed repository could meet regulations to be adopted by NRC and EPA, that would be no assurance of safety. Indeed, no regulatory agency has previously attempted to issue regulations to insure

safety for a one-million-year period. The regulations to be issued, at best, will represent the agencies' best current guess on how to do the job, but will hardly be a basis for confidence in safety for even the 10,000-year period cited by DOE, let alone the necessary million-year period.

Moreover, issuance of regulations is not tantamount to a declaration of confidence. EPA, in issuing regulations, would not be deciding that it has confidence in safe disposal for the necessary period. It would be saying only that its regulations are the best it can do, given present-day data gaps. The Court of Appeals has required that this Commission determine its confidence, and the task cannot be evaded by relying on regulations to be issued by EPA.

As previously noted (p. 28), DOE frames the issue in terms of licensability of its repository. But the possible existence of a license is not proof of safety. After all, Three Mile Island-2 had a license at the time of its accident, as have other nuclear plants where mishaps have occurred. The nuclear plants whose operations have been suspended by the Commission over the years for health and safety reasons have had licenses. Therefore, whether or not DOE gets a license for a repository -- itself an uncertain thing -- is irrelevant to the safety question.

Finally, DOE's definitions of isolation and containment are so watered down as to be unacceptable. "Isolation"

by the near field is defined to mean "insuri' that any migration of radionuclides through the near field will be very slow". However, "very slow" is not defined, and hence this definition does not establish true isolation. "Containment" is defined as something which "should be virtually complete during the period when radiation and thermal output are dominated by fission product decay". Id., p. II-7. "Virtually" is not defined, and the period in question is only hundreds of years -- a tiny fraction of the 10,000 year period DOE claims is sufficient to provide a basis for confidence, and an even smaller fraction of the million-year period for which isolation is truly required. Later, we are told that the near field of the desirable repository provides containment "by minimizing the likelihood that circulating groundwater will contact the waste package." Again, "minimizing" is undefined and thus this definition does not insure containment.

Thus, all of these definitions fall far short of the true isolation required to protect public health and safety, a standard evident to the NAS 23 years ago and affirmed recently by EPA. (See above p. 21). In fact, a majority of this Commission, in the Table S-3 proceeding, assumed that there would be absolutely no release of radioactivity from a permanent nuclear waste repository after sealing. 44 Fed. Reg. 45362 at 45367-9 (Aug. 2, 1979). The standard should be no weaker now that the Commission faces the issue head on in this proceeding.

3. DOE's Projection Of A Repository By The Year 2006 Is Contrived And Unreliable.

DOE's projection that a repository will be available by the year 2006 appears contrived to meet the suggested deadline of 2007 in the State of Minnesota v. NRC ruling. Moreover, DOE projects only one repository by that date, while conceding that many repositories will be needed. No outside date is given as a deadline by which all necessary repositories will be available. (Statement, pp. II-289 and III-8 to III-13).*

The projected date for repository availability has again and again been postponed, from the early 1960's predicted by the NAS to the mid-1970's predicted by the AEC, to 1985, to 1988, to the early 1990's, and now to some date between 1997 and 2006. Moreover, the longest postponements in the projected date have occurred most recently; even as late as 1976, operations were projected to start in 1985, 9 years hence, as compared with today's projections which look 26 years hence. It is obvious that the 2006 deadline may again be postponed.** In short, the DOE

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* As previously argued (p. 24), the Commission should not gear this rulemaking to that artificial date just because the operating license involved in that case will not expire until 2007. Instead the Commission should select the year 1996. Consequently, DOE's suggestion of 1997 as the earliest possible date by which the first repository could open is, on its face, unsatisfactory.

** An editorial in a periodical of the nuclear industry has observed: "There should be no surprise at all when the next delay, or the one after that, is announced." Nuclear News, June 1978, p. 35.

Statement in this proceeding may be no more reliable than previous hopeful plans announced by the Government over the course of more than twenty years. If history is any guide, there is considerably more basis for skepticism than for confidence about fruition of the plan in the time designated.

The illusory nature of DOE's data is highlighted by the agency's recognition that many data gaps exist and in situ testing is needed. DOE has chosen to assume that the gaps will be cured, the testing will not uncover new obstacles, and institutional problems will go away, but these cannot be predicted to occur at all, let alone by a given date. The notion that everything will fall neatly into place by 2006 is totally divorced from reality. Indeed, it is inconsistent with DOE's own view expressed only last year. In commenting on a report issued by the General Accounting Office in June 1979 on the need for spent fuel storage facilities, DOE said that it was not then possible to develop specific time frames for the final disposal of spent fuel (Ref. 17, p. v). Developing specific time frames is no easier now than it was last year, but DOE has nonetheless apparently contrived an artificial date solely for the purpose of this proceeding.

B. DOE Says That A Basis For Confidence Will Arise In The Future, And Will Be Based On Facts Which It Hopes Will Exist In The Future.

Repeatedly throughout its Statement, DOE offers promises that at some time in the future a basis for confidence

will emerge in some aspect of the plan of action:

> Confidence in the suitability of the repository will be high at the time waste emplacement operations commence...
>
> * * *
>
> The Department's approach ensures... that a high confidence in safety will be attained....
>
> * * *
>
> Site and host rock characterization will be carried out using state-of-the-art techniques which will provide confidence in the characterization of geologic and hydrologic conditions existing at the site.

(Statement, pp. II-280, II-299, II-300-301) (emphasis supplied). These are no more than promises, of a type that have proven illusory in the past, that at some time in the future there will be a factual basis for what now is blind confidence. The Commission, however, is charged with deciding its degree of confidence today. It cannot assume that the results of the proposed experiments will achieve everything DOE says they will. It must instead limit itself to determining its confidence today, based on the objective facts known today.

DOE's Statement of Position sets out a proposed plan of action toward development of a geologic repository. However, a written plan of action is no basis for confidence that the plan will be implemented as written, or that the

result will assure public safety. As noted above (p. 25), the Court of Appeals has ruled that similar plans by DOE's predecessor were no basis for confidence -- and, indeed, those plans failed to materialize.

Further, as more fully appears in Section IV, below, p. 77 , DOE recognizes that significant technical data gaps now exist concerning geologic disposal. The Department's response is twofold: first, research and development which will be done in the future will reduce the data gaps and thereby provide the basis for confidence; and, second, the sheer diversity of programs underway ensures that enough of them will succeed to provide confidence. (Statement, pp. II-160, 298, 302.)

DOE's reliance on methodology still to be developed is reflected in the following passages:

> [T]echniques for efficient seal emplacement methods, quality assurance techniques, and in situ characterization of seals will be developed.
>
> * * *
>
> Systems will be designed such that, in the event of accidents, involuntary exposure of both workers and the general public will be minimized.

Statement, pp. II-185, II-279 (emphasis supplied).

Once again, these hopes are no substitute for a factual basis for confidence. We simply do not know whether further research will lead to progress on the geologic repository concept, as envisioned by DOE, or whether it will instead reveal new obstacles tending to undermine the proposal. Research could lead to bad news, as indeed it has on more than one occasion in this very field, rather than to good news. Also, diversity is clearly no answer since it is very possible that no aspect of the program will result in a repository meeting all criteria.

DOE's confusion between fact and hope is aggravated by the agency's lack of objectivity about nuclear waste disposal, which has been recognized by sister agencies of the Government. Its optimistic conclusion in the draft GEIS that waste disposal can be accomplished safely in geologic formations was questioned by NRC staff, which suggested "restructuring the GEIS to support a more modest conclusion." (Ref. 7, p. 1). Similarly, the Department of the Interior -- the agency that encompasses the USGS -- said that the impact statement was "biased in its technological optimism" (Ref. 8, p. 3). Interior also charged that DOE chose to rely upon the judgment of "experts" who shared the prejudices of DOE and the "pro-nuclear industrial-government sector," to the exclusion of disinterested professionals employed by other government agencies, academic institutions or environmental groups. Id. at 7-8.

Perhaps the clearest rebuke to DOE and its predecessors came in President Carter's message to Congress in February 1980. The President there declared that "past government efforts to manage radioactive wastes have not been technically adequate." (Ref. 21, p. 1). Mr. Carter cancelled the proposed Waste Isolation Pilot Plant ("WIPP") near Carlsbad, New Mexico, saying that further investigation of geologic media and sites was needed before any site could be selected. (Ref. 21, p. 3).

In short, DOE's expressed confidence, unsupported by fact, is based on bias and/or hope, and cannot support a finding of confidence by the Commission.

C. DOE's Proposed Standard For Confidence Is Inadequate In Light Of The Enormity Of The Risk And Gravity Of The Danger

The Commission should squarely reject the standard proposed by DOE based on "the preponderance of available technical evidence as interpreted by objective experts in the field." (Statement, p. II-9). For one thing, DOE has been known to rely on "experts" who are not "objective." See above at p. 39. Moreover, a mere preponderance of the evidence is insufficient because an erroneous conclusion by the Commission could have consequences that are calamitous for future life on earth. Thus, if a Commissioner believes that the weight of evidence tips only slightly toward confidence,

his vote should be for no confidence.*

* In its Statement of Position in this proceeding, USGS expresses confidence in ultimate disposal, but is unable to give a date -- and therefore expresses no confidence that repositories will exist even by the year 2007 (p. 1). It also ignores the institutional obstacles to repository siting -- terming them "significant [but] outside the scope of this filing" (p. 9). It therefore is not even addressing the question of whether a repository will ultimately be established, but only the technical possibility. Furthermore, USGS acknowledges and outlines many gaps in technical knowledge and the research that must still be done -- including in situ testing (pp. 9-12). Indeed, it indicates that confidence will not come before successful in situ testing -- something which is years or more in the future. Therefore, its conclusion that safe disposal will some day be available -- although not necessarily by 2007 -- is based not on existing fact but on hope, and fails to satisfy the critical elements of the confidence issue facing this Commission.

IV. THERE IS NO FACTUAL BASIS FOR CONFIDENCE THAT NUCLEAR WASTE WILL BE SAFELY DISPOSED OF IN REPOSITORIES BY ANY GIVEN DATE.

This section demonstrates that there is no factual basis for the Commission to have any confidence that nuclear waste will be safely disposed of by any given date. The reasons that no such basis for confidence exist are:

A. Radioactive waste disposal presents a unique challenge, because it is necessary to predict far into the future, yet we are not able to do so;

B. There are serious technical and institutional problems that preclude confidence that even one satisfactory site, let alone the sufficient number of sites, will be selected; and

C. There are a myriad of defects, uncertainties and gaps in the many technologies which will be needed to implement waste disposal.

Each of these three areas is discussed below. Although DOE's Statement is filled with conclusory expressions of confidence, it will be seen below that in fact DOE's Statement, upon careful reading, concedes a great many of the specific factors which show that there cannot be a finding of confidence at this time. The data gaps are further spelled out by USGS and by various other reliable sources, primarily reports and studies recently published by the Government.

A. Radioactive Waste Disposal Presents A Unique Challenge, Because It Is Necessary To Predict Far Into The Future, Yet We Are Not Able To Do So.

Never before have science and technology been called upon to develop a safe method for disposing of deadly substances in such a way that they will remain isolated from the biosphere for up to a million years. As DOE observed in its Statement:

> The unique requirements of radioactive waste management have generated the first demands for applying long-term geologic predictions.

Statement, p. II-102. NRC staff has said that "geologic disposal is an entirely new enterprise -- no experience exists with geologic disposal." 45 Fed. Reg. 31395 (May 13, 1980). Yet it is not simply that we have no experience in meeting such a challenge; more fundamentally, the very requirement that our actions today assure the safety of our descendants for tens of thousands of generations is inherently fraught with great uncertainty. As DOE has explained:

> A prime uncertainty in conventional geologic disposal is verification of the safety and reliability of the concept in the long term. To verify the safety and reliability with certainty would require observation of the repository throughout the time the emplaced wastes have the potential to jeopardize the public health and safety. The ability to assure observation for such a time is clearly beyond any human experience. The use of analytical models and in situ testing then become an essential first step for predicting the long-term safety and reliability of a repository.

(Ref. 1, p. 3.1.239).

Despite the inherent difficulties in long-term prediction, DOE has recognized the importance of such prediction:

> Since HLW disposal systems will be required to function far into the future without active assistance from man, the ability to assess and predict long-term system performance is a key factor in determining licensability.
>
> * * *
>
> Confidence in the capability of a technology requires that its performance be predictable by currently available techniques.

Statement, pp. II-3, II-18.

The fact is, however, that we are simply unable to predict long-term geologic processes. This inability has been recognized both by DOE and by the USGS. The latter has termed geology itself "a retrodictive rather than a predictive science," (Ref. 4, p. 11) and has observed:

> [U]se of the geologic record to predict future events is a formidable task.
>
> * * *
>
> The past rates of occurrence of geologic events and processes have varied widely over time and there appears to be no clear philosophical basis for determining rates for these events or processes in the future.

(Id., p. 11). DOE has acknowledged that "many important aspects

of the evolution of the lithosphere ... are difficult, if not impossible to forecast," and that "simple projection into the future from local geologic history alone is not a satisfactory basis for repository site selection." (Ref. 1, p. 3.1.22). Moreover, according to DOE:

> Much basic knowledge about geologic processes, their interactions and particularly their time of next occurrence is lacking for certain types of events over the time periods being considered. The events are those that would be possibly disruptive to a repository... It is questionable how much these problems can be resolved in the near future, and there will always be some uncertainty which must be considered in the repository design.

(Id., p. 3.1.50).

Nor does DOE see a quick answer to the problem of predictive uncertainty:

> "Some events and geological processes may not be resolvable in the next decade or two to the degree of certainty presently felt to be necessary to time periods of hundreds of thousands of years and longer."

(Ref. 1, p. 3.1.51) (emphasis supplied).*

* In view of these candid acknowledgements appearing in DOE's draft generic EIS on commercial waste management last year, the Commission should view with the utmost skepticism DOE's present claim that the "geologic principle of uniformitarianism" is a basis for confidence today. See Statement, p. II-101.

There are a number of kinds of geologic events which are important to be able to predict over a long future period. Earthquakes are perhaps the most obvious. In fact, a major breach of the repository as the result of a severe earthquake "would release enough radiation to make the site uninhabitable if the event occurs within the first few thousand years." (Ref. 29 , p. 1-18). Our historical records of earthquakes, however, go back only 200 to 300 years (Ref. 4, p. 11; Ref. 5, p. 37). These records simply do not enable us to predict future earthquakes for thousands of years, let alone a million years.

Earthquake prediction suffers not only from a lack of data but from a lack of reliable theory as well. The theory of plate tectonics holds that earthquakes are concentrated in belts, and occur infrequently in the large stable plates of the United States. However, the "New Madrid" earthquakes, among the most violent earthquakes known, occurred in the North American stable plate:

> From 1811 to 1812, a series of hundreds of earthquake shocks devastated the central part of the Mississippi Valley ...Three very large shocks...were felt over two-thirds of the United States. In Washington, D.C., 1300 km away, sleepers were awakened, dishes and windows were rattled, and walls were cracked... The vibrations rang church bells in Boston. The earthquakes caused major changes in topography over 130,000 square kilometers.... The course of the Mississippi River was changed.

(Ref. 13, p. 51) (emphasis supplied). The history of large earthquakes in the United States "does not give a useful

indication of where future earthquakes might occur," except in certain regions of high frequency earthquakes. "At the present time we have no way of predicting the likelihood of such an occurrence [as the New Madrid Earthquake] in the supposedly stable plates." (Id., pp. 51-52).

The problem of predicting seismic events is compounded because, as DOE recognizes, the building of a repository could itself increase the risk of faulting:

> Fault movement could also result from repository placement in several ways: from changes in the stress field due to the geomety of the repository cavity, from added thermomechanical stresses due to heating, or from influx of water along a fault plane.

(Ref. 1, p. 3.1.27)

Another problem is that continental re-glaciation has "a very high probability of occurring within the time period of concern," and could bring with it faulting, flooding, and dramatic changes in climate. (Ref. 5, p. 38). For example, the effects of a shift from arid to rainy climate upon the hydrological regime of a waste repository has been "largely ignored in current risk assessments of repositories such as Hanford and the Nevada Test Site." Id. DOE has stated that inundation by rising sea level, creation of lakes, and formation of ice sheets are sufficiently likely to occur that their effects should be assessed for each region of the United States. (Ref. 1, p. 3.1.27; see also p. 1.14). If the top of a salt dome repository were accessible to sea-water, a large

quantity of salt could dissolve and the waste could be exposed. (Ref. 5, p. 39).

Penetration of a repository by groundwater is considered by DOE to be a "potentially significant release and transport process" which would bring nuclear wastes into the biosphere and thus into contact with human life. (Ref. 1, p. I.1). In fact, in its Statement in this proceeding, DOE states:

> Knowledge of groundwater hydrology is perhaps the most important requirement for understanding the long-term behavior of a mined geologic repository. The transport of radionuclides away from the waste-emplacement zone by moving groundwater is by far the most likely mechanism by which radionuclides might migrate from a repository to the biosphere....
>
> Surface water must also be evaluated as a potential source of flooding during repository operation.

(Statement, pp. II-76, II-77). And, since water is almost universally present in the underground, no rock formation can be considered to be completely impervious to water entry. (Ref. 20, p. 521). A report prepared for the NRC concurs:

> Seams within the salt can be quite permeable and hence could possibly provide a major pathway for water or waste movement. Even if these features are found to be initially quite dry... there remains the potential for future water intrusion.

(Ref. 9, Vol. 4, p. 7-12)*

* The adverse effects of groundwater entry are further discussed below at p. 83.

In addition to unpredictable changes in the physical characteristics of the repository environment, future human activity must be considered:

> It is clearly impossible to predict what the world will be like 50 years from now, let alone in several centuries.

(Ref. 19, p. 43). DOE has recognized as much (Ref. 1, p. 3.1.62), and accepts the "general consensus" that "we cannot rely alone on the continuity of existing governments and institutions over this long time period to insure isolation of the concentrated wastes." (Ref. 2, p. 7.1). In the area of land use, DOE has admitted that our predictive capabilities beyond even 100 years are "virtually non-existent." (Ref. 1, p. 3.1.25). Future generations might forget that a particular site is a repository (Ref. 20, p. 521). Or, they might prospect for salt (id. at 522): Significantly, 95 of the 263 salt domes of the Gulf Coast region have already undergone industrial development. (Ref. 27, p. 174). People might also prospect for oil, gas, sulfur, potash, or other commercial minerals which tend to be near salt deposits (Ref. 8, p. 6); or for the uranium and TRU elements that were buried at the site (Ref. 5, p. 35). They might also dig to satisfy archeological curiosity (id). In the words of the EPA Panel of Scientists:

> Man's unpredictability far outstrips most of the imagined geologic hazards we can foresee, and we doubt that it is amenable to meaningful probability analysis. (Ref. 5, p. 35).

The severity of the human intrusion problem was stated by NRC staff, as follows:

> Simply stated, human intrusion cannot be prevented; In spite of all efforts to avoid sites which may prove attractive to humans, there may be deliberate or inadvertent intrusion.

45 Fed. Reg. 31398 (May 13, 1980).

Significantly, DOE has no answer to the problems posed to the repository by possible human intrusion. The Department admits that "work is just beginning in this area and there is much to be learned" (Statement, p. I-18), yet it concludes without analysis that the problem could be reduced to an acceptable level. This is just one of many areas in which DOE's case is based on fantasy rather than a factual basis for confidence. DOE also contravenes its own stated objective to isolate the environment from the effects of "any reasonably foreseeable events or processes." (Statement, p. II-9).

Because of the impossibility of predicting geologic or human events with any certainty for the period of necessary isolation, DOE purports to rely on risk assessment models for its conclusion that disposal will be "adequately" safe for 10,000 years. Unfortunately, however, these risk assessments are very tenuous and suffer from a lack of essential data. They cannot justify confidence in predictions for 10,000 years, let alone a million years. As the IRG has said:

> Uncertainties associated with risk assessment derive from lack of data, lack of experience, inability to identify all release mechanisms for radionuclides, the natural variability in physical properties of geologic media, and inability to predict long-term geologic and climatic processes and social evolution.

(Ref. 10, p. 46).

The models must account for all of the variables which affect the repository viewed as parts of an integrated system of activity. As DOE explains:

> All of [the] analyses [of the components of the waste disposal system] are strongly interrelated and must be considered together in predicting the performance of all or any of the components of the disposal system. In order to make quantitative predictions, analyses like these require the use of mathematical descriptions, called models, of the phenomena. Before the models can be used with confidence, they must be developed and verified.

(Statement, pp. II-201 to II-202) (emphasis supplied). The fact is, however, that these models have neither been developed nor verified. Modeling analysis of effects on the environment near the repository is "just beginning." (Ref. 15, p. 57). "Realistic modeling of flow in fractured rock and of possible geochemical reactions remains to be achieved," says the IRG, "and this will undoubtedly be necessary before site suitability analyses can be made." (Ref. 11, p. 19). DOE admits

that developed and/or verified models will not be available until 1983 for overall repository performance, 1985 for waste-rock interaction, and 1987 for thermomechanical impacts on ground water. (Statement, pp. II-203, II-222, II-219). The development of detailed, accurate hydrologic models will require "considerable time." (Id., p. II-98).

The requirement of verification, of course, is not merely a formality; it is a substantive requirement that all steps in the verification process lead to positive results. During the verification process, facts may be revealed showing that an operating assumption is wrong, or that a proposed technique will not be feasible.
See above, pp. 38-39.

Thus, there is no dispute that models for predicting the long-term performance of geologic repositories are still under development and will not be available for years, and that data on specific sites to use in the models are incomplete (Statement, p. I-19). Nonetheless, DOE expresses confidence, arguing that the "analyses performed to date give no indication that a geologic disposal system, designed and constructed according to the requirements described in this Statement, cannot isolate radioactive waste safely." Id. However, the claim that analyses to date using models which are not fully developed and which lack data do not prove the impossibility

of safe isolation can hardly justify a conclusion that the inverse is true -- that, when all the data are in and the model is further developed, the analyses will affirmatively establish the safety of repository storage. The only honest response is that we do not know what the analysis will show -- and that in any case we cannot begin an analysis until a site has been fully tested. Selection and testing of a site are years away, and therefore we will not know for years whether or not models will ultimately suggest a basis for confidence.

The limited value of models is discussed by NRC staff in its proposed regulations for a geologic repository. Staff there says that the models necessarily contain many uncertainties and approximations, and are qualitative rather than quantitative; indeed, it may be impossible to develop credible quantitative models. 45 Fed. Reg. 31393 at 31395, 97-98 (May 13, 1980).

The inadequacy of risk assessment models was highlighted as well in the USGS Preliminary Statement in this rulemaking, dated April 15, 1980. As pointed out by USGS, much of the data and "understanding of the processes and events involved" are not available, and much of it will become available only "from site-specific investigations" (p. 11). Once again, therefore, until a site has been selected, and tested, the necessary assessment cannot be

made. Furthermore, says USGS, predictive models suffer from inherent uncertainty (p. 12).

The IRG has characterized estimates of probabilities which have been made for disruptive events as "little more than guesses," and notes that "for many geologic processes, it will never be possible to estimate probabilities without large uncertainties." (Ref. 11, pp. 49-50; See also Ref. 29, p. 7-19). It is evident that if the probability of a certain geological event is not known, a reliable risk assessment of the potential impact of such an event cannot be calculated. (See Ref. 8, p. 5).

DOE says that while there are residual uncertainties in waste disposal -- i.e., "uncertainties that cannot be eliminated" -- the problem is not unique to this field, and engineered barriers can "accommodate" the uncertainties. Statement, pp. II-17, I-8. It may be true that other projects involve uncertainty, but here the damage which can flow from an accident -- contamination of large regions of the earth -- is enormous and incomparable. Moreover, the likelihood that accidents will occur is particularly high because we must plan for a million years. That factor also is unique to radioactive waste management; in no other human endeavor do we attempt to plan for even a thousand years.

Engineered barriers could be built to last perhaps decades, or conceivably centuries, but not longer. They are of very limited value where the uncertainties against which they are designed to protect will last for a million years. Moreover, even if such barriers could be helpful in the short-term for a narrow, quantitative uncertainty, they are virtually useless when there is great qualitative uncertainty with respect to virtually every geologic, meteorological and human element involved. If we knew what the future condition would be but were unsure of its precise dimensions, the problem would be somewhat easier. But we cannot predict even what type of conditions will exist, so we cannot begin to rely on engineered barriers or "conservative assumptions" to overcome the uncertainties.

In conclusion, the risk assessment models utilized by DOE are too speculative and lacking in data to compensate for the inherent impossibility of prediction. They cannot form a basis for confidence in safe disposal.

B. Serious Technical and Institutional Problems Preclude Confidence That Even One Satisfactory Site, Let Alone The Sufficient Number of Sites, Will Be Selected.

The preceding discussion has demonstrated the great uncertainty that we will be able to achieve safe waste disposal, largely because we are unable to predict geologic and human events for even a fraction of the necessary isolation period. Yet, even if we were somehow able to predict the future, there would still be no basis for confidence in safe waste disposal. This is because we can have no assurance at this time of our ability to identify and select even one repository site -- let alone the necessary number of sites -- meeting all relevant criteria. On the contrary, as shown below, the difficulties inherent in selecting satisfactory sites may well be one of the greatest obstacles to a finding of confidence by the Commission, especially since a dozen or more sites may be needed. See p. 18, above.

In particular, site selection for repositories can be expected to be very difficult and time-consuming for both technical and institutional reasons. Extensive in situ testing will be needed, and might reveal, or even produce, unacceptabl conditions -- such as fractures which would permit water intrusion. Institutional problems would include the likely public opposition as well as difficulties in obtaining

approvals from State and local governments and Federal agencies.

Because of all these siting difficulties, DOE has recognized the possibility that no site will be found to satisfy all criteria of the selection process. (Ref. 1, p. 3.1.19). Until we know that a sufficient number of satisfactory sites do exist, have been thoroughly tested, and have received all necessary Federal, State and local approvals, we cannot be confident of safe disposal. As will be discussed below, it will be many years at best before we will be able to know if any such site exists.

In this section, the technical problems involved in assessing, selecting, and evaluating candidate sites will be outlined (pp. 58-67). In addition, the institutional problems in site selection will be discussed (pp. 68-76). The many gaps in the technologies needed to implement waste disposal -- apart from site selection problems -- are discussed below, in Section IV (C) (pp. 77-101).

1. Technical Problems Preclude Confidence That A Sufficient Number Of Satisfactory Sites Will Be Found.

(a) Geologic Siting Constraints Will Limit The Areas Which Can Be Considered For Possible Repository Sites.

DOE admits that site characterization and site selection require extensive technological analysis, and that the necessary technology has not been adequately developed. (Ref. 2, p. 2.2). Among the technologic constraints are geologic criteria which impose limitations on site selection.

First, groundwater often constitutes the major potable water supply of many regions, and is the most likely agent for transporting radioactivity away from the repository and into the environment. Thus, known major aquifers should be avoided. (Ref. 7, p. 3-42; Ref. 1, pp. 3.1.48, 3.1.49; Ref. 16, p. 16). Similarly, areas near large rivers and lakes should be avoided because of risks of flooding or water entry into the repository. (Ref. 1, p. 3.1.47). Further, areas of interior drainage can become covered with water during wet climatic eras, and thus might not be suitable for a repository. (Ref. 7, p. 3-28).

Second, areas of known active faults, joints or fractures, zones of recent earthquakes or volcanic activity, and crusted plate boundaries should be avoided. (Ref. 1, pp. 3.1.47, 3.1.48).

Third, the selection of some potential site locations may result in unacceptable, irreversible losses of valuable oil, gas, sulfur, potash, or other commercial minerals. (Ref. 8, p. 6). The importance of natural resources as a siting limitation has been recognized by DOE (Statement, pp. II-79 to II-80).

Significantly, these various limitations are cumulative, and may lead to ruling out very large areas of the country, perhaps making it impossible to find one potential site meeting all criteria -- let alone the many sites that are needed.

(b) In Situ Investigation Has Not Been Conducted At Potential Sites, Yet Such Investigation Itself Could Undermine The Sites' Integrity

Few propositions elicit more agreement among those concerned about nuclear waste disposal than that in situ tests must be performed before any candidate site can be considered acceptable. DOE repeatedly acknowledges this in its Statement. For example:

> An understanding of the character, condition and geometric configuration of the rocks in the vicinity of a repository is essential for developing predictive models used to estimate the performance of a repository.
>
> * * *
>
> [S]ubsurface exploration [is necessary to] allow the character and configuration of the rocks to be determined in detail. The data

> thus collected are used ... in computer models to predict the site's containment and isolation qualities... The potential effects of fractures ... must be evaluated for each site... Subsurface characterization and testing methods may need to be developed at each site before final decisions on suitability can be made.

(Statement, pp. II-72, II-73).

The IRG has explained the need for in situ tests as follows:

> Because the behavior of rock masses is influenced by inhomogeneities and discontinuities, results of laboratory tests of small, relatively homogeneous and intact specimens can be seriously misleading as predictors of rock mass behavior. In situ tests will be needed to develop reliable information on mechanical, thermal, and fluid flow properties at the site, and techniques will need to be developed to permit utilization of laboratory test data in the design and interpretation of in situ field measurements.

(Ref. 11, p. 58). Data from laboratory experiments, said the IRG, "are not adequate in themselves for engineering design of a repository because they do not represent the rock mass." (Id., p. 33). A report prepared for the NRC concurs:

> The only practical method to achieve final design must rely upon in situ monitored experiments conducted after initial excavation of a portion of the repository.

(Ref. 9, Vol. 4, p. 3-29) (emphasis in original). See also, Ref. 23, p. 4-95; Ref. 7, p. 3-9; USGS Statement of Position, pp. 7-9. President Carter recognized this principle in his

recent policy statement:

> Because the suitability of a geologic disposal site can be verified only through detailed and time-consuming site-specific evaluations, actual sites and their geologic environments must be carefully examined.

(Ref. 21, p. 3) (emphasis in original).

Moreover, no site can be assumed to be adequate for use as a repository until in situ testing has been conducted for many years -- and even then, new discoveries may require abandonment of the site. One well-known example of the elimination of a proposed site on the basis of in situ testing is Project Salt Vault (see above, p. 10). After several years of exploratory work in the 1960's at the unused salt mine near Lyons, Kansas, the AEC decided that the site was suitable for use as a federal repository for disposal of commercial high-level waste. Nonetheless, despite the years of exploration, the site was later found to be subject to water penetration and hence unsuitable, and the project was abandoned. (Ref. 2, Vol. 1, p. 1.5.1; NRDC v. NRC, 547 F. 2d at 648 n.46 and 651 n.52).*

* DOE's Statement of Position briefly discusses Project Salt Vault (pp. II-251 to II-253), summarizing five "significant results" from the Project. Incredibly, the discussion makes no mention of the Government's subsequent plans to use the mine as the nation's first underground radioactive waste repository, nor of the ultimate abandonment of those plans. See p. 10 of this Statement, above. This incomplete portrayal is a telling example of DOE's lack of objectivity about nuclear waste disposal, discussed above at p. 39.

The experience with Salt Vault demonstrates that *in situ* testing must continue for many years, including at least the period of waste emplacement and the retrievability period, so that technical problems with the site can be detected. If such problems do materialize, it could be necessary to remove some or all of the wastes already emplaced and move them to other repositories. Therefore, it is necessary to have additional repositories available for such contingencies. (See above, p. 18, footnote). It is consequently necessary that for each repository ultimately needed, several must be selected for *in situ* testing. As a dozen or more repositories will be needed, several dozen candidate sites will have to be tested.*

* Unfortunately, retrieval of the wastes in case a repository proves unsuitable is itself hazardous, to both the workers and the public. For example, as NRC staff has pointed out, canisters may be corroded, damaged or stuck, creating a risk of exposure to retrival workers. Overcoring could result in radioactive dust to which workers would be exposed. In addition, retrieval creates a risk of escape of radionuclides to the biosphere if the integrity of seals separating main airways from storage rooms has not been maintained. (Ref. 7, pp. 3-14, 3-15).

Unfortunately, however, the in situ tests that are so essential to assure a safe repository are also likely to ruin the site by breaching the integrity of the candidate repository and permitting water intrusion. As the IRG has found:

> The more extensively a potential site is examined, except with remote sensing geophysical techniques, the greater the likelihood that the integrity of the site will be jeopardized.

(Ref. 11, p. 46). Despite the clear need for in situ testing, DOE has acknowledged:

> Standard techniques for analyzing geologic formations in a non-destructive manner are not available. Uncertainties in this area center around the ability to develop instrumentation to measure certain in situ bulk rock characteristics without resorting to existing techniques which require core drilling.

(Ref. 1, p. 3.1.238) For example, wave-probing of rock to determine inhomogeneities or structural flaws is "in its infancy, and a substantial amount of basic work is needed before operational status can be claimed," including "considerable improvement" in instrumentation, understanding of wave-propagation phenomena, and development of interpretive tools and techniques. (Ref. 15, pp. 18, 19.) "There is a significant need to measure fracture geometry in hard rock...

The data obtained [in local measurements] are difficult to interpret" because of the non-uniformity of the medium. "A satisfactory global-type fracture geometry measurement is not yet available." (Id., p. 131).

The problem of non-destructive testing is a major obstacle to adequate exploration of specific sites. The IRG has said that "accurate prediction of the transport of radionuclides from a repository requires detailed knowledge" of many site-specific facts and processes, but "[t]hese types of hydrogeologic and geochemical information are currently not fully available even for the best known aquifers, and would require considerable effort to obtain at a repository site because of the need to minimize disruption of the repository area by drilling." (Ref. 11, p. 38).

DOE's Statement of Position wishes away the many technical gaps that could prevent or delay for many years selection of a repository. That Statement (e.g. at pp. III-65 to 68) discusses some of the many vital areas in which necessary information is lacking, but says that work is being done or planned and that the information will be available by specified dates.

DOE again appears to be indulging in wishful thinking. It cannot predict exactly how long it will take to get all the data. Indeed, it is possible that by the specified dates the researchers will conclude only that still more

information is needed. Furthermore, DOE assumes that all the data will be favorable to site selection, but that too is an arbitrary assumption.

(c) The Site Investigation Work Which Has Been Conducted To Date Affords No Basis For Confidence That Satisfactory Sites Will Be Found.

A good example of DOE's unfounded optimism about site selection lies in its conclusion that "the diversity of media under evaluation, the large number of potentially suitable sites... and the NWTS* Program's ability to successfully screen for sites using criteria and the available performance assessment techniques will result in identifying, qualifying, and licensing repository sites." (Statement, p. II-128). Assuming, for the moment, that DOE meant to say that a sufficient number of acceptable repository sites would be found, close examination of DOE's own description of its site exploration efforts shows the claim to be utterly devoid of any factual basis.

Thus, according to DOE, in 1980 two or three domes from the Gulf Interior Region Salt Domes will be "recommended for further examination in the 'location' study phase of the

* Nuclear Waste Terminal Storage Program.

site exploration process. Several characteristics need careful evaluation against the siting criteria." (Statement, pp. II-108, II-106). With regard to the Paradox Basin, "existing information is not yet sufficient for assessing the suitability of individual parts of the region for a repository." (Id., p. II-109). The data assembled to date on the Palo Duro and Dalhart Basins are "preliminary." "Specific questions pertaining to hydrology, tectonics, geology, and resource evaluations will be the subjects of proposed investigations." (Id., p. II-112, emphasis supplied).

Although the Carlsbad, New Mexico site has been under investigation for 8 years, DOE says that the site may suffer from a conflict with natural resources, and it is possible that future exploration at depth or improved understanding of geologic processes could reveal aspects undesirable for a repository. (Id., p. II-114) No field investigations have even been carried out by the Department in the Salina basin; the amount of glacial scour in valley areas needs to be investigated further, and resource conflicts may be severe for siting a repository anywhere in Ohio. (Id., p. II-117) "Much additional information is needed before a repository site could be identified in the Salina basin. At the present, no part of the basin can be judged acceptable or unacceptable for repository siting." (Id.) At DOE's

Hanford site in the State of Washington, "[q]uestions about the location and movement of the water in the interbeds and interflows of Wanapum and Grande Ronde Basalts are being addressed and should be resolved in the next 2 to 3 years." (Id., p. II-118). Finally, one location is being explored at DOE's Nevada test site. The geology is complex. Welded tuff within the site may contain up to 10% water by weight; the effects of this water "have to be assessed and are being investigated." Moreover, "few reliable estimates of ground water flow velocity are available" for the region. (Id., pp. II-118 to II-124).

This, then, is the status of DOE's investigations to date, almost none of which have proceeded beyond regional evaluations to studying or even identifying specific candidate sites. As already observed, a dozen or more repositories may be needed, yet no candidate site will be selected until 1985 at the earliest. (Ref. 21, p. 3). The discussion above shows that there is no basis for knowing whether any of the ongoing investigations will identify even one technologically satisfactory region, let alone a specific site.

In claiming that many sites will be available, DOE places reliance on its "ability to successfully screen for sites using criteria," see p. 65 , above, But careful screening will simply distinguish between unsatisfactory sites and, if any are found, satisfactory sites. The screening process cannot transform an unsatisfactory site into a satisfactory one.

2. Institutional Problems Preclude Confidence That Satisfactory Sites Will Be Established.

Apart from the many technical obstacles which create doubt about establishment of repositories, institutional problems must be considered. Among these issues are the possible opposition by State and local governments, the public, and even other federal agencies, as well as the uncertainty about DOE's obtaining the necessary licenses from the NRC. See above, p. 29.

As earlier observed, the primary issue as posed by the Commission is whether "radioactive wastes produced by nuclear facilities will be safely disposed of." 44 Fed. Reg. 61372-3 (Oct. 25, 1979) (emphasis added). This question cannot be answered by looking at technical issues only. Even if those issues are ultimately resolved, nuclear waste will not be safely disposed of unless all the institutional problems are also resolved satisfactorily. Resolution of the matter requires not only a technical consensus by the scientific community on the methodology to be employed, but also a political consensus and a social consensus by the public to accept that methodology (Ref. 15, p. 5). The IRG report concluded that:

> the resolution of institutional issues, required to permit the orderly development and effective implementation of a nuclear waste management program is equally important as the resolution of outstanding

> technical issues and problems and... the resolution of institutional issues may well be more difficult than finding solutions to remaining technical problems.

(Ref. 10, p. 87). (emphasis supplied). The reason for this is obvious. There can be no confidence that "radioactive wastes... will be safely disposed of" if society -- for whatever reasons, rational or emotional -- refuses to permit repositories to be constructed. "Only if such a social consensus is obtained," said the IRG, can disposal of nuclear waste in geologic formations "actually be implemented." Id. at 47.

We will discuss below public acceptability of the repositories, as well as the problem of using land subject to federal jurisdiction.

(a) It Is Doubtful That Repositories Will Be Accepted By The Affected Public As Well As State and Local Governments.

Significantly, DOE acknowledges that all of the waste disposal options being considered -- including geologic disposal -- rate very poorly in terms of public acceptability. The GEIS comparative analysis includes discussion of "Policy and Equity Considerations," which is supposed to assess public acceptability (Ref. 1, p. 48). That criterion, in turn, is

subdivided into two items, one of which is labeled "Distribution of Risk" and is said to measure the "Index of Perceived Risk" (Id. at 4.9). The analysis concludes that on a scale of 1 to 5, each of the ten disposal options receives the lowest possible score of only 1 for "Distribution of Risk," id. at 4.11, a score which "represents the less desirable [condition]". Id. at 4.10. In short, all of the options are acknowledged by DOE to have very low public acceptability and high perceived risk.

Indeed, he possibility of public opposition was spelled out by Battelle's Pacific Northwest Laboratory in a report prepared for DOE (Ref. 19). Battelle pointed out that increasing numbers of State officials were seeking to veto proposed repositories within their States, and added:

> These expressions of interest by State government can be backed by legal and political actions that can impede or halt efforts by the federal government to site nuclear repositories or implement a national nuclear waste management program.

Id. p. 88. Battelle noted that State and local governments could frustrate repository development through their environmental laws and regulations of land use, construction, and transport of radioactive materials. Id. pp. 96-103.

There is already impressive evidence to the effect that opposition to the siting of waste repositories could be

significant. The federal government's plan to bury wastes at Lyons, Kansas aroused local opposition ten years ago; the Waste Isolation Pilot Plant has faced intense citizen protest in New Mexico. Science, Vol. 202, Nov. 3, 1978, p. 501; Vol. 199, Mar. 10, 1978, pp. 1050-1; Vol. 172, Apr. 16, 1971, pp. 249-50; Wall St. Journal, Aug. 29, 1978, pp. 1, 32. In 1976 ERDA sought to conduct exploratory drilling for a repository in Alpena County, Michigan. In response to questions from State Governor William Milliken, ERDA stated: "The project will be terminated in Michigan if the state raises issues...that are not resolved through a mutually acceptable procedure." Two months later, local voters overwhelmingly opposed waste repositories in their counties. As of November 1978, twenty-three States had passed or considered laws or resolutions to limit or ban radioactive waste disposal within the State. Nuclear News, Nov. 1978, p. 86). Eleven States passed such laws during 1979.

Thus, at the present time public acceptance of repositories cannot be assumed. Moreover, even if the scientific community were able to devise methods which reduced the probability of a repository accident, that would not necessarily improve public acceptability. The public's perception of

risk differs from that of the technical community, which defines risk as the probability that an event (such as major release of radioactivity from a repository) will occur multiplied by the expected consequences of the event. By this definition, if the probability is small enough the risk may be viewed as modest, despite the possibly calamitous consequences of an accident. But the public does not accept that reasoning. According to Battelle's report to DOE:

> The general public often perceives the outcomes of an event to be more important than the probability. This may be due to the fact that the public is familiar with Murphy's Law: If something can go wrong, it will go wrong. Thus, probabilities are often perceived to be less meaningful than outcomes.

Ref. 19, pp. 13-14 (citations omitted). The point is that whichever definition of risk may be considered technically correct, the public's perception of risk is high and its willingness to take risks is low. Public opposition, therefore, can be expected.

The most vigorous opposition might be expected to come from those living near proposed repository sites or along the many proposed routes for shipping nuclear waste to each repository. People living in any of these areas would be exposed to "low levels" of radiation from normal operations,

and to extremely dangerous levels from major accidents. They are not likely to be persuaded by DOE's conclusion that repository operations or spent fuel shipments pose only "acceptable" levels of risk. Their opposition can be expected and must be considered.*

The DOE Statement of Position in this proceeding fails to deal realistically or candidly with the institutional difficulties facing repository siting. On the one hand,

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* DOE fails to acknowledge that even within the scientific and federal regulatory communities, the health effects of "low-level" radiation are the subject of considerable controversy. Significantly, the NRC has expressed its desire to "reduce the risks of occupational radiation doses in Commission-licensed activities," and has proposed amendments to current dose regulations. 44 F.R. 10388 (Feb. 20, 1979).

Moreover, the health effects of radiation are cumulative; doubling present exposures by adding "acceptable" doses from nuclear wastes should not be countenanced. Indeed, other phases of the nuclear fuel cycle, such as uranium mining and reactor operation, add their share of radiation to people and the environment. Thus, waste disposal cannot be discussed in a vacuum; the entire nuclear fuel cycle may add a several-fold increase in prior levels of radiation.

Finally, DOE argues that the public should accept radiation from nuclear wastes because comparable levels of radiation from voluntary activities are "routinely accepted without question." (Statement, p. II-14). The truth is that the public has clearly demonstrated its unwillingness to accept the risk of radioactive waste, or to have that risk forced upon it.

DOE says that "[b]ecause social concerns are less easily predicted [than technical considerations], less confidence can be placed in assessment of their impacts on the repository program" (p. III-87). DOE also acknowledges that it is "possible that unanticipated or unresolved issues of concern at the State or local level could cause prolonged perturbations in the schedule." Id. at p. III-31. On the other hand, DOE proceeds to discount these problems on the mere hope that the particular State and local governments having potential sites will agree to the siting of repositories within their borders.

DOE's assumption of State and local cooperation is without factual basis. DOE assumes that simply because it will discuss siting with the concerned State and local officials, the latter will agree to the siting. In the eyes of DOE, discussion inevitably leads to consensus; however, in the real world it often leads to disagreement. Since the public perceives and is unwilling to accept a high level of risk, State and local officials are likely to oppose the repository.

In the face of this evidence of public fear and opposition, DOE says that creation by the President of a State Planning Council will eliminate friction (p. III-24). This appears to be naive, for it cannot be assumed that the Council will agree to any particular site -- or, if it did, that the host State or local government would agree. Again, DOE relies on the unrealistic notion that discussion must inevitably lead to agreement.

DOE's failure to come to grips with institutional problems was recognized by the Hearing Board which it appointed to hold public hearings across the country on the draft GEIS. In its report to DOE in February 1980, the Board said that the GEIS gave inadequate attention to social and political issues although "the degree to which human concerns are taken into account could result in the success or failure of any waste management plan" (p. 10).

(b) Other Institutional Factors Could Prevent Selection of Repositories.

Statutory environmental requirements are imposed by the National Historic Preservation Act and the Land and Water Conservation Act. (Ref. 8, p. 6). The Interior Department has said it would not agree to repository selection inconsistent with those Acts. (Id.) In addition, the Interior Department has expressed opposition to repository siting on or adjacent to other lands subject to its jurisdiction, such as portions of the National Park System, the Wild and Scenic River System, and the National Trail System, as well as Indian Trust lands. (Id., p. 7).

DOE assumes that the Secretary of the Interior would make lands under his administration available to DOE temporarily for repository testing (P. III-48). In light of Interior's expressed views on the subject, that cannot be assumed. Nor can it be assumed that Congress would then agree to a permanent transfer of the site to DOE for a repository, as assumed at p. III-49.

In conclusion, even apart from the many technical problems and gaps still to be resolved, consideration of the institutional issues alone requires the conclusion that there is no basis for confidence that nuclear waste will be safely disposed of. DOE has not forthrightly addressed the institutional barriers which shed serious doubt on its plans for repositories.

C. There Are A Myriad Of Defects, Uncertainties, And Gaps In The Many Technologies Which Will Be Needed To Implement Waste Disposal.

DOE has chosen to found its confidence on the mined geologic repository concept. Yet, according to the IRG, that concept has not yet bee shown to be scientifically feasible (Ref. 10, p. 42). Indeed, it is an oversimplification to say that the methodology for geologic disposal is not available, because geologic disposal actually would involve a series of stages of implementation, each of which requires its own methodology. Thus, to begin with, one must learn a great deal about the properties of various potential host rocks, and about how radioactive wastes would interact with them. After acquiring this type of knowledge, a generic decision must be made as to which rock medium or media, if any, are feasible for geologic repositories. Then, in order to actually place nuclear waste in a repository, methods must first be developed to (1) place the waste in canisters and ship it to the repository site; (2) excavate the repository without destroying the site's integrity; (3) insure for an adequate period that the waste can be retrieved if a particular site is determined to be unsatisfactory after waste emplacement there has begun; (4) seal the boreholes, shafts, and buildings at the surface after the repository operations are concluded, to prevent leakage; and (5) monitor underground activity within the site from remote locations for the necessary period of time. None of these methods has been developed;

to date, DOE has offered only "conceptual" plans and "technologies of the future" to dispose of real nuclear waste.

Two broad categories of difficulties help explain why the technologies for the various phases described above do not exist. The first is that, as to many phases, we have already learned enough to know that all options now under study are plagued with serious defects and drawbacks which so far cannot be overcome. Secondly, in almost every phase, we know so little about the critical aspects of the available technology that no one is in a position to say whether it will work. In the earlier-quoted words of the USGS, "some key geological questions are unanswered, and answers are needed before the risk associated with geologic containment can be confidently evaluated." (Ref. 4, p. 3).

1. The Properties of Potential Host Rocks And Their Interactions With Radioactive Wastes Are Not Understood.

As DOE has recognized, "important gaps exist in knowledge regarding rock properties and responses under extreme conditions of temperature, stress and radiation over long periods of time". (Ref. 1, p. 3.1.26). "Additional research is needed to develop accurate methods for determining rock strength". (Id., p. 3.1.30).

Moreover, apart from the properties of the host rock as measured in the laboratory, there are many things about how the wastes and the host rock would interact which are not understood, including the effects of heat, radiation, chemical reactions, and water,and the potential for migration of wastes out of the repository. In the words of USGS, "the uncertainties associated with hot wastes that interact chemically and mechanically with the rock and fluid system appear very high." (Ref. 4, p. 6; see also Ref. 23, p. 4.94; Ref. 5, p. 2). DOE's Statement acknowledges that verified models describing interactions between waste and rock are not expected to be available until 1985. (Statement, p. II-222). These models,even if verified, however, would be of limited use. See above, pp. 52-54.

The effect of the heat emanating from the wastes on the surrounding rock of a repository is acknowledged by DOE to be "a major unknown geologic factor [presenting] the most difficult engineering uncertainties." (Ref. 1, p. 3.1.34). The heat flows through the canister and other protective materials into the host rock and eventually into the atmosphere. (Ref. 2, p. 7.3.1). The heat affects

1) the integrity and recoverability of the waste canisters

2) room and pillar stability

3) integrity of the waste matrix over long periods of time

4) integrity of the host rock and the surrounding rock

5) overlying aquifers and groundwater flow

6) long-term uplift and subsidence of overlying rock. (Id.)

Comparatively little work has been done on the effect of temperature on the compressive strength of rocks; more investigation is required. (Ref. 9, Vol. 4, p. G-2). We do know, however, that heat will induce stresses in the surrounding rock (Ref. 2, pp. 3.1.35, 1.13), and will reduce its strength (Statement, p. II-165). This can cause increased permeability. (Ref. 1, p. 3.1.34). Some data show that these stresses can significantly affect pillar stability within a mere five years after waste placement (Id., p. 3.1.35).

Moreover, displacement of the overlying rock mass by heat can cause fracturing in the rock, thereby giving rise to "perturbations in the hydrologic flow regime" and "potential pathways for waste migration". (Statement, p. II-165; Ref. 1, p. 3.1.24). NRC staff has observed that high-velocity flow paths for underground water, resulting from fractures, can bring radionuclides into the biosphere. (Ref. 7, p. 3-35).*

* Salt might not be expected to fracture, but if the surrounding strata were breached by fracturing, salt could be vulnerable to rapid solution by groundwater. (Ref. 1, p. 3.1.24). Moreover, stress can exacerbate creep. (Statement, p. II-75). See below, p. 86.

DOE has accordingly recognized that "limiting the impacts of heat generated by the waste is a principal consideration in the design of a repository." (Statement, p. II-164). Moreover, "precision [in thermal models] is important in insuring that heat loads designed for the repository will not produce adverse effects in the host rock." (Id., p. II-215).

As DOE has observed, there is comparatively little information on the influence of radiation on rock strength. (Ref. 1, p. 3.1.24; see also Ref. 9, Vol. 4, p. G-6). Indeed, radiation effects have not yet been assessed "even in the most cursory manner" (Ref. 15, p. 114). Because of this lack of data, in-depth comparisons of alternatives with regard to radiation are not available.

Much of what is known about radiation effects, however, is disturbing. Tests have shown, for example, that radiation can reduce the compressive strength of salt by 30 to 40%. (Ref. 1, p. 3.1.36). Also, underground pressure can increase as a result of the entrapment of gases such as helium and radon which are released through radioactive decay. "This increased pressure, if not properly relieved, could lead to the development or reopening of fissures that would result in the escape of radioactive materials to the surface." (Ref. 8, p. 12). Finally, radiolysis of brine can lead to

buildup of gas pressure, formation of explosive gas mixtures or chemicals, and unknown interactions with the high-level waste. DOE identifies radiolysis as "one of the principal factors that could affect canister longevity." (Statement, p. II-177).

The IRG found "major gaps" in current knowledge of the chemical interactions of spent fuel, its cladding and containers with salt or any other candidate host rock. DOE acknowledges that our understanding of spent fuel stability is limited, and that the long-term chemical, mechanical, thermal and radiation effects have not even been assessed. (Ref. 1, p. 1.15). According to the IRG:

> There are a number of questions associated with the disposal of spent fuel that require resolution through further research. Specifically, it is necessary to determine if the fission gases and the significant quantities of uranium and plutonium in the spent fuel present a potential problem in the repository, either during the operation phase or after closure. At least several years of experimental work needs to be conducted to determine the chemical reaction among the fuel pellets with their cladding, the spent fuel container, and the potential host rocks. More needs to be known about the chemical forms of the fission products and actinides in the spent fuel pellets and cladding, and about the resistance of these forms to leaching or reaction with repository rocks.

(Ref. 11, pp. 27-28; see also Ref. 10, p. 74) (emphasis supplied).

Moreover, there are wide variations in the characteristics of different fuel assemblies. (Ref. 26, p. 4). As USGS has observed, the chemical properties of spent fuel"depend on its burnup, location within the reactor core, age and physical integrity." (USGS Statement of Position, p. 9). Therefore, "[d]esign of a system of engineered barriers to accommodate this heterogeneity within the context of a given geohydrologic environment will be a major undertaking" (Id., pp. 9-10). Spent fuel also poses the added problem of "its potential for release of gases" (Id., p. 10).

There are also "large uncertainties" concerning the speed and modes of migration of radionuclides through the underground. (Ref. 18, p. 10; see also Ref. 4, p. 8). Indeed, "uncertainty is the distinctive element of radionuclide transport analysis." (Ref. 5, p. 32). Measurement of the physical and chemical properties that control underground transport for a sufficiently long flow path is theoretically feasible but "still in the future". The USGS has said:

> We need, as a minimum, the permeability and porosity of the media and the hydraulic head gradients all in three dimensions. In addition, we need to know the sorptive characteristics of the media along all paths, and we need to estimate the variable rates at which the solidified wastes will enter the transporting fluids. Needed, in particular, is information on the distribution and extent of major heterogeneities. The need for such data severely taxes both the available data base and the technology for generating it. Most of the requisite data are

presently unavailable; most of the available data have such large error limits that their usefulness in predictive models is limited.

(Ref. 4, pp. 8 .) (emphasis supplied) (See also Ref. 5, p. 33, and Ref. 11, p. 38).

2. No Geologic Medium Or Media Have Been Determined To Be Capable Of Assuring Safe Isolation

Assuming a decision to establish geologic repositories, there remains the question of which geologic medium or media will be used. Salt has been most thoroughly studied, but, as shown below, it has significant drawbacks which may ultimately exclude it from being used. Nor have shale, basalt, or granite been shown to be suitable host rocks; rather, as with salt, serious deficiencies are already known to exist with each of these media. The IRG and the President have explicitly refrained from endorsing any particular medium (Ref. 10, p. 42; Ref. 22, p. 15), because no medium has been shown as yet to be satisfactory.

(a) Salt

More is known about salt than about other candidate media. Nevertheless, despite many years of research, "major uncertainties" remain concerning the viability of using salt formations as waste repositories. (Ref. 16, pp. 16, 17). The reason for continuing uncertainty is that we already do know of serious troubles with salt. Those troubles arise because salt is soluble in water, forming brines; salt creeps,

threatening mine stability; salt is adversely affected by heat; salt is vulnerable to fractures; and disposal of mined salt poses an environmental hazard. Salt also carries with it the potential dangers of "focusing" and breccia pipes. Each of these liabilities of salt is briefly described below.

First, salt is highly soluble in water (Ref. 2, p. 7.2.4; Ref. 1, p. 3.1.32). This solubility constitutes a serious defect for several reasons. As DOE has acknowledged, "trapped brine can be released with considerable energy when heated and can fracture the rock." (Ref. 2, p. 7.2.18). "The protective metal canisters and sleeves will certainly degrade quickly in the strong brine environment, and leaching of the wastes will be enhanced." (Ref. 4, p. 5). Interstitial brine is known to reduce the mechanical strength of the salt. (Id.) Also, as DOE recognizes, brine tends to migrate towards heat sources, such as radioactive waste (Statement, pp. II-175, II-252; see also Ref. 8, p. 11); migration in volume "is likely to be deleterious and must be accounted for when considering long-term isolation." (Ref. 11, p. 65). Brine can also be expected to decrease the sorptive properties of the salt (Ref. 15, p. 45); "the capacity of the salt to fix or adsorb the nuclides from the waste in insoluble form is apparently low." (Ref. 4, p. 5).

Solubility affects mine operations and retrievability of the wastes. As USGS has said:

> If relatively small amounts of brine can cause substantial decrease of me-

> chanical strength and possible movement of waste during a relatively short time, special efforts will surely be necessary to insure retrievability from a salt repository for periods as short as 10-25 years. The question of whether the workings of a mine in salt can be predicted to stay dry will have to be faced.

(Ref. 4, p. 12).

Second, as DOE recognizes, salt creeps. Creep is the viscous flow of the medium under constant stress. Creep occurs in three stages. The first stage is short and occurs at the time of initial stress. Then there is a longer "steady state creep," during which there is a gradual increase in stress. Most important is the third stage, which lasts less than a day and leads rapidly to failure. (Ref. 2, p. 7.2.15). Thus, a salt formation can collapse literally overnight

Experiments in the laboratory have yielded empirical equations to describe the creep behavior of salt. However, as DOE has admitted:

> These equations are complex and no agreement has been reached as to which is the best one. The important point, however, is that salt does creep and a repository cannot be rationally designed unless the creep behavior under the appropriate conditions of pressure and temperature is properly understood.

(Id.) (emphasis supplied).

Third, the physical behavior of salt is "drastically affected by temperature." (Ref. 2, p. 7.2.18). The heat emitted by the wastes "may cause complex mechanical and chemical changes. Increased temperatures in salt would further decrease mechanical strength of the salt-brine mixtures... and would increase the creep rate of dry salt." (Ref. 4, p. 6).

Fourth, as NRC staff has observed, while it is often claimed that salt's plastic properties tend to heal any opening, it "may not be realistic to depend on this 'self-healing behavior' to produce an impermeable seal around the repository.... Water under great pressure "could keep [thermally or mechanically induced] fractures open and increase the dimensions of the fractures as a result of the flow." (Ref. 7, p. 3-29).

Fifth, bedded salt may be plagued by the presence of vertical structures known as breccia pipes, which extend vertically through several geologic strata. If such a pipe is permeable, and near a proposed repository site, it "could provide a shortened path to the biosphere... [and] provide a sufficient reason to preclude construction of a repository." (Ref. 11, pp. 66-67).

Sixth, in a dry salt dome the canisters containing the waste "would tend to migrate downward," perhaps complicating future attempts to retrieve. (Ref. 5, p. 20). It is not known whether the sinking would "focus" the canisters -- i.e., draw them closer together. If so, the

result could be further sinking and focusing, producing very high temperatures Id. If this occurred, the thermal loading criteria limiting the density of waste in each repository could be violated. These questions still need to be answered.*

Because of the many problems listed above, a salt formation may become unstable after placement of high-level waste (Ref. 16, p. 17), or the waste containment could be breached (Ref. 1, p. 3.1.32; Ref. 7, p. 3-9). More information is needed to determine whether the potential danger of a salt repository failure can be avoided. The rate and extent of waste dissolution in brine are unknown. (Ref. 11, p. 65). "How ion exchange rate, reaction to radioactivity, and other associated potential chemical reactions of salt deposits and related rock type affect isolation are not adequately understood at present." (Ref. 2, p. 7.2.4). These potential chemical reactions include explosion of unstable species formed by radiolysis; formation of explosive hydrogen-oxygen mixtures near the waste or in an unventilated storage room; and formation of volatile chemical compounds from the combination of fission products and brine (Ref. 9, Vol. 7, p. 2-5). All of these "potentially significant topics" should be investigated more extensively (Id). The "most

* In addition, salt formations are located in areas where oil and gas are frequently found, but hydrogen sulfide, a deadly gas, is often found near oil and gas. This poses problems to waste repository operations. (Ref. 16, p. 17).

crucial aspect of the development of predictive capability is the appropriate selection of a law describing material behavior," yet:

> For materials such as salt which exhibit time-dependent deformation and strength characteristics, no one type of model has been accepted as adequate by all workers in the field of rock mechanics. Depository structural stability is highly dependent upon these time-dependent material characteristics of the material.

(Ref. 9, Vol. 4, p. 4-29; emphasis in original). In particular, a satisfactory method of measuring the stress state around an opening to the mine is unknown at this time. (Id., p. 4-22). Moreover, room closure rates may be high in an unsupported salt repository. The cost of engineered support depends on the room closure rate, which is "an unresolved technical issue." (Ref. 1, p. 3.1.31).

Finally, of course, in situ trial excavations and monitoring are essential prerequisites to final repository design. (Ref. 9, Vol. 7, p. 2-6; See also id., Vol. 4, p. 7-14). The problems raised by in situ testing have been described above at pp. 63-64.

In addition to all the problems with a salt repository per se, significant environmental issues affecting plant life and soil productivity are presented by the more than 30 million tons of mined salt which will be removed and

placed on the surface above a single repository. (Ref. 1, pp. 3.1.41; 3.1.226). "Mitigating procedures would be needed to reduce salt dispersal at least two orders of magnitude to ensure that emission concentrations are well below toxic levels.... The potential also exists for salt deposited as dust on the land to be transported by run-off to nearby surface waters," which could receive "amounts of salt sufficient to damage indigenous aquatic plants and animals". (Ref. 1, p. 3.1.121). Loss of vegetation because of the effects of salt "would reduce cover and food supplies for mammals and birds and result in their displacement or elimination." (Id.).

(b) Shale

Numerous drawbacks to the designation of shale repositories have been identified. Considerable water is to be found in shale deposits. (Ref. 5, p. 9.). As DOE acknowledges, heating and subsequent dewatering in shales can produce fractures. (Statement, p. II-175). Shales are subject to "slaking," which is deterioration and loss in strength due to drying and wetting. (Ref. 1, p. 3.1.30). The mining process itself would be difficult. (Ref. 11, p. 74). Shale is believed to weaken and become more ductile with increased temperature. (Ref. 2, p. 7.2.23). Swelling clays resulting from the presence of water can create pressures great enough to cause buckling of steel supports. (Id.) Shales are susceptible to mineralogical alterations which could weaken the physical structure and promote cracking and disintegration at the pressures anticipated in

a repository. (Ref. 5, p. 21).

Finally, as DOE has recognized, we do not have enough data to evaluate the performance of shale over the necessary temperature and pressure ranges. (Ref. 1, p. 3.1.51) And the results of various chemical and physical reactions in shale are "difficult to predict." (Id., p. 3.1.27). "Years of intensive effort" would be required to obtain adequate generic knowledge concerning the suitability of shale repositories. (Ref. 11, pp. 74-75).*

(c) Granite

Granite, too, has serious defects as a repository medium. Groundwater inflow can be expected to be significant (Ref. 7, p. 3-30; See also Ref. 5, p. 9).** Granite will deform under varying combinations of high confining pressure, high temperature, or long-term stress (Id, p. 3-6), and will decompose at surface temperatures and pressures (id, p. 3-5). Granites are brittle, and thermal expansions can cause ruptures and surface heave. (Ref. 5, p. 22; Ref. 2, p. 7.2.9). Rock bolts may be required to prevent buckling of granite in underground openings. (Ref. 1, p. 3.1.31). As with shale, the data needed to evaluate potential repository performance are not

* There are also unsolved problems relating to the disposition of the mined shale, because the run-off of acids derived from a shale constituent will cause adverse environmental consequences. (Ref. 1, p. 3.1.41).

** Laboratory tests showing low permeability of granite and basalt cannot be relied on, since actual rock mass permeability is frequently several orders of magnitude higher than the value of a laboratory sample. (Ref. 7, p. 3-23).

available. (Ref. 1, p. 3.1.51; Ref. 2, p. 7.2.9).

(d) Basalt

Basalt repositories are unlikely to be established within the next 30 years. Because the thermal conductivity of basalt is low, the wastes would have to be cooled at the earth's surface for several decades prior to emplacement. (Ref. 11, p. 81). Further, it will be difficult to find a basalt site that can be opened and resealed without developing unacceptable fractures (Ref. 5, p. 23). Like granite, basalt can buckle, jeopardizing underground stability. And, as with every proposed medium, our present knowledge is insufficient. For example, we do not know what consequences would flow from an inundation resulting from a climate change (Ref. 11, p. 81); nor do we know the effects of irradiation on basalt (Ref. 2, p. 7.2.27). "Considerable generic and site-specific research over the next decade will be required to quantify" the concept of a basalt repository. (Ref. 11, p. 81).

In conclusion, there is no basis for confidence today that any of these four media will be found adequate for a repository. To the contrary, serious questions and problems are known to exist for each one.

3. Technologies Needed To Package And Ship The Waste Have Not Been Developed.

Before wastes can be placed in final isolation, they must, at the very least, be placed in canisters and shipped. The wastes and their containers must be resistant to leaching and to transportation accidents, and must be retrievable for a specified period.

(a) Canisters

The design of canisters, says DOE, "has received little attention"; "almost no effort has been expended ... in estimating the potential lifetimes under geologic disposal conditions of the canister designs that have been proposed." (Ref. 1, p. 3.1.59). The EPA Panel of Earth Scientists has said that it is "likely" that the canisters would be breached within a decade or less. "For this reason," continues the Panel, "we do not consider the canister to be a significant barrier to the solutions, at least for the time scales of centuries to a million years with which we are dealing." (Ref. 5, p. 10). Clearly the canisters are almost worthless for insuring long-term isolation.*

* Significantly, the Commercial Waste and Spent Fuel Packaging Program, conducted by Rockwell Hanford Operations, has been designing spent fuel packaging with a design life of only 10 years. (Ref. 15, pp. 158-159).

As DOE has acknowledged in this proceeding:

> It is obvious that much remains to be learned about individual package components and their interactions within the waste repository environment.

(Statement, p. II-159).

(b) Shipment

Transporting waste from the many reactors and other storage points to repositories would require hundreds, or even thousands, of shipments -- each of which represents a possible danger to public health. First of all, DOE admits that individuals living along the many transport routes will receive doses of radioactivity from passing shipments of waste, even in non-accident situations. (Ref. 3, p. 7.1.3.) In addition, DOE acknowledges that in the event of a severe impact and fire in a high-level waste cask, persons living along the transportation paths could receive radiation doses sufficient to result in serious illness and -- in DOE's euphemistic language -- "substantial life shortening". Id., p. 7.1.6). While the Government has had tests performed for the purpose of demonstrating the integrity of shipping casks in crashes, these tests have been rejected by the railroad industry as scientifically deficient. (Ref. 10, p. 112).*

*Sandia Laboratories reports that 655 radioactive transport incidents have occurred since 1971, including 120 with releases of radioactivity and 228 where surface contamination was found.

Downplaying the public health impacts of nuclear waste, DOE severely understated the consequences of trucking accidents in its impact statement. According to NRC staff, "impacts presented in the GEIS for 100% of all shipments by truck should be about 25 times greater than the impacts given.... A severe [transportation] accident occurring in a suburban or urban area would have a substantially greater environmental impact than the accident consequences presented in the GEIS." (Ref. 7, pp. 2-9, 2-15).*

Not surprisingly, the public perceives a severe danger in transporting nuclear waste, and public opposition, therefore, could develop to plans for shipping waste to repositories. As previously noted, public opposition is important because it could frustrate DOE's plans and require a negative response to the question whether nuclear waste will be safely disposed of. Public opposition has found expression in the many State and local laws passed to limit radioactive shipments within their jurisdictions (Ref. 17, pp. 25-26), and the refusal of rail carriers to transport spent fuel (id., p. 24). According to the IRG transportation subgroup:

> Lack of high quality, credible and candid information about defense and commercial nuclear transportation methods, equipment, and performance has left State and local officials and questioning citizens with little confidence that health, life and property are adequately protected.

Id. p. 25.

* The discussion of truck accidents is especially significant, since about half of the nation's currently operating reactors must rely on truck shipments because they do not have access to rail lines. (Ref 25, p. C-6).

4. Non-Destructive Excavation Technology Has Not Been Developed.

The first step in actually building a repository will be to excavate the site. Like in situ testing (see above, p. 63), however, excavation itself will produce fractures which could breach the integrity of the site and render it unsuitable for use as a repository. NRC staff has said that the mining process will fracture the rock and create a series of joints near the excavation point, and is likely to increase hydraulic conductivity of the rock mass. (Ref. 7, pp. 3-23, 3-25). NRC staff has also said that the effect of the excavation process on "the important and complex problem of groundwater mass transport" and, more generally, on long-term repository performance, needs to be addressed (Id., p. 3-25). DOE acknowledges that fracturing "must be considered," and that fracturing, if extensive, "may provide a potential pathway for groundwater." (Statement, p. II-161). A symposium of DOE's National Waste Terminal Storage Program observed that the permeability of fractures and of the overall rock mass is "extremely important," yet techniques for minimizing damage to the host rock during excavation are "poorly developed". (Ref. 15, p. 109).

5. A Methodology For Assuring Retrievability Of The Wastes Has Not Been Developed.

DOE has identified many important reasons requiring that wastes be placed in the repositories in a way which assures

their retrievability: (1) to provide a period for observing waste-rock interactions and repository operations (Ref. 2, p. 1.5.5); (2) to allow examination of the entire host rock formation before the wastes become irretrievable (id.); (3) to allow removal of wastes "if tests and acquired data show that a sufficient degree of confidence could not be provided" (Statement, p. II-281); (4) to correct defective waste packages which have already been emplaced (id.); and (5) to allow relocation of wastes if a portion of a repository were found to be unsuitable (id.).

DOE states that retrievability is needed throughout the operating phase of a repository. (Statement, p. II-281). Because selection and construction of repositories constitute "a new human enterprise," says NRC staff, it is "reasonable to expect that, whatever the care exercised and however advanced the techniques, mistakes will occur..." 45 Fed. Reg. 31398 (May 13, 1980). Accordingly, proposed NRC regulations would require DOE to design each repository "so that the radioactive waste stored there can be retrieved for a period of 50 years after termination of waste emplacement operations, if the geologic repository operations area has not been decommissioned." (Id at 31400; see also Ref. 9, Vol. 4, p. C-3).

No final decision has been made as to how many years' retrievability is necessary, and thus the extent of the capability which must be developed is unknown. Yet, serious problems have been identified, at least for salt and shale. NRC staff believes that maintaining retrievability in salt is "questionable", even for five years:

> There is significant evidence that salt rock behavior under thermal and mechanical stress is such that rapid closure rates can be expected. It may be impossible to maintain integrity of seals under such closure rates.

(Ref. 7, pp. 3-9, 3-15). And a repository in shale would entail "massive support requirements" to keep all corridors and storage rooms open and maintain retrievability. (Id., p. 3-15). Another unresolved technical problem with retrievability is that as long as the rooms and passages of the repository remain open, flooding is possible. (Ref. 12 , p. 83).

The IRG has found that:

> Further definition of the retrievability concept, the circumstances in which waste would be retrieved, and the technical aspects (including development of waste packaging, containers and handling) is necessary.

(Ref. 10, p. 62). (emphasis in original).

6. Adequate Sealing Methods Have Not Been Developed.

DOE recognizes that "repository seals must retain their integrity for much longer periods of time than those

considered in previous applications." (Statement, p. II-183). Satisfactory techniques for backfilling and sealing a repository have not been developed or proven. (Ref. 8, p. 20; Ref. 15, p. 142; Ref. 9, Vol. 1, p. 3-33). This lack of technology is a "serious potential problem," according to NRC staff, (Ref. 7, pp. 5-2, 5-3), which makes it "difficult to see how one could do an adequate job of either backfilling or retrieving if a repository becomes flooded." (Id., p. 3-30).

There is no consensus that the technology which is currently anticipated will provide adequate seals even for a period of decades. (Ref. 11, p. 42). One problem is that "the data that is generally available from mining industry experience is considered inadequate to properly predict the long-term integrity of shaft sealing techniques." (Ref. 9, Vol. 1, p. 2-25). Moreover, "the effect of thermal expansion on the integrity of the shaft lining and the shaft seal is not well documented." (Id., p. 2-26). In short, "much more work is needed to define the reliability of achieving a low permeability backfill.". (Id., p. 2-24).

The Department of Energy has termed the sealing problem a "key unknown". (Ref. 1, p. 3.1.238). Inadequate sealing would, of course, act as a "dangerous short circuit from the repository to the biosphere." (Ref. 8, p. 16; Ref. 11, p. 42).

7. Equipment And Methodology To Monitor The Repository After Closure Have Not Been Developed.

A new technology will be needed to detect migration of wastes from the repository. (Ref. 5, p. 41). DOE believes that a monitoring system should be designed and developed to operate for a few centuries. (Ref. 1, p. 3.1.63). One component of the system would consist of instrument packages sealed into the boreholes, shafts and repositories. No existing instrumentation system has been required to function for so many years, or shown to be capable of doing so. (Ref. 9, Vol. 7, p. 2-4). During the entire monitoring period, no one would be able to gain physical access to these devices to test their reactions to water, to radioactivity, or to waste-rock interactions; and no one could adjust or fix them if they failed to function properly.*

DOE has utterly sidestepped the monitoring problem, saying only that:

> Instrumentation will be installed with the initial canisters. The details of this monitoring program will be developed in conjunction with the Commission licensing review.

* Of course, even a perfect monitoring system would be powerless to prevent or mitigate releases of radioactivity. At best, monitoring can only warn people to leave the area rendered uninhabitable.

(Statement, p. II-280). That review, of course, is many years away, while the Commission must decide whether it has confidence today that a safe, complete disposal system will be available when necessary. In truth, monitoring equipment is not available.*

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* Because DOE has chosen to base its case for confidence on the mined geologic repository concept, much of the discussion in this Statement refers specifically to that concept. Significantly, neither the draft generic EIS nor the Department's Statement in this proceeding claims that any of the other 9 concepts is either feasible or a basis for confidence at this time. In fact, three of the technologies are admittedly unavailable for spent fuel (chemical resynthesis, reverse-well injection, and partitioning/transmutation), and three more are, as a practical matter, equally unavailable for spent fuel (very deep hole, ice sheet disposal, and space disposal). (Ref. 1, pp. 4.5 to 4.7). Since DOE says that this proceeding is limited to spent fuel, and the Presiding Officer has agreed, this shortcoming is rather fundamental. Rock melting is not really a separate technology, but is rather a variation on geologic disposal (Ref. 1, pp. 3.4.5, 3.4.7). Island and subseabed disposal have more serious drawbacks than mainland geologic disposal (Ref. 1, pp. 3.5.25, 3.6.1ff); the latter also involves international legal and political obstacles (id, pp. 3.6.1, 1.27). Indeed, all of the nine "alternatives" are far less developed than the geologic disposal concept, and none can be viewed as a serious basis for confidence that safe nuclear waste disposal will be available by the time it is needed.

V. THERE IS NO BASIS FOR CONFIDENCE THAT NUCLEAR WASTE WILL BE SAFELY STORED UNTIL SAFELY DISPOSED OF.

If the Commission decides it does not have confidence that final disposal will be available by the time it is needed, then it must reach the question of whether spent fuel can be stored safely "for an indefinite period." State of Minnesota v. Nuclear Regulatory Commission, 602 F.2d 412, 419 (D.C. Cir. 1979) (Tamm, J., concurring).

One of the major problems with storage, however, is precisely that it would have to be for an "indefinite period" -- because we do not know when, or even if, the necessary number of safe repositories will be available. Storage, therefore, might have to continue for many decades, or even centuries or longer, a period during which the wastes are extremely toxic. But there is no basis for confidence that these wastes can be stored safely for an indefinite period, because there simply has been no experience with storage over a very long-term. On the other hand, we do know that many storage accidents have occurred during even short storage periods. In addition, the danger of transportation accidents, terrorism or sabotage is great, and all the more so over longer periods of time. Indeed, surface storage in some respects presents greater and more immediate hazards than disposal, because the waste is at the surface of the earth, and thus any releases of radioactivity

could more easily inflict direct injury to the storage facility workers and surrounding population. Moreover, the difficulties of predicting geologic and human activities far into the future (pp. 42-50) come into play for indefinite long-term storage.

1. There Is No Basis For Confidence That Indefinite Long-Term Storage Is Safe.

Waste storage at the sites of existing reactors is becoming increasingly difficult because of space constraints and the growing volume of spent fuel. Increasingly, indefinite long-term storage would necessitate transporting very large quantities of spent fuel from reactor sites to away-from-reactor ("AFR") storage sites. These AFR's would have very high concentrations of radioactivity and would pose a serious threat of a large accidental release into the atmosphere, thus endangering the local population. Indeed, smaller but frequent releases can be expected to result from routine operations. There would also be a risk of sabotage and terrorism at the AFR. Even with constant surveillance, security and monitoring, there would be no assurance of safety. Psychological and physical danger to the surrounding community could also be anticipated.

Another problem with indefinite long-term storage is the necessity for transporting radioactive materials. Hundreds or thousands of shipments from the many reactor

sites to the AFR's would be required, each of which would pose a great danger to the public. As already noted, see above p. 94 , in the event of a transport accident there could be a large release of radiation, with obviously serious consequences to life and health. Even without such an accident, the populations living around transport routes would be subject to radiation on a regular and continuing basis, as would the workers involved in the transportation. These shipments would also be subject to terrorist attacks and sabotage.

It is true that transportation of wastes would be necessary as well for ultimate disposal, and therefore the hazards represented by waste shipments would be borne anyway. Nonetheless, it would be foolish to multiply our exposure to such dangers by transporting the wastes initially to intermediate storage sites and later having to ship them again, to a repository -- should one be available.

DOE's Statement of Position is unjustifiedly optimistic about the safety of storage, as some parties were unduly optimistic about the safety of nuclear power plants prior to the accident at Three Mile Island. That accident demonstrated that despite the so-called "redundant" safety systems, accidents can and do occur. There is suraly ample evidence that mishaps can occur as well with storage.

Indeed, DOE has acknowledged that many accidents have occurred in the handling of spent fuel assemblies, and that "high intensity tornadoes will blow away the roof over the [storage] basin." (Ref. 25, pp. B-22, B-59).

Moreover, NRC compilations of Licensee Event Reports ("LER's") relating to spent fuel storage reveal that between August 1971 and October 1979 about 67 events were reported, involving mechanical failure, human error and violation of NRC requirements.* In many cases, the cause of the problem was unknown. Twelve events involved leaks or cracks in equipment, and sometimes multiple failures -- such as 30 leaks in the stainless steel fuel pool liner at Millstone-1 in March 1972, six leaks in spent fuel pool cooling system piping at Three Mile Island-1 just days after the TMI-2 accident in March 1979, and cracks in eight spent fuel storage racks delivered to Dresden-2 in May 1978. The LER's also report improper handling or storage of spent fuel on many occasions, insufficient water in refueling water storage tanks several times, inadequate design problems, and insufficient boron in the spent fuel pools.

* It is also possible that other events occurred but were not reported.

Apart from these incidents, the LER's also point out that several serious accidents have occurred; luckily, so far as we know, no calamity resulted. For example, in August 1974 at the Surry-1 plant in Virginia there was a "minor unplanned release of radioactive liquid effluent," up to 150 gallons, which went into the James River through the storm sewers. At the Haddam Neck-1 plant in Connecticut, in November 1973, there was an "unplanned release of radioactivity" into the storm sewers when 270 liters of water from the refueling water storage tank leaked, releasing Tritium.

Several spills have also occurred at Turkey Point-4, in Florida. In April 1975 there was an unplanned release of radioactivity during refueling, with 2960 gallons of contaminated water absorbed by the soil, and a release of Cobalt-58. Another spill at the plant, in May 1978, was contained, but contaminated two operators. A third incident occurred in September 1978, when radioactive water contaminated a paved area outside the pump room. Similarly, at Commonwealth Edison's Dresden-1 plant, in February 1978, contaminated water leaked out of the plant and onto the outside gravel. That plant had had a spill of several thousand gallons of water in April 1977, but evidently without being released. Releases evidently did occur at the Ginna plant

in New York during August 1975, and at the Peach Bottom-1 plant, in Pennsylvania, during November 1976.

DOE cannot take comfort from the fact that none of these events has resulted in a major accident, because, after all, that may have been said of nuclear power plants before Three Mile Island. That accident was caused by multiple technical and human failures. Similar failures at storage facilities are also possible, and could cause serious health effects and require the relocation of many people, resulting in severe economic and personal disruption. The likelihood and number of accidents increases, of course, as the period of storage is extended. That no disaster has yet emerged is reason to be thankful. It is no reason to be confident that a major accident will never occur.

In addition, it appears that a major accident involving stored nuclear waste did occur in the Soviet Union. While the event was not officially disclosed by the USSR, it has been pieced together from numerous sources, and was recently reported by researchers at the Oak Ridge National Laboratory (Ref. 24). The report concludes that the accident, in the winter of 1957-58, was the result of an explosion of reprocessing wastes stored in tanks at a Soviet military waste-storage facility. It resulted in a high contamination of the air with Strontium-90 and the

resettlement of the population from an area of from 38 to 380 square miles (Id. p. v). While many details are not known, the magnitude of a possible waste storage accident is vividly demonstrated by the Oak Ridge report.

2. There Is No Basis For Confidence That The Necessary Number Of Storage Facilities Will Be Accepted By The Public.

Because of these grave risks, the institutional problems that are involved in the selection of a repository will likewise arise with selection of sites for AFR's (See pp. 69-75 above.) It must be assumed that there will be local opposition to establishing an AFR. Opposition can be expected from people living near the proposed sites or along the shipment routes, and conflicts with State and local laws regulating shipping are likely. Opposition from the Interior Department can also be expected to siting on land under its jurisdiction. DOE concedes that public acceptance of a repository is extremely low; it will be very low for an AFR as well -- particularly since removal of the wastes from the AFR to a repository could be postponed for decades or more. Without political and social consensus, indefinite storage cannot be implemented. DOE has acknowledged that public opposition to AFR siting exists. It has said that State and local governments and interested citizens have opposed such construction, in part because they fear it

"would result in de facto permanent storage." (Ref. 25, p. VIII-10). DOE has also acknowledged the existence of State and local laws restricting the transportation of radioactive materials. (Id., p. C-4). State laws, however, are of vital importance, because DOE recognizes that any AFR would have to obtain all State and local permits and follow local regulations. (Id., p. B-15). The expected opposition from State and local government, therefore, could prevent the establishment of storage facilities.

To be successful, the AFR option would require the establishment of many storage facilities around the country so as to reduce the costs and risks of transportation as well as the concentration of radioactivity in any one facility. Because of the likely opposition to siting, however, it cannot be assumed that any AFR site -- let alone many sites -- will be approved.

The fact is, however, that many sites would be needed. The quantities of spent fuel that would require AFR storage are very great. For example, DOE projects that if the first repository becomes available in the year 2006, there would then be 70,000 metric tons of uranium (MTU) which would require off-site storage. Assuming each AFR could be built to store 5,000 MTU, 14 storage facilities would be needed by that year. If, however, a repository

is not available until the year 2010, off-site storage will be needed for over 90,000 MTU -- which would translate into 18 facilities. (DOE Statement, p. VI-3; Ref. 25, p. I-6). Further projections appear in a draft report prepared for the Office of Technology Assessment (Ref. 28). That report indicates that if the first repository goes into operation in the year 2005, a total of 19 AFR facilities would be required to store the wastes from nuclear plants now in operation or under construction, but 27 facilities would be needed if the Commission continues to license new plants. Moreover, assuming that no repository is available for 50 years -- or that spent fuel is allowed to cool for a long period before disposal -- the corresponding number of facilities needed would be 35 or 67.

However, as shown above, there is no basis for confidence today that even one AFR will be built. Surely there can be no confidence that the required number of facilities will be established, having met all technical requirements and gained public acceptance. Nor can there be confidence that any AFR that may be established will operate safely and without serious releases of radioactivity for an indefinite period of time.

VI. THE COMMISSION SHOULD ORDER A MORATORIUM ON LICENSING NEW PLANTS PENDING RESOLUTION OF THE WASTE ISSUE.

The Attorney General's position, in short, is that reasonable persons should not feel even close to having a factual basis for confidence that nuclear waste will be safely disposed of, or safely stored until safely disposed of. Planners are faced at the outset with the nearly impossible task of predicting geologic or human events tremendously far into the future. In addition, we now know enough to see that there are many unresolved problems that have and could continue to put off a technical solution for many years. We know that many repositories will be needed, and that many years of testing will be needed after each candidate site is chosen -- assuming non-destructive testing methods have been found -- and that conclusion of such testing is at least a decade away. We know that no rock medium has been determined to be acceptable. We know that none of the needed methodologies -- from waste packaging to mine excavation to retrieval to sealing the repositories -- has been developed, or is even around the corner. Finally, we know that substantial public opposition exists, and is likely to continue.

Unfortunately, it has been the policy of this Commission, and the AEC, to license nuclear plants without considering how the wastes would be disposed of. This

short-sighted approach was rejected by the court in NRDC v. NRC, 547 F.2d 633, 640 (D.C. Cir. 1976) as a violation of the Commission's duty under the National Environmental Policy Act. As the Court of Appeals there said:

> Once a series of reactors is operating, it is too late to consider whether the wastes they generate should have been produced, no matter how costly and impractical reprocessing and waste disposal turn out to be; all that remain are engineering details to make the best of the situation which has been created.

Id. (footnote omitted) (emphasis added).

As a result of the Commission's policy in past years, we now have substantial quantities of hazardous waste that must be managed safely, yet we know of no method for doing so. Eventually they will have to be handled somehow, whether or not the Commission makes a finding of confidence in safe disposal.

Even if we must do the best we can in the short run -- because we have no choice -- we have it within our power not to continue limiting ourselves to unacceptable options. The Commission's decision in these proceedings must look to the future production -- and thus the disposal -- of radioactive wastes. The Commission cannot make the existing wastes disappear, but it does have both the power and the duty to protect public health and safety by regulating the licensing of new plants. It should determine

that the facts at hand do not afford a basis for confidence that any wastes, even the existing inventory, will be safely disposed of. Once it does so, the Commission must act by using its licensing powers to prevent the problem and the hazard from becoming worse.

Continued licensing of new plants would result in a waste inventory far greater than that which exists today. Many more repositories would be needed. However, the many stringent siting criteria which must govern the site selection process could eliminate all potential site locations. Because the number of acceptable sites, if any, could be very small, the threat to public health and safety would be substantially enlarged by a many-fold increase in the amount of waste requiring isolation. The Commission must do whatever it can to limit the growth of the waste inventory until the disposal issue has been resolved.*

* A moratorium will significantly reduce the number of repositories needed despite the continued generation of military wastes. The accumulated inventory of fission products generated by civilian reactors now exceeds that generated to date by U.S. military nuclear programs, and the civilian proportion is rising. While the volume of military waste is large, it is on the average almost 100 times more dilute than commercial high-level waste. Science, Vol. 197, August 26, 1977, pp. 883-884.

We must in the final analysis return to fundamental responsibilities. Under the Atomic Energy Act and the Energy Reorganization Act, Congress has placed the responsibility to assure public health and safety upon this Commission. As the Commission has stated:

> [P]ublic safety is the first, last, and a permanent consideration in any decision on the issuance of a construction permit or a license to operate a nuclear facility.

Power Reactor Development Corp. v. International Union of Electrical Radio and Machine Workers, 367 U.S. 396, 402 (1961). In fact, this duty to protect public safety continues beyond the issuance of licenses:

> If, in the Commission's judgment, the public health and safety so requires, the Commission may take action to revoke, suspend, or modify licenses, impose civil penalties, or issue cease-and-desist orders....Such actions may be taken with immediate effect.

In the Matter of Petition for Emergency and Remedial Action, 7 NRC 400, 404 (1978). Thus, "the fundamental principle guiding all Commission licensing actions is the paramount consideration of public safety." In the Matter of Nuclear Engineering Company, Inc., 9 NRC 673, 676 (1979).

In view of the substantial waste inventory which will continue to grow even if no new reactors are licensed,

and because we are not even close to having a factual basis for confidence in safe disposal, it is incumbent on the Commission to stop the licensing of new plants until what appears to be a fool-proof method has been established and fully tested at specific sites, accepted by State and local government, and other federal agencies if necessary. To continue licensing without a satisfactory disposal method violates the Commission's duty to assure public health and safety. It is totally unreasonable.

Because of its duty to protect public health and safety, the Commission has from time to time ordered nuclear plants shut down. It is equally necessary that the Commission hold up licensing new plants until the serious public health issues involved in nuclear waste disposal have been resolved. Such a moratorium has been recommended by the President's Council on Environmental Quality.

If new plants are licensed, and their waste must ultimately be disposed of in a less than satisfactory way, the fault will lie squarely with the Commission. Some courts have even gone so far as to say that the Commission has the exclusive power in the field of protecting the public from radiological hazards. If those decisions are correct, it appears that unless this Commission protects the present and future generations from the dangers of nuclear waste, nobody else will be able to. We urge the Commission to make the necessary decision today not to foreshorten the future.

CONCLUSION

We have shown above that there is no factual basis for confidence today that nuclear waste will be safely disposed of by any given date, and that even DOE's Statement reveals many of the factual gaps and known problems which preclude a finding of confidence. We have also shown that there is no basis for confidence that nuclear waste will be safely stored for the indefinite period until safely disposed of -- conceivably a period of decades or centuries or more.

We therefore ask the Commission to make a finding of no confidence on both disposal and storage, and to impose a moratorium on the licensing of new nuclear plants until the technical and institutional problems of nuclear waste have been resolved.

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Respectfully submitted,

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