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REPORT TO THE LEGISLATURE

LOW-LEVEL RADIOACTIVE WASTE
PRELIMINARY REPORT
(Assembly Bill 1513, Chapter 95)

Radiologic Health Branch
California Department of Health Services
Sacramento, California 95814

TABLE OF CONTENTS

EXECUTIVE SUMMARY 1

INTRODUCTION 4

AMOUNT AND TYPES OF LOW-LEVEL
RADIOACTIVE WASTES PRODUCED 7

WASTE CLASSIFICATION 14

DETERMINATION OF INTERIM STORAGE AND COSTS . . . 16

CRITERIA FOR TEMPORARY SITE SELECTION 19

FINAL DISPOSAL OF LOW-LEVEL WASTE 21

INTERIM STORAGE PROBLEMS 23

CONCLUSIONS AND RECOMMENDATIONS 24

APPENDICES

Appendix A:
Low-Level Waste Classification Scheme

Appendix B:
Siting Criteria for Storage, Treatment, and
Disposal Facilities

Appendix C:
Analysis of Interim Storage Requirements and Costs

Appendix D:
Applicable State and Federal Laws and Regulations

Appendix E:
Glossary of Frequently Used Terms

EXECUTIVE SUMMARY

This report represents the first step toward establishment of a plan for the long range management of low-level radioactive waste, including contingency plans for short-term or interim storage. It was prepared in response to the legislative mandates contained in AB 1513 (Chapter 95, Statutes of 1982). Included in this report are: 1) the amount and types of waste produced in California; 2) a determination of interim storage requirements and costs; 3) criteria for selecting an interim site; 4) anticipated problems; 5) criteria for the selection of a final disposal site, and 6) recommendations for future action.

Background

The immediate need for planning arises because of the federal Low-Level Waste Policy Act (PL 96-573) which makes low-level waste disposal a responsibility of the states. California generated and shipped to commercial sites 186,000 cubic feet of low-level radioactive waste in 1981 (this amount may be expected to increase about 25 percent by the year 2000). The commercial radioactive burial sites may be closed to California under the Federal plan by 1986 and without adequate, safe disposal, medical, industrial and other operations which contribute to the health and safety of California's people may be seriously impaired.

Interim Storage

An interim storage facility was designed by the California General Services Department. Costs for building and eventually decontaminating such a building were estimated to be $16.6 million.

In order to use an interim storage facility, low-level waste would have to be separated since flammable material and biological material could not be stored. Some treatment facility for these wastes is necessary, thus an incinerator which would cost $2.2 million is recommended, -- a total of $18.8 million for interim storage.

Site Criteria (Interim Storage)

Criteria for an interim storage facility were determined. These included: distance from major population centers; all-weather access; adequate water and power; freedom from known seismic activity and flooding; security. The criteria are designed so that there would be reasonable assurance that the general population would not receive, under general operating or accident conditions, a radiation exposure greater than that specified by the Nuclear Regulatory Commission.

Waste Classification

A waste classification scheme was developed to facilitate the handling and storage of wastes. In essence, the scheme divided the waste into: that which could be stored as is; that which had to be treated before storage -- flammables, toxics and biologicals; that which, because of level of activity, had to be shielded; and de minimis (i.e., trivial, not radioactive for purposes of regulation and ultimate disposal).

Site Criteria (Shallow Land Burial)

Criteria were also developed for a final disposal or burial site. These included those criteria developed for interim storage, plus other criteria relating to stability for an in-ground site and the

ability to maintain the site integrity for a period of 500 years (by which time the radioactive material would have decayed to de minimis levels).

Recommendations

1. The search for a qualification of a permanent burial site should begin immediately.

2. California should renew its efforts to form a "compact" either with other states, or, with Congressional consent, alone.

3. All efforts should be made to avoid the necessity of building and operating an interim low-level waste storage facility. Arrangements should be sought with current compacts of states having a site for the acceptance of waste for burial for a limited period pending completion of the California site.

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INTRODUCTION

This report is in response to legislative mandate under Chapter 95, Statutes of 1982. In it the Department of Health Services is to provide, by the end of 1983, a plan for the long-range management of low-level radioactive waste, including contingency plans for short-term or interim storage of such wastes. The Legislature, in this statute, found and declared "...that without means for adequate, safe disposal of low-level radioactive waste, medical, industrial, and other operations which contribute to the health and safety of the people of California as well as to the state economy, may be seriously impaired."

The urgency of this effort has come about as a result of two conditions. 1) Congress passed the Low Level Waste Policy Act (PL96-573) making the disposal of low-level radioactive waste the responsibility of the states. It further permitted, upon Congressional approval, the establishment of regional waste disposal facilities for the exclusive use of regional compact member states. The bulk of California's waste now goes to Washington state but California is not a member of the recently formed Northwest compact and thus may expect to be denied access to their disposal site as early as 1986. 2) There are only three commercial low-level radioactive waste disposal sites currently in operation in the United States -- one in the state of Washington, one in Nevada, and one in South Carolina. Nevada is attempting to close its site and South Carolina has put a limit on the amount of waste its site can accept each year.

Under the current federal low-level waste policy, California will have two options: to join a compact (and probably commit to becoming a host site at some point in the future) or go it alone, which will mean the immediate establishment of a low-level radioactive waste disposal facility in the state. Exclusive use of the state site by California could not be assured unless the Congress consented to the establishment of compact status for us as a single state.

This report covering the first parts of the plan requested by the legislature consists of the following:

1) The amount and types of low-level radioactive waste generated in California.
2) Contingency plans for interim storage
   a. Design of the facility and determination of costs of construction
   b. Operational costs of the interim site and costs to be borne by the generators of low-level waste
   c. Interim site criteria
   d. Problems
3) Waste classification scheme
4) Criteria for land disposal site selection

A subsequent report due to the legislature on December, 1983 will cover a plan of action to minimize the environmental, occupational and public health impact of low level waste. This later report will include studies of volume reduction, and plans for substituting non-radioactive or short-lived radioactive materials for those radionuclides which require long-term isolation from the environment.

Finally, by June 30, 1984, the Department, in consultation with other State agencies, is to complete a study identifying regions of the state in which the criteria established for land disposal could be met.

AMOUNT AND TYPES OF LOW-LEVEL RADIOACTIVE WASTE PRODUCED *

A survey was conducted among all facilities licensed either by the State or the Nuclear Regulatory Commission (NRC) to determine the amounts and types of waste produced. Not included were those wastes exempt from the National Low Level Waste Policy Act such as Department of Energy and Defense wastes. A total of 1,714 responses were received. These represented 1,821 licenses giving a response rate of 85.5% (Table I). Non-respondents were examined to determine whether there would have been a significant amount of waste produced but not reported. Non-respondents were found to be, for the most part, county health departments, smaller hospitals, and physicians' offices (which produce small amounts or no waste at all).

Amount of Waste Generated in 1981

A total of 186,314 cubic feet of waste was generated and shipped to a commercial low-level waste site by respondents to the questionnaire. Additional waste was generated but either met de minimis requirements of the NRC (i.e., was so low in radioactivity that it was declared non-radioactive for control purposes) or was a short-lived radioactive material which was stored on site until it decayed to approximately background radioactivity and was then shipped to other commercial sites.

Commercial nuclear power plants produced 35.5 percent of the low-level waste. This excludes spent fuel which is maintained in safe storage on site or sent to centralized high-level storage site out of state.

* For definition of low-level waste see Appendix A. California Health and Safety Code 25805(1).

Medical and educational institutions produced approximately 34 percent of the waste. This included both radioisotopes used in nuclear medicine procedures and those used in research. Much of the institutional low-level waste is trash -- e.g., paper towels, rubber gloves, protective coverings. In addition, there appears to be a relatively large amount of this waste (scintillation fluids, animal carcasses) that, if well sorted, either meets the de minimis criteria and could be sent to other disposal sites or is short-lived and could be held for decay.

Industrial waste constituted 27 percent of the total. These wastes were generated in the manufacture of sealed sources for instruments, preparation of radioactive tracers and radiopharmaceuticals.

Types of Waste

The types of waste shipped to commercial sites included solid, liquid and biological waste, each needing different types of handling and treatment (Table III). As the costs of shipping and storing waste continue to rise, waste generators are becoming more careful in the sorting and treatment of wastes. Trash compacting is currently taking place at many but by no means all institutions. Separation of wastes, particularly scintillation fluids and biological wastes which now meet de minimis limits, is now occurring in some institutions, but can in the future be used to further reduce the quantity of wastes that will need disposal as radioactive material.

TABLE I

RESULTS OF LOW-LEVEL WASTE SURVEY

(1981)

NUMBER OF QUESTIONNAIRES MAILED (1 Per License): 2,160

RETURNED (Undeliverable):	14
TERMINATED LICENSES:	16
	30

TOTAL SENT: 2,130

NUMBER OF QUESTIONNAIRES RETURNED:		TOTAL LICENSES REPORTED
GENERATORS - SHIPMENT TO SITES:	155 (+ 42)*	197
GENERATORS - NO SHIPMENT TO SITES:	297 (+ 20)	317
NON-GENERATORS WITH FUTURE ESTIMATE:	117 (+ 22)	139
NON-GENERATORS:	1,139 (+ 23)	1,162
SHIPMENT TO D.O.E. SITES:	6	6
TOTAL RESPONSES:	1,714 (+ 107)	
TOTAL LICENSES REPORTED:		1,821
RESPONSE RATE: 85.5%		

NON-RESPONDENTS INCLUDED PRIMARILY COUNTY HEALTH DEPARTMENTS, EMERGENCY SERVICES, HOSPITALS, PHYSICIANS' OFFICES

* Response for additional licenses included on primary questionnaire

TABLE II

TOTAL LOW-LEVEL WASTE SHIPPED TO COMMERCIAL RADIOACTIVE WASTE SITE

(1981 SURVEY)

	AMOUNT OF WASTE SHIPPED	
	Ft^3	Percent
Medical	28,437	15.1
Educational	35,253	18.7
Industrial	50,708	26.9
Governmental	5,286	2.8
Power Plants	66,930*	35.5
	186,614	99% **

* Atypical, average year expected volume of low-level waste would be from 8,000 - 12,000 ft^3 per reactor or approximately 40,000 ft^3

** Percent not equal to 100% due to rounding

TABLE III

TYPES OF WASTE SHIPPED TO COMMERCIAL* SITES

(1981 SURVEY)

	Solid	Scintillation** Fluids	Other Fluid	Biological Waste
	Ft^3	Ft^3	Ft^3	Ft^3
Medical	19,742	7,461	3,572	1,622
Educational	20,126	6,476	5,549	2,011
Industrial	50,603	890	11,513	82
Governmental	2,951	42	40	-
Power Plants	64,805	2,147	160	132
TOTALS:	158,277	17,016	20,834	3,847

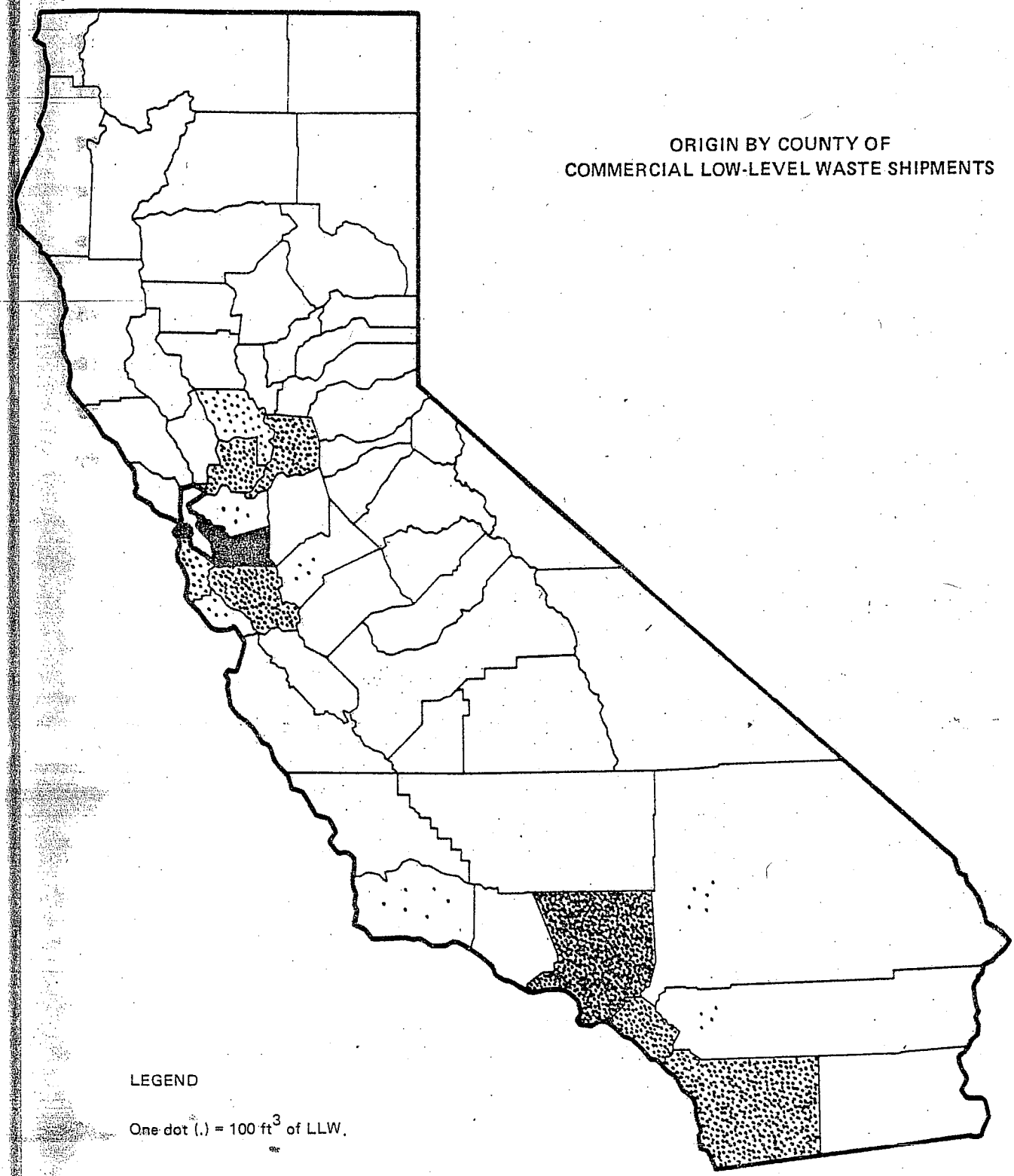
* Question specified only "commercial", not commercial radioactive - not all generators provided breakdown. The total in this table exceeds the total in Table II.

** Much of this is probably going to a regular hazardous chemical dump site.

Origin of Waste

As might be expected almost all of the low-level waste is produced in the two major manufacturing areas of the state - in Southern California from Los Angeles to San Diego, and Northern California centering on the Bay area. Both areas are well served by freeways which should facilitate the selection of low-level waste storage and/or disposal sites. (See Figure 1)

FIGURE 1


ORIGIN BY COUNTY OF
COMMERCIAL LOW-LEVEL WASTE SHIPMENTS
LEGEND
One dot (.) = 100 ft^3 of LLW.

WASTE CLASSIFICATION

The purpose of a waste classification scheme is to facilitate the handling and storage of low level radioactive waste while protecting employees and the public. The goal of a classification scheme is to provide a basis for sorting waste that is both effective and practicable.

Even though problems to be addressed through waste classification differ between interim storage and permanent disposal facilities, the need for treatment of the various types of waste remains. The classes of waste proposed are:

Class I: Radioactive - intermediate-level, requires special packaging, handling or shielding because of its radioactivity (i.e., radiological properties are the most significant hazard).

Class II: Radioactive - requires special packaging and handling or treatment prior to storage because of its non-radioactive hazardous properties.

Class III: Radioactive - requires no special handling or treatment at an interim storage facility. Suitable for burial or storage as is.

Class IV: de minimis - not radioactive for purposes of regulation and ultimate disposal.

Class II wastes are those which cannot be stored without treatment. They contain flammable or corrosive materials which could compromise the integrity of an interim storage facility, or biological wastes which in decomposing over even a brief period of time compromise their packaging. Biological wastes currently receive special packaging and much of what is considered pathological waste is autoclaved or treated at its source by the licensee produce Final disposal or burial of these wastes is possible, although special segregation to allow for decomposition and subsidence would be required. Interim storage, on the other hand, is not possible. The hazard of maintaining these unstable wastes in an above-ground facility is too great.

The classification or waste segregation scheme developed must be practicable and auditable. It is believed that the proposed scheme fits these criteria. Even the smallest waste producer should be able to segregate waste in the manner proposed.

DETERMINATION OF INTERIM STORAGE REQUIREMENTS AND COSTS

The requirements for an interim waste storage facility are based on the following:

1. California's low-level waste consists of chemically and biologically unstable material; stable wastes, and intermediate level wastes.
2. the volume of low-level waste produced per year in California is presently 180,000 cubic feet, and is expected to increase moderately over the next few years.
3. the volume of intermediate-level waste produced by existing nuclear power plants per year is expected to be 86,000 cubic feet.

The design concept for the "low-level" waste storage building was based on specifications detailed in a Department of Energy (D.O.E.) publication, EGG-5434. This concept was selected because of its economy and use of sheet metal buildings and because it provided the enclosed storage space adequate for California's needs. The facility was designed to economize materials, labor and energy while meeting the necessary fire and safety codes.

After consulting with various engineering firms and utilities, the design concept used by Rancho Seco for the storage of "intermediate-level" waste was selected. The design utilizes individual storage cells which provide a maximum of protection for workers, should a malfunction occur. After examining different design concepts it was concluded that this facility afforded the greatest degree of

protection. Problems associated with the unstable waste referred to as in "1" above can be resolved by the use of an incinerator. The unstable waste can be rendered stable by incinerating the material at 1,200° to 1,500° Fahrenheit. The residual inert ash would then be placed in 55 gallon drums and stored in the storage building. This incineration would resolve any concerns for flammabl solvents and decomposable or infectious biological waste.

The design concept for a waste incinerator is based on information supplied by D.O.E. in the publication, EGG-2192, and in consultation with Burrows-Welcome in Research Triangle Park, North Carolina. Whi various types of incinerators are on the market, many have been desi to meet very specific needs. The incinerator selected is one which designed to accomodate the wide variety of waste produced in the sta It is competitively priced and appears to be economical to operate.

The building and development costs have been estimated by General Services; the incinerator cost was obtained from the manufacturer. operating staff of 14 full-time employees are based on information contained in D.O.E. publication, EGG-5434, and discussion with vario radioactive waste brokers and waste handlers. Salaries and benefits were based on state employee data supplied by the State Personnel Bo

The total estimated costs for facility development and operation is approximately $18.8 million ($29.4 million if concrete buildings are used). A detailed description and cost identification is contained in the Appendix.

CRITERIA FOR TEMPORARY SITE SELECTION

The criteria for an interim low-level waste site are based on the need for protection of the health and safety both of employees and of the public and for protection of the environment during and after the operation of the site. There are basic differences between an interim site and a permanent burial site for low-level waste which influence the criteria for site selection. The interim site will be above ground and will be a temporary facility, used to house waste for five years, which must be returned to unrestricted land usage seven years after it is opened, whereas a permanent site must provide for waste containment for 500 years.

An interim waste site poses problems not associated with a permanent disposal site. Because it is a temporary facility and the stored waste materials will have to be removed to a permanent site, failure of the waste containers, through corrosion and seepage, can be expected to cause a significant hazard to the facility operators. Fire in an interim facility is the most serious accident scenario since products of combustion and radionuclides will enter the atmosphere. It is that accident which will dictate the buffer zone required to assure that there is no significant problem for those people who reside or work in the vicinity of the storage facility.

Specific criteria are:

1. The site shall be placed away from population centers which might expand in its direction within seven years.

2. There shall be all-weather road access to the site.

3. Potable water and power should be available for normal operation of the facility and additional water must also be available to handle such contingencies as decontamination or fire fighting. This water need not be potable. A natural gas supply for firing an incinerator would be desirable.

4. The area selected must not be subject to known seismic activity which would jeopardize the ability of the facility to meet its performance objectives.

5. The interim storage facility shall not be located in a 100 year flood plain.*

6. "Back up" security and fire fighting service must be available. (The facility must, however, be able to provide primary security and fire services.)

7. The site must be so located as to provide reasonable assurance that under both routine operating and accident conditions, no member of the general population will receive an annual radiation dose exceeding an equivalent of 25 millirems to the whole body, 75 millirems to the thyroid, and 25 millirems to any other organ at the perimeter of the site.

* The facility should be subject to less than a one percent chance of flooding in any given year.

FINAL DISPOSAL OF LOW-LEVEL WASTE

If an interim facility is used, material stored there must eventually be moved to a permanent burial site. The criteria for a permanent site will include all those cited for an interim site (p. 19) plus criteria necessary for long term separation of radionuclides from the environment.

To reiterate, the interim site criteria include: 1) distance from major population centers; 2) all-weather road access; 3) adequate water supply; 4) freedom from known seismic activity; 5) avoidance of 100 year flood plain; 6) availability of security and fire-fighting backup service; and 7) protection of the general population in the vicinity of the site.

The permanent site criteria become more specific relating to land use and containment of radionuclides until they decay.

1. The site must be located on state or federal lands (Health and Safety Code 25812).
2. The site shall be under institutional (State or Federal) control for a period of 100 years and shall be protected against intrusion for 500 years.
3. The waste disposal facility site should be selected with consideration given to land use and resource development and not located where recovery of subsurface minerals or groundwater resources would result in increased erosion or significant changes in the hydrogeological system. Areas containing critical habitats of endangered species or cultural resources should be avoided.

4. The disposal site must provide sufficient depth to the water table that waste intrusion into the groundwater will not occur.

5. Areas where wind or soil erosion processes may interfere with the integrity of the site should be avoided.

6. The natural attributes of the site shall allow for characterization, modeling, monitoring and analyses of geologic, hydrologic, and radiologic factors.

7. Animal and plant intrusion into the disposal trenches should be controlled.

INTERIM STORAGE PROBLEMS

An interim storage facility presents some serious problems to the total low-level waste management program. Some provision will have to be made for interim storage since assurance of out of state disposal will end in 1986. The requirements of the current law that the interim site be decontaminated and returned to its original usage, places limitations on the program and adds to the total cost. The following are some of the problems anticipated:

1. Costs - There will be basic costs involved in both an interim storage site and a permanent facility. These include access roads, facilities for inspection, unloading, and if necessary, decontaminating vehicles. In addition, the considerable costs involved in California Environmental Quality Act would have to be duplicated if a second site is required for permanent burial.

2. Moving - There will be an avoidable hazard to employees and potentially to the public when waste stored in an interim site is moved to a permanent site as required by law. Use of an interim site will double the handling of the waste and greatly increase disposal costs for the waste producer.

CONCLUSIONS AND RECOMMENDATIONS

A program for development of an interim storage site for low-level waste, a waste classification scheme which is compatible with that of U.S. N.R.C. and general criteria for a permanent disposal site are presented in this report. At this point, it seems appropriate to make the interrelationships between these three issues explicit and similarly, to make explicit a course of action which appears to recommend itself.

An interim site presents difficulties in terms both of cost and of health and safety. California may be forced to take care of its own waste by 1986 and may be forced to develop an interim site to "buy time" while a permanent disposal site is being developed. Permanent site development and licensing would take about five years and that lead time simply is not available. The interim storage option however, commits the State to a series of actions which present as many if not more problems than would a permanent disposal site.

One of those problems is that of segregating the waste into classes that can and classes that cannot be stored safely in a warehouse. That segregation, curiously, is not based on consideration of radioactivity but chemical or biological reactivity. The worry is not with the radiation from which protection is available but from

those other things in the container that will, like acid, eat through the containers, or from biological materials that will rot and seep through the seals. These anticipated container failures will present serious problems to the warehouse caretakers. These caretakers will have to sweep up the spilled radioactive wastes which they can detect but, at the same time, be exposed to potentially hazardous chemical and biological agents which they cannot detect.

It is not intended that unstable materials be stored. Rather each of the waste generators will be asked to carefully categorize and segregate flammable, reactive, and biologic materials. If all the generators are sucessful in this separation, what then becomes of this non-stable waste? The recommended plan is to burn it and re-package the ash.

However, this means that in addition to an interim storage warehouse, a radioactive waste incinerator must be constructed and operated. While such incineration has been, and can continue to be, safely carried out, the cost is high and the difficulties significant. If a small incinerator is built, one just large enough for that material the survey identified must be treated, considerable effort and expense will be incurred for a very short term solution to the problem created in opting for (or resorting to) interim storage.

With a larger incinerator all the combustible low-level waste could be burned not just that which must be treated to make it storable. But, such an incinerator facility would not be easier to site than

a permanent disposal site, and for short-term use, it certainly could not be recommended.

In consideration of the information gathered in the preparation of this report, three actions are recommeded:

1. A search for and the qualification of a permanent burial site should begin immediately.

   The problem of disposal of low-level waste was clearly assigned to the states by the Congress in Public Law 96-573, the Low-Level Waste Policy Act. Action, therefore, must be taken to comply with that mandate.

2. California should renew its efforts to form a compact with other states or seek Congressional consent to becoming a "compact of one".

   The National Low-Level Policy Act encouraged the formation of compacts among the states wherein a waste disposal site for the members' common but exclusive use would be developed. Non-compact states could be denied access to a compact's site after January 1, 1986, once the compact had received the consent of the Congress.

   Presently, all states but California and Texas are, or potentially are, members of a compact of states and will, in 1983, be asking the Congress to consent to their formation. If California continues to remain outside such

an organization, for whatever reason, it will still have to develop a site for the use of its licensees but will be unable to limit access to its site. To limit the use of a California site, either Congressional consent to a "compact of one" must be secured thus overcoming Constitutional provisions against restriction of interstate commerce, or the State must finance and operate a State-run facility and prepare to defend its exclusive use in the courts. In following either of these paths, however, the State would appear to commit itself to development of an interim storage facility with all that option's inherent problems.

3. All efforts should be made to avoid the necessity of building and operating an interim low-level waste storage facility.

   Arrangements should be sought with the existing compacts of states elsewhere for continued access to existing disposal sites pending completion of the California site. To the extent that measurable progress has been made on site development and compact formation, California can expect consideration in making such a temporary arrangement while its permanent disposal site is being completed.

APPENDICES

TABLE OF CONTENTS

APPENDIX A: LOW-LEVEL WASTE CLASSIFICATION SCHEME

Summary 1

Low-Level Radioactive Waste Characteristics 3

Summary of Federal Regulations for Classification of LLW . . 5

Summary of AB 1513 LLW Classification Criteria 11

Proposed LLW Classification Scheme 13

References 21

APPENDIX B: SITING CRITERIA FOR STORAGE, TREATMENT, AND DISPOSAL FACILITIES

Summary: Conclusions and Recommended Standards 27

Introduction 29

Land Use 33

1. Proximity to Population Centers 33

2. Present and Projected Uses of Land, Water, and Natural Resources 35

3. Economic Impact of Location and Operation 40

4. Transportation of Radioactive Material to Site 41

5. Public Health (Boundary Doses to Adjacent Land Users) . . 43

Environmental Factors 44

1. Seismicity and Vulcanism 44

2. Geology 46

a. Topography; Geologic and Natural Barriers to Surface Water Contamination 46

b. Geologic and Natural Barriers to Groundwater Contamination 49

c. Erosion 56

3. Climate/Meteorology 56

Characterizability, Modelability and Monitorability 59

Infrastructure Requirements 61

1. Energy and Natural Resource Needs of the Facility 61

2. Security, Fire Protection, and Housing Needs of the Facility 62

Waste: Site Interactions 63

Bibliography 65

APPENDIX C: ANALYSIS OF INTERIM STORAGE REQUIREMENTS AND COSTS

Basic Assumption 71

Low-Level Waste Storage Building 71

1. Design Concept 71

2. Description of Low-Level Waste Storage Building 72

3. Costs of Low-Level Waste Storage Building and Associated Facilities and Equipment 73

4. Decontamination and Decommissioning Costs 73

Table I: Total Projected Costs for a Five Year Complete Interim Waste Storage Facility 74

Table II: Cost Facility Breakdown Low-Level Waste Interim Storage 75

5. Personnel Costs 76

Table III: Personnel Costs for a Low-Level Waste Facility . 76

Intermediate-Level Waste Storage Building 77

1. Justification 77

2. Description of Intermediate-Level Waste Storage Building 77

3. Costs for Intermediate-Level Waste Storage 77

4. Personnel Costs 77

5. Decontamination and Decommissioning Costs 78

Waste Incinerator 78

1. Justification 78

2. Description of a Waste Incinerator 78

3. Costs for a Waste Incinerator with Stack Emission Control 78

4. Operational Costs for a Waste Incinerator 79

5. Decontamination and Decommissioning Costs 79

Special Projects Area for Low-Level Waste 79

1. Justification 79

2. Costs 79

3. Decontamination and Decommissioning Costs 79

Table IV: Radioactive Waste Incinerator Costs 80

Cost to Users of the Facility 81

Figure 1-A: Interim Storage Facility Low Level Radioactive Waste 82

Figure 1-B: Interim Storage Facility Low Level Radioactive Waste 83

Figure 1-C: Interim Storage Facility Low Level Radioactive Waste 84

APPENDIX D: APPLICABLE STATE AND FEDERAL LAWS AND REGULATIONS

10 CFR 61 DRAFT 05/19/82 85

Assembly Bill 1513 90

Public Law 96-573, 96th Congress, Dec.22,1980 94 STAT. 3347 98

APPENDIX E: GLOSSARY OF FREQUENTLY USED TERMS 100

APPENDIX A

LOW-LEVEL WASTE CLASSIFICATION SCHEME

Introduction

Low-level radioactive waste (LLW) includes materials which are generated from a wide variety of activities in the state. It is produced by hospitals, educational and research institutions, manufacturers and nuclear utilities. The physical, chemical and biological forms of the materials, in addition to the amount and type of radioactivity must be considered to facilitate the preparation of this material for safe transportation, storage, treatment and disposal.

Background

The federal government has recently adopted regulations (10CFR61) for the disposal of LLW by shallow land burial (SLB). These regulations provide general guidance for the classification of LLW. However, these guidelines are directed at SLB technology and do not specifically address the classification needs of waste requiring treatment for interim storage before its ultimate disposal by SLB. California Assembly Bill 1513 (Chapter 95 of 1982 statutes) recognizes the need for and requires the development of a special classification scheme for waste undergoing interim treatment and storage.

Scope

This report describes a classification scheme which incorporates federal requirements for shallow land burial of LLW while considering both radiological and non-radiological health and safety aspects. It is intended to serve as the framework for the development of operating procedures for the producers of LLW, the operators of an interim storage-treatment facility and operators of a shallow land burial site.

General Description of the Classification Scheme

LLW may be divided into four major classes with subclasses to facilitate treatment for interim storage and future handling requirements at a burial site.

Class I: Radioactive - requires special packaging, handling or shielding because of its radioactivity (i.e., radiological properties are the most significant hazard).

Class II: Radioactive - requires special packaging, handling or treatment prior to storage because of its non-radioactive hazardous properties.

Class III: Radioactive - requires no special handling or treatment. Suitable for storage or burial as is.

Class IV: de minimis - not radioactive for purposes of ultimate disposal.

Conclusions

The recommended classification scheme will provide for the safe and efficient management of California's LLW, while allowing the flexibility to make refinements as better treatment and handling techniques may be identified.

It is anticipated that this scheme will facilitate the management of LLW, while not significantly increasing the burden on California producers.

LOW-LEVEL RADIOACTIVE WASTE CHARACTERISTICS

Sources of LLW

LLW is generated by hospitals, public and private educational and research institutions, manufacturers of radioactive compounds and sources for industrial uses (termed non-fuel cycle uses), in addition to nuclear power plants and manufacturers of nuclear reactor fuel (termed fuel cycle uses). Pursuant to the federal Low-Level Radioactive Waste Policy Act, states are responsible for the management of LLW which is not generated as a result of federal defense-related research and development activities.

Definitions of Low-Level Radioactive Waste

AB1513 defines low-level waste as follows:

> ". . . .Any radioactive waste except high-level radioactive waste and transuranic waste. High-level radioactive waste means: (1) irradiated reactor fuel, (2) liquid waste resulting from the operation of the first cycle solvent extraction system, or equivalent, and the concentrated wastes from subsequent cycles, or equivalent, in a facility for reprocessing irradiated reactor fuel, and (3) solids into which such liquid wastes have been converted. Transuranic waste includes includes any waste containing more than 10 nanocuries of transuranic elements per gram of waste of material. . . ."

Subsequent to the enactment of AB1513, Federal Regulation 10CFR61 has changed the definition of transuranic waste to increase the threshold concentration to 100 nanocuries per gram. Our recommendation is that California law be consistent with this change.

Physical, Chemical and Biological Nature of LLW

LLW is produced by such a wide variety of activities that it can be in any physical form (i.e., solid, liquid, gas), can be of almost any chemical form, and can be associated with biological materials. Therefore, it is important to consider the potential non-radiological hazards of LLW, in addition to the

quantities and types of radioactive materials in the development of a classification scheme to facilitate the treatment, handling and packaging of LLW for safe interim storage and disposal. (See Appendix B for a more detailed description of waste forms)

Following sections in this report will discuss those parameters which might affect operational safety at an interim storage facility and potential mobility of wastes in a burial site.

SUMMARY OF FEDERAL REGULATIONS FOR CLASSIFICATION OF LLW

Introduction

For the purpose of LLW classification to support the actual disposal of low-level radioactive waste in a shallow land burial site, Federal Regulation 10CFR61 is fairly well defined in terms of radiological health concerns. This regulation provides a basis for classification that could be revised only in the more restrictive direction. Assessment of the regulation and the draft environmental impact statement that provides the technical background indicates, that, although its classification scheme is not based on the concept of total hazard, it is nevertheless conservative in nature and should provide a reasonable level of protection of public health safety, particularly considering the siting conditions likely to be selected in the State of California.

Summary of LLW Classification Provisions of 10CFR61

The classification provisions of 10CFR61 have the objectives of protecting the general population and individuals from releases of radioactivity, protecting individuals from inadvertant intrusion, protecting individuals during operations and ensuring site stability after closure. Relevant sections of a recent draft are reproduced in Appendix A.

The major categories of waste defined under 10CFR61 are referred to as Class A, B and C type waste.

Class A waste is the basic category of low-level wastes which, while meeting the minimum standards of para. 61.56(a), is not required to meet the more stringent requirements of the other two classes of waste. The requirements of para. 61.56(a) include:

- prohibition of cardboard or fiberboard containers
- restriction of liquid content of wastes
- restriction of explosive and pyrophoric nature of waste

- restrictions of wastes based on generation of toxic gases
- restrictions of gaseous waste packaging
- requirement to treat nonradioactive hazardous nature of waste

Class B waste - in addition to meeting the minimum Class A requirements, must meet physical form (stability) requirements of para. 61.56. These stability requirements include:

- structural (physical) stability under burial conditions
- additional restriction of liquid content
- restriction of void space in waste

Class C waste is waste that must meet the minimum requirements for Class A and B wastes and require additional measures at the disposal facility to protect against inadvertant intrusion.

Nuclide-by-nuclide classifications are provided, depending on the isotopes present in the waste. Two tables of nuclide concentration are included: (See page 9)

Table 1 presents the waste classification as determined for waste containing long-lived radionuclides. Those wastes containing <u>only</u> nuclides occurring in Table 1 are classified as follows:

- If the concentration of the nuclide does not exceed 0.1 times the value in Table 1, the waste is Class A.
- If the concentration of nuclide exceeds 0.1 times the value in Table 1, but does not exceed the Table 1 value, the waste is Class C.
- If the concentration of the nuclides exceeds the Table 1 value, the waste is not generally acceptable for near-surface disposal.
- If the waste contains a mixture of nuclides from Table 1, the waste class is determined using the sum of the fractions rule.

Table 2 presents the waste classification as determined for waste containing short-lived radionuclides. If the waste does not contain any nuclide listed in Table 1, the Table 2 values are used. For wastes containing only nuclides contained in Table 2:

- If the concentration does not exceed the Column 1 value the waste is Class A.
- For concentrations between those of Column 1 and 2, the waste is Class B.
- For concentrations between those of Column 2 and 3, the waste is Class C.
- If the concentration exceeds that of Column 3, the waste is not generally acceptable for near-surface disposal.
- For wastes containing mixtures of nuclides listed in Table 2, the waste class is determined using the sum of the fraction rule.

If the waste contains a mixture of nuclides from both Table 1 and 2, classification is as follows:

- If the concentration of a nuclide listed in Table 1 is less than 0.1 times the value in Table 1, the class is that determined by the concentration of nuclides listed in Table 2.
- If the concentration of a nuclide listed in Table 1 exceeds 0.1 times the value listed in Table 1, the waste is Class C, if the concentration of nuclides listed in Table 2 does the concentration of nuclides listed in Table 2 does not exceed the value shown in Column 3 of that table.
- If the radioactive waste does not contain any nuclide listed in either Table 1 or 2, then it is Class A.

Important considerations that were incorporated into the 10CFR61 classification scheme include:

- nuclide quantity (expressed in terms of concentration)

- nuclide specific activity
- persistence
- principal radionuclides and procedures for evaluating mixtures
- physical form
- non-radiological hazards as they might affect potential releases to the environment from a shallow land burial site.

TABLE 1

Radionuclide	Concentration Curies/cubic meter
C-14	8
C-14 in activated metal	80
Ni-59 in activated metal	220
Nb-94 in activated metal	0.2
Tc-99	3
I-129	0.08
Alpha emitting transuranic nuclides with half-life greater than five years	100*
Pu-241	3,500*
Cm-242	20,000*

*Units are nanocuries per gram

TABLE 2

Radionuclide	Concentration, Curies/cubic meter Column 1	Column 2	Column 3
Total of all nuclides with less than 5 year half life	700	**	**
H-3	40	**	**
Co-60	700	**	**
Ni-63	3.5	70	700
Ni-63 in activated metal	35	700	7000
Sr-90	0.04	150	7000
Cs-137	1	44	4600

**There are no limits established for these radionuclides in Class B or C wastes. Practical considerations such as the effects of external radiation and internal heat generation on transportation, handling and disposal will limit the concentrations for these wastes. These wastes shall be Class B unless the concentrations of other nuclides in Table 2 determine the waste to be Class C independent of these nuclides.

Conclusions

10CFR61 together with 10CFR20 define acceptability for waste disposal at a shallow land burial site (waste forms, radionuclide concentration, permissible radiation exposure levels, etc.) but does not provide guidance on classification for purposes of interim storage or treatment for disposal.

SUMMARY OF AB1513 LLW CLASSIFICATION CRITERIA

In addition to the requirements prescribed by 10CFR61 for shallow land burial, AB1513 requires the development of a classification scheme which will facilitate the management for treatment and storage of LLW before its ultimate disposal.

The following matters are required to be considered in the development of the classification scheme:

1. possible de minimis radiation levels for specific radionuclides
2. the quantity and specific activity of materials
3. their persistence (i.e., half-lives)
4. toxicity, chemical form, reactivity (e.g., flammability, corrosivity)
5. principle radionuclides

The classification scheme must include specifications necessary to determine which classes of waste:

1. may or may not be suitable for storage at an interim storage facility;
2. may or may not be held by the licensees (on site) for decay to specified residual radioactivity levels;
3. require long-term isolation from the environment;

as the case may be, for the protection of public health and safety.

In considering those matters and determining those classes mentioned above, (i.e., those identified in AB1513), the following considerations are also important:

1. The scheme must be compatible with the federal regulations for LLW disposal facilities. To be consistent with 10CFR61 and DOE Order 5820, the definition of LLW in AB1513 should be changed to include transuranic radionuclides in concentrations up to 100 nanocuries per gram.
2. The scheme must be compatible with federal regulations regarding the de minimis radiation issue.

3. Some types of LLW will require treatment before they are suitable for either interim storage or long-term isolation from the environment. Therefore, different treatment options must be considered in developing a classification scheme.

4. The scheme must be as simple as possible to facilitate its administration by DHS and the licensees.

The scheme suggested in this report provides a basis for the DHS to use in its development of requirements for the segregation waste generated by California LLW producers.

PROPOSED LLW CLASSIFICATION SCHEME

Introduction

An important consideration in the management and disposal of low-level waste is the process of storage and treatment of the waste in preparation for permanent disposal. These operational aspects of waste management are considered in much less detail in 10CFR61 than is classification for burial. In many cases, reference to these operational activities is vague and not helpful in establishing standards. A problem in this regard is that classification for storage and treatment will strongly influence the specific design of the storage-treatment facility itself. Therefore, the intent of this classification scheme is to suggest a basic framework to be further refined as more efficient treatment and handling procedures may be identified.

Purpose

The basic goal of a classification system is to provide a basis for sorting (segregating) waste types that is simple (i.e., small number of categories) yet detailed enough to provide for efficient and safe management.

General Description of the Scheme

This system reflects overall hazards based on operational safety considerations, requirements for treatment and disposal of wastes which might present both radiological and non-radiological hazards. This leads to the necessity for sub-categories within each class.

Class I: Radioactive - requires special packaging, handling or shielding because of its radioactivity (i.e., radiological properties are the most significant hazard).

Class II: Radioactive - requires special packaging and handling or treatment because of its non-radioactive hazardous properties.

Class III: Radioactive - requires no special handling or treatment at an interim storage facility. Suitable for burial as is.

Class IV: de minimis - not radioactive for purposes of ultimate disposal.

The following sections provide a more detailed description of each class.

CLASS I

This class of LLW requires special handling or packaging because of its radiologic properties: either because of the type or quantity of radioactivity (i.e., it is NRC Class B or C) or the external radiation levels are high enough to require remote handling and shielded storage (i.e., surface dose rate - 200 mR/hr. or higher).

Waste in this class would probably be shipped to an interim storage facility in a form which already meets the requirements for burial as prescribed in 10CFR61. This would minimize the need for special processing and treatment for higher activity waste at the interim storage facility.

It may be appropriate to segregate this class into two major subcategories for operational reasons at the interim storage facility:

(1) Required to be kept in a shielded storage area

(2) Not required to be kept in a shielded storage area

CLASS II

This class of LLW requires special handling, treatment and/or packaging because of its non-radiological properties. These wastes must be segregated to prevent incompatible chemical reactions, to reduce the potential for fires, to reduce the problems associated with biological decay (i.e., putrification) and/or to reduce the potential for adverse chemical or physical interaction with its container and/or the environment.

Sub-categories of this class will also consider treatment options which may be utilized to improve the stability of the waste and/or reduce its potential for migration at a burial site. Further refinements in this class may be appropriate as the practicality of alternative volume reduction and treatment methods are evaluated during the next year. The following is a general description of sub-categories:

(1) Biological/pathological (e.g., animal tissues, excreta, micro organisms or their toxins)

(2) Flammable or combustible toxic organics

(3) Corrosives

(4) Water reactives

(5) Pyrophorics (i.e., spontaneously combustible)

(6) Chelating agents and other materials which may increase mobility in a burial site.

Sub-categories (1) and (2) would be destined for incineration at the interim storage facility. The packaging of sub-categories (1) and (2) should be designed to minimize the requirement for handling in preparation for treatment by facility personnel. The use of combustible and/or reuseable containers should be considered. Sub-categories (3) through (6) probably should be treated, neutralized and/or stabilized, by the generator before being shipped to the interim storage facility in a form which already meets the requirements for burial prescribed by 10CFR61.

CLASS III

This class of LLW requires no special treatment before it is suitable for interim storage. Most of the waste in this category has already been subjected to volume reduction by mechanical compaction and/or shredding. An alternative means of volume reduction is incineration.

It may be desirable to segregate this class into two major sub-categories:

(1) Treatment optional. Subject to incineration or some other treatment option for purposes of further volume reduction and/or stabilization.

(2) Treatment undesirable. (i.e., the volume is already reduced to the maximum extent practicable).

Further refinements in this class may be appropriate as the practicality for various volume reduction and/or treatment techniques are evaluated next year. Generally, it is desirable to reduce the volume of this type of waste to the maximum extent practicable to reduce the potential for burial trench subsidence and thereby enhance burial site stability over the long term. This benefit must be carefully weighed against the risk to personnel who would be involved in any additional segregating or processing operations.

CLASS IV

This class of LLW is destined for disposal as non-radioactive waste and not required to meet 10CFR61 burial requirements. This material will fall into two major sub-categories:

(1) short-half life (i.e., less than 90 days) which can be safely stored for decay until it reaches a de minimis level. (See following discussion) This material may be stored by licensees on-site or at an ISF for the appropriate time before release.

(2) Very low concentrations of radioactivity such as that which is already at a de minimis level. This material would not be shipped to an ISF, but be handled by the generator as any non-radioactive waste of that physical, chemical or biological form.

Definition of de minimis Waste

Introduction

Essentially, all materials on earth are, to some degree, contaminated with radioactivity. This condition is due largely to the ubiquitous presence of naturally occurring radionuclides such as Potassium-40, Uranium and its progeny, Tritium, Carbon-14, etc. There is also widespread contamination from worldwide fallout due to atmospheric testing of nuclear explosives. Levels of background radioactivity vary considerably and generally are too low to warrant concern. Similarly, the radioactive content of much of the waste from radioactive materials licensees may be too low to warrant concern. For this reason, it is desirable to establish a class of wastes as "de minimis" level waste. This class of waste may be disposed with no considerations as to its radioactivity (i.e., direct disposal to sanitary sewage or as normal municipal trash). It should be noted however that certain wastes, regardless of radioactivity content, may require special handling due to their chemical or biological hazardous nature.

Proposed Definition of de minimis Waste

Previous study has established the need and rationale for the de minimis concept in radiation safety programs (Davis, 1981). For low level radioactive wastes, any of several possible approaches may be applied toward determination of suitable de minimis levels below which the waste may be considered essentially non-radioactive for purposes of disposal. Most prominent among these possibilities is the deterministic method whereby "worst case scenarios" are analyzed to assess whether a given radiation dose to any individual could be exceeded assuming shallow land burial conditions. To date, the most complete study utilizing this method was sponsored by the Atomic Industrial Forum (AIF/NESP-016). This study calculated de minimis concentration levels for radionuclides in solid wastes by determining maximum concentrations of individual radionuclides for LLW under typical shallow land burial conditions that, via any of several exposure scenarios, would not result in individual radiation dose exceeding 1 mrem/yr total body dose or 3 mrem/yr to any organ.

Although future study may provide a rationale for higher (less restrictive) de minimis levels, it is believed that the conservative levels suggested in AIF/NESP-016 establish a reasonable basis for initial definition of de minimis class LLW.

Some alternative approaches which may be applied toward determination of de minimis concentration levels include:

1. Determination of a suitable fraction or percentage of natural background radioactivity.

2. Determination of a suitable fraction of maximum permissible concentrations already established in the regulations for releases to unrestricted areas.

3. An equivalent level as related to de minimis levels for Tritium and Carbon-14 set in 10CFR20.

4. Cost-benefit analysis considering each waste stream individually.

   (Note: This approach may establish a basis for determination of de minimis levels based on ALARA (As Low As Reasonably Achievable) principles)

5. Application of probabilistic risk analysis which considers not only potential consequences of disposal, but also the probability for their occurrence.

Selection of the optimal method or combination of methods for determination of de minimis levels will require assessment of social and economic as well as technical factors. The major consideration is that establishment of de minimis class of radioactive waste is essential since without it all waste streams could, in a literal sense, be considered radioactive.

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APPENDIX B

SITING CRITERIA FOR STORAGE, TREATMENT, AND DISPOSAL FACILITIES

I. SUMMARY:

Standards for the selection of a low-level waste disposal facility are developed as they relate to meeting the performance objectives and prescriptive requirements outlined in 10 CFR 61. The standards and rationale behind their development are general and cite more specific discussions of the relevant issues. Flexibility must be preserved in considering how individual characteristics of the site and the waste will interact. Meeting long-term performance objectives is paramount. Recommended standards for selection of a shallow land burial disposal site are:

1. Disposal facilities should be located away from large expanding population centers.

2. The waste disposal facility site shall be selected with consideration given to land use and resource development and not located where recovery of subsurface minerals or groundwater resources could result in increased erosion or significant changes in the hydrogeological system. Areas containing critical habitats of endangered species or cultural resources should be avoided.

3. Economic impact analysis of proposed sites should be undertaken using acceptable procedures (such as those offered by the State of California, Office of Planning and Research). Use of compensatory mechanisms should be considered.

4. Disposal sites shall be accessible by all-weather roads.

5. The site shall demonstrate acceptable exposure limits (i.e., the performance objectives) in modeling simulations of facility performance as delineated in 10 CFR 61.41.

6. The site shall not be located over zones of active faulting where seismically induced phenomena would jeopardize the ability of the facility to meet performance objectives. Similarly, the site shall not be located near zones of igneous or volcanic activity that will jeopardize the ability of the facility to meet performance objectives.

7. The waste disposal facility shall not be located in a coastal high hazard area or wetland, 100 year flood plains, arroyos, dry washes, areas of poor drainage, within the upstream or downstream influence of manmade dams, or regulatory floodways, on the down gradient from mountain canyons where flash flooding is likely to occur, or in an area with conditions that will be conducive to flooding.

8. A suitable site must meet the following general hydrologic criteria:

   (a) maximum fluctuations of the water table and associated capillary fringe should not intrude the proposed lower boundary of the disposal units (16m);
   (b) the hydrologic setting of the proposed site should be fully characterized according to methods presented in NRC (1982) and EPA (1974);
   (c) the disposal site should not be located in areas where it would degrade groundwater quality; and
   (d) excavated soil shall be evaluated for appropriateness as backfill and trench cap material.

9. Areas where wind or water erosion processes may present a significant potential to jeopardize facility performance should be avoided.

10. A semi-arid to arid climate is optimal for siting. The site should demonstrate a low frequency of extreme weather events during the short-term to ensure site operation integrity.

11. The natural attributes of the site shall allow full characterization, modeling, monitoring, and analysis of geologic, meteorologic, hydrologic, and radiologic factors.

12. The facility should be located where utilities can be made available.

13. The low-level waste disposal facility should not be located so remotely as to impair the administration of security and fire services.

14. The disposal site should be able to meet the performance objectives outlined in 10 CFR 61 throughout the projected 500 year hazardous interval of the waste. The selected site must be able to meet the volume requirements predicted for the facility service life.

II. INTRODUCTION:

The present study adopts a systems approach to evaluation of siting criteria (Klingsberg and Duguid, 1982). The cumulative effect of all the components must meet the performance objectives presented in 10 CFR 61. These performance objectives define the limits of acceptable contaminant release to the environment:

> Section 61.40. General Requirement. Land disposal facilities must be sited, designed, operated, closed, and controlled after closure so that reasonable assurance exists that exposures to humans are within the limits established in the performance objectives in Sections 61.41 through 61.44.
>
> Section 61.41. Protection of the general population from releases of radioactivity. Concentrations of radioactive material which may be released to the general environment in ground water, surface water, air, soil, plants, or animals must not result in an annual dose exceeding an equivalent of 25 millirems to the whole body, 75 millirems to the thyroid, and 25 millirems to any other organ of any member of the public. Reasonable effort should be made to maintain releases of radioactivity in effluents to the general environment as low as is reasonably achievable.
>
> Section 61.42. Protection of individuals from inadvertent intrusion. Design operation and closure of the land disposal facility must ensure protection of any individual inadvertently intruding into the disposal site and occupying the site or contacting the waste at any time after active institutional controls over the disposal site are removed.
>
> Section 61.43. Protection of individuals during operations. Operations at the land disposal facility must be conducted in compliance with the standards for radiation protection set out in Part 20 of this chapter, except for releases of radioactivity in effluents from the land disposal facility, which shall be governed by Section 61.41 of this part. Every reasonable effort shall be made to maintain radiation exposures as low as is reasonably achievable.
>
> Section 61.44. Stability of the disposal site after closure. The disposal facility must be sited, designed, used, operated, and closed to achieve long term stability of the disposal site and to eliminate to the extent practicable the need for ongoing active maintenance of the disposal site following closure so that only surveillance, monitoring, or minor custodial care are required.

The present study interprets the performance objectives of 10 CFR 61 in light of the specific needs of siting a shallow land burial facility for the permanent disposal of low-level radioactive waste.

While California Assembly Bill 1513 does not stipulate performance objectives, it does direct that the following be considered in development of siting criteria for potential land burial disposal sites and treatment facilities:

(1) The present and projected future uses of land, water, and natural resources.

(2) The proximity of the site to major population centers.

(3) The presence of active earthquake faults.

(4) Geologic and other natural barriers which protect against surface or ground water contamination.

(5) The effectiveness of engineered barriers, waste treatment, and waste packaging in ensuring isolation of the waste from the environment.

(6) Transportation of radioactive materials as it relates to public health and safety.

(7) The relative economic impact of location and operation of treatment or disposal facilities.

To ensure that the performance objectives are met, more specific characteristics or minimum technical requirements, "prescriptive requirements", are listed in 10 CFR 61.50:

(1) The disposal site shall be capable of being characterized, modeled, analyzed and monitored.
(2) Within the region or state where the facility is to be located, a disposal site should be selected so that projected population growth and future developments are not likely to affect the ability of the disposal facility to meet the performance objectives.
(3) Areas must be avoided having economically significant natural resources which, if exploited, would result in failure to meet the performance objectives.
(4) The disposal site must be generally well drained and free of areas of flooding or frequent ponding. Waste disposal shall not take place in a 100 year flood plain, coastal high-hazard area or wetland, as defined in Executive Order 11988, "Floodplain Management Guidelines."

(5) Upstream drainage areas must be minimized to decrease the amount of runoff which could erode or inundate waste disposal units.
(6) The disposal site must provide sufficient depth to the water table so that ground water intrusion, perennial or otherwise, into the waste will not occur. The Commission will consider an exception to this requirement to allow disposal below the water table if it can be conclusively shown that disposal site characteristics will result in molecular diffusion being the predominant means of radionuclide movement and the rate of movement will result in the performance objectives of Subpart C of this part being met. In no case will waste disposal be permitted in the zone of fluctuation of the water table.
(7) The hydrogeologic unit used for disposal shall not discharge ground water to the surface within the disposal site.
(8) Areas must be avoided where tectonic processes such as faulting, folding, seismic activity, or vulcanism may occur with such frequency and extent to affect the ability of the disposal site to meet the performance objectives.
(9) Areas must be avoided where surface geologic processes such as mass wasting, erosion, slumping, landsliding, or weathering occur with such frequency and extent to significantly affect the ability of the disposal site to meet the performance objectives.
(10) The disposal site must not be located where nearby facilities or activities could adversely impact the ability of the site to meet the performance objectives...or significantly mask the environmental monitoring program.

Prescriptive requirements stipulated for disposal site design (10 CFR 61.51) must also be considered. Unfavorable physical characteristics of the site may be compensated for by engineering technologies. The ability of engineered designs to meet these disposal site design minimum technical requirements will narrow the range of acceptability of certain site selection parameters:

(1) The disposal site must be designed to complement and improve the ability of the disposal site's natural characteristics to ensure that the performance objectives...will be met.
(2) Covers must be designed to prevent water infiltration, to direct percolating or surface water away from the buried waste, and to resist degradation by surface geologic processes and biotic activity.
(3) Surface features must direct surface water drainage away from disposal units at velocities and gradients which will not result in erosion that will require ongoing active maintenance in the future.

Hawkins and Siefkin (1982) emphasize the long-term contribution of site characteristics to waste isolation: "reliance on other areas such as design features, waste form and packaging, and institutional controls, will decrease with increasing time after site closure". In the following sections, site characteristics believed to be essential to meeting performance objectives are individually developed and related to the site selection process. For each parameter the relevant performance objectives and prescriptive requirements are identified, siting concerns are discussed, and site selection standards are derived.

III. SITE SELECTION CRITERIA

A. Land Use

1. Proximity to Population Centers

Related Existing Requirements: Relevant performance objectives outlined in 10 CFR 61.41, 61.42, and 61.43 are addressed in this siting consideration. California Assembly Bill 1513 specifically stipulates that the proximity of the site to major population centers will be considered. Further, 10 CFR 61.50 instructs that "a disposal site should be selected so that projected population growth and future developments are not likely to affect the ability of the disposal facility to meet the performance objectives".

Discussion: These performance objectives and prescriptive requirements suggest that the proposed facility should be located as far as practicable from occupied areas. This would protect populations from the effects of potential accidental and chronic radiation releases during operation of the facility. Protection of the public health is the foremost reason for remote location. The risk to offsite populations is greatest during the time of operations because of the possibility of an airborne release during transportation, handling, or emplacement. Populations may be at risk along shipping routes and at truck stops or rail stations (Ford, Bacon, and Davis, 1982). Distancing of facilities from population centers minimizes interference with the expansion of those urban areas and decreases the likelihood of human intrusions after institutional controls have ended (Falconer, Hull and Mizell, 1982). In addition, locating away from large expanding populations

minimizes the economic impact of long-term land commitments to waste disposal (site land costs would also be minimized). Future demography however is often difficult to quantify and projections are uncertain beyond 50 years.

It must be assumed that large distances between the waste and present population centers will, in turn, lower the probability of unacceptable human exposures (Ford, Bacon and Davis, 1982). Given that the typical low level waste emplaced in the facility will decay to de minimis levels within a few hundred years, demographic projections over this time period should be adequate (Ford, Bacon and Davis, 1982).

Locating the facility at an arid site has the following advantages: arid sites usually have a low population density and are associated with undesirable features for urban growth such as limited water supplies, unpleasant climate, and poor agricultural soils. These characteristics suggest a low probability of population expansion onto the site in future years. Growth in tourism or recreational use intruder activity after institutional controls have ended should, nonetheless, be considered.

In most siting criteria discussions, proximity to population centers does not preclude siting: a site meeting the minimum technical requirements of 10 CFR 61 could be located near population centers. Ford, Bacon and Davis (1982) emphasize that there are no federal standards which define "high population density" or how far into the future demographic projections should be made: common sense may be the standard to apply. Population distributions within

an 80 kilometer (50 mile) radius are often used as a routine base for assessments as directed by NRC guidelines for siting of power facilities. The risk to offsite populations is greatest during the time of operations because of the possibility of an airborne release during transportation, handling, or emplacement. This most likely exposure scenario underlines the importance of current and short-term (less than 100 years) demographic projections.

Given the dynamic nature of the buffer zone required to meet the performance objectives (Falconer, Hull and Mizell, 1982), it is not possible to predict the spacing requirements of a LLW facility with respect to adjacent land users. A minimum boundary distance is suggested by current state law preventing the siting of hazardous waste facilities within 2000m of a residence. (Note: "radioactive waste" is a special material not included under the legal definition of "hazardous waste".) This distance will probably not be necessary to meet performance objectives at sites which satisfy the minimum technical requirements of 10 CFR 61. However, the 2000m distance may be a reasonable screening criterion in the site selection process: it provides a buffer from the effects adjacent land uses that jeopardize the performance objective and may improve public acceptance of the facility.

Recommended Standard: Disposal facilities should be located away from large expanding population centers.

2. Present and Projected Uses of Land, Water, or Natural Resources

Related Existing Requirements: Performance objectives outlined in 10 CFR 61.40, 61.41, 61.42, and 61.44. California Assembly

Bill 1513 directs consideration of the present and projected future uses of land, water, and natural resources. 10 CFR 61.50 directs avoidance of areas having "economically significant natural resources which, if exploited, would jeopardize meeting performance objectives". Further, "the disposal site must not be located where nearby facilities or activities could adversely impact the ability of the site to meet its performance objectives".

Discussion: These performance objectives and prescriptive requirements may be complemented by considerations of human activities that compete for a land use and/or threaten the long-term isolation of the waste. The term "natural resources" is read broadly to include land, groundwater, minerals, air, and resources that have already been dedicated to uses that exclude consideration for potential site location. Waste disposal facilities cannot be located in areas that are protected by the following federal laws and regulations:

The Wilderness Act of 1964 (PL 88-577)

Wild and Scenic Rivers Act (PL 90-542)

Endangered Species Act of 1973 (PL 93-205)

National Wildlife Refuge Act of 1966 (PL 89-665)

National Park legislation

Historical Properties - Preservation (PL 89-665)

Archeological and Historical Preservation Act of 1974 (PL 93-291)

The California Energy Resource Conservation and Development Commission (1976) concluded that the following dedicated land uses are to be avoided in siting new power plants: parks, forests,

monuments, wildlife refuges and game preserves, military test ranges and proving grounds, and other large scale local land uses encompassing more than 3000 acres.

Land use and comprehensive plans should be analyzed in determining the suitability of areas within preferred regions of siting.

Land uses associated with the mineral extraction industry may be particularily incompatible with waste facility development. Recovery of fossil fuel resources in the vicinity of the waste disposal facility may pose a risk to the facility integrity. Arid desert areas, considered under other criteria as most suitable for siting, may contain potash, borates, salt, coal or oil. Ford, Bacon and Davis (1981) point out that these mineral deposits could not be recovered if they were located near the surface but that deeper mining may be possible if it can be done without disturbing the waste. Given the dangers of subsidence posed by oil extraction and the threat of modification of surface and subsurface hydrology by typical resource recovery methods, it is prudent to site away from current mining activities or known mineral deposits. Many energy research developments are located in regions which would preclude siting because of other exclusionary criteria such as proximity to water, complex geology, and vulcanism (e.g., geothermal facilities).

Indirect effects on the waste disposal facility can be caused by exploitation of nearby water resources. These activities might cause increased infiltration rates or may steepen hydraulic gradients which could affect the ability of the site to meet

performance objectives (NRC, 1982b). In general, facilities should not be located in areas near the damming of down-stream rivers, in areas where there are extensive groundwater withdrawals which have caused land subsidence and or earth fissuring, or in areas where heavy irrigation has significantly raised groundwater levels.

Agricultural land should be avoided because of the threat to facility performance posed by irrigation. Further, conflict with a competing land use is eliminated, and the probability conversion to irrigated farmland after institutional controls have ended is minimized.

The NRC Draft EIS (1981) identifies the following non-radiological impacts to air quality: (1) emission of sulfur oxides, nitrogen oxides, carbon dioxide, carbon monoxide, hydrocarbons, and particulates from the combustion of fossil fuels during transport, processing and disposal of waste, and (2) release of particulate matter (dust) resulting from earthmoving activities. These air quality impacts will be limited to the operational phase of the facility.

Air quality considerations are of special importance if evaporators or incineration treatment processes are to be utilized (NRC, 1982b). The Historical Preservation Act of 1974 precludes siting in areas which would cause destruction or loss of sites of historical or archeological importance. Siting should be avoided in areas listed in The National Registry of Natural Landmarks and in or eligible for inclusion in The National Register of Historic Places (NRC, 1982d).

State and local registers may also dedicate areas for historic, architectural or archeological preservation. Flora and fauna may be considered natural resources. The Endangered Species Act of 1973 (PL 93-205) protects the critical habitat of endangered or threatened species. Endangered species protection is expected to be a significant concern at arid sites because of the slow resiliency of the desert environment to disturbance and the extreme "patchy" distribution of critical habitats in California desert regions. In addition to endangered or threatened species, siting should consider impacts on commercially or recreationally valuable species, species that affect the well-being of other important species, and species that are critical to the structure/ or function of the ecological system. A global perspective on potential effects is suggested: effects on migratory routes could have far reaching impact on regional ecological resources.

The overall aesthetic value of the landscape is also a factor in the evaluation of site suitability. This is not a site selection consideration per se because of available design mitigations which allow all harmonious arrangement of the facility with the surrounding environment. However, regions noted for their unique intrinsic beauty might be avoided. The California Energy Resource Development and Conservation Commission (1976) and Miller (1982) suggest methodologies for assessing aesthetic impacts in the site suitability judgement.

Recommended Standard: The waste disposal facility site should be selected with consideration given to land use and resource

development and not located where recovery of subsurface minerals or groundwater resources would result in increased erosion or significant changes in the hydrogeological system. Areas containing critical habitats of endangered species or cultural resources should be avoided.

3. Economic Impact of Location and Operation

Related Existing Requirements: California Assembly Bill 1513 requires consideration of the relative economic impact of the location and operation of treatment or disposal facilities. There are no performance objectives or prescriptive requirements relevant to this impact consideration in 10 CFR Part 61.

Discussion: Literature analysis and visits to commercially operated low-level waste disposal sites at Beatty, Nevada and Richland, Washington have revealed nominal economic impacts to adjacent communities. These facilities have low manpower needs; approximately 11 workers at Beatty and 30 workers at Richland. In remote locations even this low number of jobs might be significant to the community. Although it is difficult to predict with certainty, the implementation of 10 CFR 61 may increase manpower needs to comply with environmental monitoring and special inspection and handling requirements. As a business, the facility would provide benefits such as tax revenues to local city and county government, secondary employment, and purchases of supplies and services.

Economic impact will depend on the site's proximity to existing services for workers and their families. However, the small

work forces needed at sites make boom town effects unlikely. Discussions with site operators indicate that most labor needs can be met by even small communities. Public service requirements include security and fire protection (See Section D.2.), transportation (e.g., road maintenance), hospitals, nominal water and sewage and power (power demands depend on possible co-location of treatment facilities). Impacts to the community which are more difficult to quantify yet have economic significance include: changes in property values associated with siting; air quality changes that result from site operations and the transportation of material to the site; and increased traffic and noise.

Recommended Standard: Economic impact analysis of proposed sites should be undertaken using acceptable procedures (such as those offered by the State of California, Office of Planning and Research). Use of compensatory mechanisms should be considered.

4. Transportation of Radioactive Material to Site

Related Existing Requirements: Performance objectives outlined in 10 CFR 61.41, 61.42, and 61.43. California Assembly Bill 1513 requires consideration of the transport of radioactive material as it relates to public health and safety.

Discussion: The need to protect public safety is considered paramount in evaluating transportation needs. Convenience and economic considerations also need to be addressed. Ideally, facilities would be located where transportation routes would not pass through large population centers. This is not an

absolute requirement in siting for adjustments may be made to route incoming waste around population centers (Nevada Test Site Operations and Procedures Manual, 1982). Specific route systems for the shipment of LLW have not been mandated by the Department of Transportation because these materials do not present significant hazards (Mahathy and Jacobs, 1982).

The risk of spills and accidents may be reduced by selecting sites that allow all-weather operations and have a low frequency of occurrence of hazardous road conditions. Site selection should consider the location of waste generators in relation to the proposed site (Colorado Geologic Survey, 1980). Other siting studies have recognized that the greater the distance between waste generators and the ultimate disposal site, the greater risk posed by transportation accidents (Ford, Bacon and Davis, 1981). Circuitous routing to avoid high population densities may not be economically viable over the operational phase of the site.

Given the potentially large quantities of waste to be transported to the facility it may be advantageous to site near existing railroad lines. The DOE facility at Mercury, Nevada is serviced by a Union Pacific spur. In addition to waste of low specific activity, high specific activity wastes are transported with extra shielding to Mercury via ATMX impact resistant containers.

Presently, radioactive materials are shipped long distances across the country for disposal. The transportation of this material is regulated by the United States Department of Transportation. The safe shipping record would suggest that

present transportation methods are adequate and do not place any constraints on the siting process.

In light of the high cost of roadway construction, proximity to all-weather highways is an important economic concern for the potential developer of a commerical LLW facility. Similarly, railroad access may be considered in the site selection process.

Recommended Standard: Disposal sites shall be accessible by all-weather roads.

5. Public Health: Boundary Doses (To Adjacent Land Users)

Related Existing Requirements: All performance objectives, prescriptive requirements, and guidelines outlined in 10 CFR 61 and California Assembly Bill 1513 are applicable to this section. As specifically outlined in 10 CFR 61.41, "concentrations of radioactive material which may be released to the general environment in groundwater, surface water, air, soil, plants, or animals must not result in an annual dose exceeding an equivalent of 25 millirems to the whole body, 75 millirems to the thyroid, and 25 millirems to any other organ of any member of the public. Reasonable effort should be made to maintain releases of radioactivity in effluents to the general environment as low as is reasonably achievable".

Discussion: Human exposures are the ultimate acceptability criteria in siting. Release scenarios of human exposure include air, soil, surface water and groundwater pathways. Each may be modeled to predict the adequacy of the site to protect public health.

Recommended Standard: The site shall demonstrate acceptable exposure limits (i.e., the performance objectives) in modeling simulations of facility performance as delineated in 10 CFR 61.41.

B. Environmental Factors[1]

1. Seismicity and Vulcanism

Related Existing Requirements: Performance objectives outlined in 10 CFR 61.40, 61.41, and 61.43. California Assembly Bill 1513 mandates consideration of "the presence of active earthquake faults". 10 CFR 61.50 directs avoidance of areas "where tectonic processes such as faulting, folding, seismic activity or vulcansim may occur with such frequency and extent to affect the ability of the disposal site to meet the performance objectives".

Discussion: California is a seismically active area. Predicting an earthquake of sufficiently large magnitude to impair the ability of the site to isolate the emplaced waste is problematic. Shear force effects of a severe earthquake may result in appreciable damage to above ground structures. Disposal units by virtue of their in-ground location are not subject to these destructive shear forces. However, strong earthquakes could create fissures in the trench cap permitting inflow of runoff and precipitation or release of radionuclides to the biosphere. Displacement could alter subsurface groundwater flow patterns if faults or

[1] 10 CFR 61 requires at minimum, a full year of data collection for those environmental factors which display seasonal variation (Section 61.53). Dressen et al, (1982) estimate that the detailed flora and fauna inventory and geological, hydrological, and meteorological characterization phase of the environmental impact report will take 1.5 years. Some data will be available at regional recording stations. The NRC, 1982b suggests a prelicensing discussion of site characterization measurements to ensure timely and complete characterization in anticipation of licensing review.

other geologic anomalies are created. Faults may act as conduits through which nuclides migrate more freely (Falconer, Hull and Mizell, 1982; Ford, Bacon and Davis, 1982). They provide a direct channel for nuclides to travel to the aquifer with little or no opportunity for ion exchange or precipitation.

Ford, Bacon and Davis (1981) derived a standard of acceptable seismic risk for the siting of shallow land burial disposal sites in Utah. Areas having a peak horizontal ground acceleration of greater than 0.25g with a recurrence interval of less than 500 years were excluded as sites. This standard predicts with 90% probability that the ground acceleration will not be exceeded in the 500 year design lifetime of the waste facility. As with other hazards the frequency interval was dictated by the duration of the radiological hazard (approximately 500 years). Other geologic events also threaten the ability of the site to meet the performance objectives. Eruptive volcanic events could disperse waste material into the atmosphere. Many volcanic events are accompanied by flooding which could reach trench caps or emplacements. A large slump or slide could expose wastes. In general, siting schemes avoid locations where potential volcanic activity is likely (Falconer, Hull and Mizell, 1982; Colorado Geologic Survey, 1980; Ford, Bacon and Davis, 1981, 1982).

Recommended Standard: The site should not be located over zones of active faulting where seismically induced phenomena would jeopardize the ability of the facility to meet performance objectives. Similarly, the site should not be located near zones

of igneous or volcanic activity that would jeopardize the ability of the facility to meet performance objectives.

2. Geology

a. Topography; Geologic and Natural Barriers to Surface Water Contamination

Related Existing Requirements: 10 CFR 61.41, 61.44. Applicable prescriptive requirements state that "the disposal site must be generally well drained and free of areas of flooding or frequent ponding. Waste disposal should not take place in a 100 year flood plain, coastal high hazard area or wetland (10 CFR 61.50)". Further, "upstream draining areas must be minimized to decrease the amount of runoff which could erode or inundate waste disposal units". Another prescriptive requirement is related to design (Section 61.51): "surface features must direct surface water drainage away from disposal unit at velocity and gradients which will not result in erosion that will require ongoing active maintenance in the future".

Discussion: These siting requirements reflect the combined factors of precipitation, topography and lithology. Favorable siting characteristics are low precipitation and distance from major lines of drainage. In addition, natural areas of poor drainage could indicate seasonally high ground water levels (itself an undersirable siting characteristic discussed in Section B.2.).

Floods could jeopardize site performance by causing increased leachate formation and accelerated subsurface water flow. Of lesser concern is interference with operations. Falconer, Hull and Mizell (1982) note that "site selection is the most effective way to minimize the possibility of flooding". They identify the following flood hazard areas to avoid: flood plains; regulatory floodways; topographic depressions; coastal low lying areas; and areas within the influence of an existing or potential dam. Guidance in determining areas of 100 year flood plain may be found in Executive Order 11988 (NRC, 1982). Mitigation of flood hazards by engineered barriers is not considered reliable because of the risks associated with failure after the 100 year operating period. Threats are presented down stream by flooding resulting from dam failure and upstream from rises in subsurface water level behind dams. The NRC (1982) concludes that "diversions of perennial streams in most cases would not be acceptable".

Upstream drainage areas should be evaluated to assess the impact of potential land modifications by neighboring users. This assessment takes into consideration land clearing and cultivation, and the development of roads, which may occur after the facility is in operation (NRC, 1982b). Again land use and comprehensive plans will be helpful in this assessment.

The Colorado Geologic Survey (1982) has emphasized in the siting of hazardous waste facilities the evaluation of all perennial and ephemeral streams for potential loss of contain-

ment. The risk of a breach of containment is greatest during the operational period of the site. Periodic flooding such as flash floods from mountain canyons could widely disperse contaminants. The site should optimally have a natural grade elevation above that of the calculated flood water level. At the DOE's Nevada Test Site and the Beatty facility stream flow reportedly occurs only during and immediately after high intensity summer rain storms. The site manager of the DOE shallow land burial facility indicated that arroyos split around the burial site and water was generally channeled away from the disposal units. Apparently, water in Frenchman Lake or nearby playas at the NTS will stand for only a few days or weeks before evaporating. Despite historical evidence that flash flooding is an infrequent event, the DOE built a dike at the site periphery. The limits of engineered flood protections, including the ability of a dike to protect a site over the 500 year design lifetime, remain unknown.

The major reason for siting away from surface water resources is the danger of erosion. Erosion may uncover waste subjecting it to transport, and increasing surface radiation levels above federal limits. Even if the waste is not completely exposed, erosion shortens radionuclide release pathways. Erosion potential cannot be predicted solely on the basis of type, size, and location of surface waters. It is also dependent on the character of the geologic material used to cover the waste, the general topography of the site and its surrounds, land uses adjacent to the disposal site, the

amount of vegetative cover, and intensity of the runoff. It is possible that site operations may significantly alter these erosion rates.

Recommended Standard: The waste disposal facility shall not be located in a coastal high hazard area or wetland, 100 year flood plains, arroyos, dry washes, areas of poor drainage, within the upstream or downstream influence of manmade dams, or regulatory floodways, on the down gradient from mountain canyons where flash flooding is likely to occur, or in an area with conditions that will be conducive to flooding.

b. Geologic and Natural Barriers to Groundwater Contamination

Related Existing Requirements: Performance objectives as outlined in sections 61.41 and 61.44 of 10 CFR 61. Prescriptive requirements in section 61.50 specify that "the disposal site must provide sufficient depth to the water table that groundwater intrusion, perennial or otherwise into the waste will not occur." California Assembly Bill 1513 directs consideration of "geologic and other natural barriers which protect against groundwater contamination."

Discussion: Groundwater contamination receives the major focus in most siting efforts. It has been considered the most probable pathway of nuclide exposure to humans (E.P.A., 1974; Falconer, Hull and Mizell, 1982; Ford, Bacon and Davis, 1981, 1982; NRC, 1982b and c). Thus, site characteristics which impair the movement of nuclides from the waste unit to groundwaters are considered very favorable. These character-

istics are of greatest relevance in locations where meteoric water percolates through the surface and are of minimal importance at more arid sites where input is nil. Water is the major vehicle for transport of nuclide contaminants through earth materials.

Radionuclides may be removed from solution by sorption or precipitation processes. Although the geochemical behavior of nuclides varies, migration rates are largely dependent on sorption capabilities of the geologic medium: particle size distribution; particle surface area; cation exchange capacity; and mineralogy (Falconer, Hull and Mizell, 1982; NRC, 1982b and c). However, if the rate of water movement is fast, as occurs in channelized flow along fractures, joints, faults, and exploratory borings, the contact with retarding medium is minimized. Thus, there is decreased opportunity for binding of cationic nuclides. pH and concentration of dissolved salts can influence nuclide migration by increasing corrosion of containers and decreasing the absorption potential of nuclides for available exchange sites.

The E.P.A. (1974) specifies seventeen parameters for which data are needed to fully characterize the hydrogeologic and hydrochemical nature of a region or a specific site. These data require a two year monitoring commitment and generate a comprehensive hydrologic characterization. Similarly, the U.S. Army Corps of Engineers (NRC, 1982c) has developed a set of parameters to characterize the hydrogeologic setting.

Hydrologic continuity, transmissivity, storativity, porosity, pressure gradient, and dispersivity measurements will allow characterization of the saturated zone.

Perhaps of greater importance to arid site consideration is the comprehensive characterization of the unsaturated zone. Water content, specific retention, suction pressure functions, and permeability functions are important parameters controlling nuclide migration through soil to the aquifer.

Augmented with analysis of the geologic profile (i.e., stratigraphy, structure, lithology, and soils) an overall geologic characterization may be made. This type of analysis would only be performed at the candidate site level in the selection process.

The importance of excavated soil as a backfill material must be analyzed; the compaction and drainage characteristic of the soil covering the waste cell "outweighs the importance of soil as an in situ material outside the trench" (NRC, 1982c).

While conventional thought on migration of radionuclides from disposal trenches focuses on groundwater migration (NRC Draft EIS, 1981), recent research indicates that several other long-term release pathways may be of special concern at arid sites (Hakonson, Cline and Packard, 1982; Hakonson, Martinez and White, 1982; Hakonson, White and DePoorter, 1982). These pathways include biological intrusion into the shallow land burial units by deep-rooted plants and burrowing animals.

Subsequently, mobilization of toxic and radiotoxic materials may occur. Hakonson, Cline and Packard (1982) observe that trench covers are disturbed soil systems which are readily invaded by plants and animals. Of major concern is the influence of biological intrusion on the dynamics of water movement: excess erosion of the trench cover; and excess water percolating into the waste trench. Promising engineering methods for limiting biological intrusion include the use of multilayered rock materials in the trench cover and or chemical toxins (Hakonson, Cline and Packard, 1982; Hakonson, White and Karlen, 1982). While not expected to be constraining on the site selection process, the potential for biological intrusion and the availability of materials for construction of bio-barriers may be particularly important in evaluating site suitability. It would be preferable to avoid the cost of importing special backfill materials to the site. Biological intrusion is worthy of consideration because of its interaction with the major site selection factor, erosion (See Section 2.c.).

In order to minimize the amount of water contacting the containers and wastes, the bottoms of disposal units should be above the saturated and transition zones (Colorado Geologic Survey, 1980; Falconer, Hull and Mizell, 1982). This would limit the wastes to contact with only that portion of the water which infiltrates through the trench cap (NRC, 1982b and c). The present technology utilized at arid shallow land burial facilities is trenches of 16 meter (50 foot) depths.

Therefore, maximum fluctuations of water table and associated capillary fringe should not intrude this lower trench boundary during the 500 year design life of the facility.

Site visits to shallow land burial disposal sites revealed depths to static water table of greater than 575 feet at Beatty, greater than 800 feet at Mercury, and greater than 300 feet at Richland. A perched aquifer exists at the Beatty facility at 375 feet (Clebsch, 1962). The town of Beatty is upgradient from the disposal site, while Mercury is downgradient.

Poor groundwater quality may be an effective screening criteria to minimize conflict with siting near usable supplies. Chem-Nuclear (1982) defines "poor quality" as total dissolved solids (TDS) concentrations exceeding 1,000 parts per million (by weight).

The Colorado Geologic Survey recommends a minimum of 33 meters (100 feet) vertical distance above historical high water table to bottom of the waste trench and also sets a standard of a minimum vertical thickness of 50 meters (150 feet) of undisturbed material with an inplace permeability of no greater than 1×10^{-7} cm/sec (0.1 feet/year) to the nearest (or potential) aquifer. These standards are comparable to vertical distances observed at western arid sites; however, no reliable data exists on permeability at these operating sites.

The dry disposal technology typical of the proposed design of the interim treatment/storage facility is completely above the

natural grade of the site. Therefore, requirements of unsaturated zone depth are not appropriate. Siting criteria for the interim facility probably need not be concerned with depth-to-water table constraints.

Recommended Standards: A suitable site must meet the following general hydrologic criteria:

(1) maximum fluctuations of the water table and associated capillary fringe should not intrude the proposed lower boundary of disposal units (16m);

(2) the hydrologic setting of the proposed site should be fully characterizable and characterized according to methods presented in NRC (1982c) and EPA (1974);

(3) the disposal site should not be located where it would degrade groundwater quality; and

(4) excavated soil shall be evaluated for appropriateness as backfill and trench cap material.

Related Existing Requirements: 10 CFR 61.50 specifies avoidance of areas where surface geologic processes such as "mass wasting, erosion, slumping, landsliding, or weathering occur with such frequency and extent to significantly affect the ability of the disposal site to meet the performance objectives".

Discussion: The performance capabilities of a shallow land burial facility may be reduced by removal of trench cover material by erosion processes. Falconer, Hull and Mizell (1982) observe that exposed waste is more susceptible to

transport, and that erosion of cover can shorten migration pathways and increase surface radiation levels. Further, increased infiltration of meteoric water into the emplaced waste may occur.

There are two types of erosion: (1) surface erosion from the slow entrainment of soil particles by surface water runoff and wind, and (2) gully erosion resulting from the rapid movement of water such as the migration of channels and shorelines.

The most important determinant of surface erosion is moisture availability (Falconer, Hull, and Mizell, 1982). If precipitation is low, plant cover may be sparse and soil cohesiveness may be reduced. These conditions, typical of arid sites, enhance the potential for wind erosion. Wind erosion rates are also affected by soil particle size, ground surface roughness, wind velocity, surface topography, and vegetation (Falconer, Hull and Mizell, 1982).

As soil moisture input increases, soil cohesiveness increases and wind erosion rates drop off. However erosion by surface water runoff increases. Raindrop impact may loosen soil particles, which are subsequently transported overland in sheets and rills. Erosion rates are determined by the intensity and tempral distribution of rainfall, physical characteristics of the soil, the length and steepness of slopes, and the vegetative cover.

To minimize sheet and rill and gully erosion, it may be preferrable to site a shallow land burial facility on uniform and gently sloping terrain. This preference must be balanced against flooding and ponding concerns of topography (see Section 2.a.). Overall erosion threats to performance might be minimized by siting in areas of net deposition (EPRI 1982).

Erosion by gullies, migration of channels and shorelines threaten performance. Erosion rates by these processes are affected by topography, physical characteristics of soil, volume of runoff, and wave action (Falconer, Hull and Mizell 1982). Erosion rates by these mechanisms are also influenced by adjacent land use.

Estimates of erosion rates should recognize the disturbed nature of the backfill and trench cover and the impacts of facility operations on plant cover.

c. Erosion

Recommended Standard: Areas where wind or water erosion processes may present a significant potential to jeopardize facility performance should be avoided.

3. Climate/Meteorology

Related Existing Requirements: 10 CFR 61.41, 61.43 and 61.44. No prescriptive requirements are outlined in either 10 CFR 61 or California Assembly Bill 1513 for this factor.

Discussion: The following meterologic considerations are important to siting: (1) wind direction, frequency, and proximity to popula-

tions; (2) amount of rainfall and evaporation; (3) frequency of extreme weather events.

These weather factors determine the risk of both air and water-borne nuclide transport to adjacent population centers, the moisture conditions of the site, and the facility operability throughout the year.

The greatest probability for accidential release of nuclides exists during the operational phase of the facility. After the disposal unit is closed surface weather patterns would be expected to have very little influence on the waste if percolation does not reach the emplaced waste (i.e., arid site conditions). Therefore maximum storm frequency is an important concern to the disposal unit during the operational phase. Twenty-four hour and fifty-year maximum anticipated storm conditions and historical records of large storm effects should be considered in site characterization.

If waste treatment processes are to be performed at the site, the potential for discharge and transport would have to be evaluated.

Absolute rainfall and absolute evaporation are not themselves criteria for site selection. Climatological characteristics of the site closely interact in a complicated manner with geologic features to yield a "moisture quality" for the site. An indicator of site moisture quality may be derived from the ratio of evaporation to precipitation. Humid sites are defined by a ratio of

less than 1, semi-arid sites between 1 and 2, and an arid site as greater than 2 (Ford, Bacon and Davis, 1981). For example, the Nevada Test Site where the DOE shallow burial facility is located averages less than 130 millimeters (5 inches) of rainfall per year, and experiences an annual lake evaporation of 1600 millimeters (63 inches) per year to yield an evaporation to precipitation ratio of more than 12 (Ford, Bacon and Davis, 1982). The time distribution of meteoric water (i.e., frequency and intensity) is such that there is very little penetration of surface water at this site.

Studies have identified other harsh weather patterns that jeopardize uninterrupted waste disposal operations throughout the year: frequent high winds; frequent thunder showers; snow accumulation; severe heat or cold; and, severe snow storms. Ford, Bacon and Davis (1981) offered an acceptability standard of 200 working days per year as indicated by U.S. Weather Service records. The main concern of this criterion is operability, but safety in transport of the waste to the site is an additional rationale. Sites should be located in regions with good road weather conditions throughout most of the year. Special threats to safe operations should be evaluated; for example, an arid site may be prone to high winds and sand storms.

The above ground exposure of the proposed interim treatment/storage facility may increase the relative importance of extreme weather events (e.g., tornadoes, high straightline winds) in site selection.

Recommended Standard: A semi-arid to arid climate is optimal for siting. The site should demonstrate a low frequency of extreme weather events during the short-term to ensure site operation integrity.

C. Characterizability, Modelability and Monitorability

Related Existing Requirements: Performance objectives as outlined in 10 CFR 61.40, 61.41, and 61.44. No specific performance objectives are outlined in California Assembly Bill 1513. Prescriptive requirements outlined in 10 CFR 61.50 specify that "the disposal site shall be capable of being characterized, modeled, analyzed, and monitored" directs avoidance of areas "where tectonic processes such as faulting, folding, seismic activity or vulcanism may occur with such frequency and extent to affect the ability of the disposal site to meet the performance objectives".

Discussion: An appropriate site is one that is of simple physical structure. Anomalies in geology, hydrology, or meteorology make site characterization more difficult, decrease confidence in performance prediction by modeling efforts, and increase monitoring requirements. The prescriptive requirement delineated in 10 CFR 61.50 is intended to ensure site location where physical conditions allow reliable and valid performance prediction.

Subsurface geologic structures may be deformed by folding (reflexing of rock zones), faulting (fracturing of rock zones with relative displacement), and jointing (fracturing without relative displacement). Any of these conditions can provide increased hydraulic conductivity, that is, they provide pathways to groundwater movement (Falconer,

Hull and Mizell, 1982; Ford, Bacon and Davis, 1981, 1982). In addition, some faults act as barriers to groundwater flows--effectively damming movement. Areas of highly folded, jointed, or faulted rock should be avoided because of the difficulty of analyzing and predicting nuclide migration. Complex structural factors such as these will generally preclude the prediction of nuclide migration under the modelability requirement. If a site is to be characterized and its performance predicted with a reasonable amount of certainty by modeling methods, the proposed site must be of simple geology and hydrology. Site characterization and monitoring programs can sample only a small fraction of the disposal site surface and subsurface environment (NRC, 1982b).

Similarly, artesian springs, subsurface channelized flow patterns, cavernous flows, or geothermal processes decrease certainty of prediction. Complex meteorological events such as high winds of variable direction and intensity also decrease confidence in the prediction of overall site performance.

The presence of naturally occurring or manmade background radiation sources could complicate monitoring efforts at the site. Nearby ores or mill tailings, airborne drifts from cooling water towers or other industrial entities or ajacent hazardous waste disposal facilities could impair early detection of disposal unit leakage. The effect of these releases on a monitoring program could be minimized by a preoperational and operational background radiation survey (NRC, 1982b; Eugene Kendall, Reeco, personal communication). Confounding of monitoring programs will occur for select isotopes only; most insti-

tutional wastes will show a distinctive isotope mix. Monitoring must provide for identification and differentiation between the releases of separate facilities. The influence of urban area background radiation (e.g., disposal facilities located close to industries that use radioactive isotopes) must be considered.

Recommended Standard: The natural attributes of the site shall allow full characterization, modeling, monitoring, and analysis of geologic, meteorologic, hydrologic, and radiologic factors.

D. Infrastructure Requirements

1. Energy and Natural Resources Needs of the Facility

Related Existing Requirements: No specific performance objectives or prescriptive requirements are outlined in either 10 CFR 61 or California Assembly Bill 1513.

Discussion: The water, power, and sewer needs of a low-level waste disposal facility are similar to those required of a warehouse operation. Electricity demands are minimal at a site used only for disposal. Electrical usage would be greater at a facility that also treated waste such as for reduction through shredding, compaction and incineration. If greater confinement disposal techniques are to be performed at the site, an electrical off-loading gantry crane may be needed to facilitate handling and decrease occupational exposures (Ford, Bacon and Davis, 1982). Therefore the co-siting of a treatment facility would have larger power needs. Most electrical motors used in industrial applications of this type require 3-phase 240 volt power.

Potable water needs are nominal, and can be met by imported water. Treatment, decontamination and fire protection require industrial quality water which should be available on site.

Energy requirements must be viewed in the shorter rather than the longer term. If the site is stable at closure energy needs terminate.

Suitable fill and trench cover materials are needed. The excavated fill may not possess the consolidation or cohesive qualities appropriate for back fill for trench capping; acquisition of trench capping soil from adjacent areas would then be required.

Recommended Standard: The facility should be located where electrical power and water are accessible.

2. Security, Fire Protection, and Housing Needs of the Facility

Related Existing Requirements: No specific objective or prescriptive requirements are outlined in 10 CFR 61 or California Assembly Bill 1513 for these factors.

Discussion: The support services required by a low-level waste disposal facility are generally no greater than those required by a typical chemical warehouse operation. Security, fire protection, and housing needs are also nominal. Existing commercial sites have agreements with local peace keeping authorities for security patrols of the facility during nonoperational hours. In these remote locations incidence of breaches of security has been nil. Fires can occur in disposal operations. Site workers are trained in fire fighting methods and are able to extinguish small fires

and fires in an incipient stages, but professional fire fighters should be able to reach the site quickly in the event of a major fire. Proximity to urban centers would facilitate a quick response.

Because of the low manpower requirements of a disposal facility, the operation is not anticipated to pose a burdensome housing demand on adjacent communities.

Recommended Standards: The low-level waste disposal facility should not be located so remotely as to impair the administration of security and fire services. Housing needs of the employees of the site should be considered judging site suitability.

E. Waste: Site Interactions

Related Existing Requirements: No performance objectives or prescriptive requirements are specified in California Assembly Bill 1513.

Discussion: Waste classification elements important to the siting process include toxicity, persistence, mobility, volume, and points of generation. The persistence of the radiological hazard is predictable based on the half life of the radioactive materials. These elements determine the physical degree of isolation required, and influence the economics of site location. 10CFR61 prescribes a 500 year lifetime design basis for Shallow Land Burial sites.

The waste container is the first barrier to waste migration. Availability for transport is greatly influenced by this first barrier. In general, containers are only designed to provide containment during transport and emplacement. A secondary factor in mobility is

the waste form of the material. Container integrity and waste form will determine the rate which toxic materials might enter a transport pathway. If the container should remain intact there will be no release of waste and the radiological hazard will decrease as the waste decays in place. When the container is breached, the waste form will determine the rate of leaching or diffusion to the surrounding area. The hazard posed to an inadvertent intruder or adjacent land user is determined by the physical transport pathway and the route of exposure.

A 500 year design basis lifetime for the facility dictates that to meet performance objectives, events which could threaten the integrity of the disposal unit must not occur within the 500 year lifetime. The frequency of occurrence for geological and meteorologic hazards must meet this probabilistic threshold. As outlined in 10 CFR 61 institutional controls must remain in effect at the waste facility for 100 years. This time period of strict site control and maintenance is aimed at meeting performance objectives during the period in which the waste is most hazardous.

Site capacity would be largely determined by the volumes of waste generated in the desired operation lifetime of the facility. The potential service area of the site must be inventoried.

Recommended Standard: The disposal site should be able to meet the performance objectives outlined in 10 CFR 61 throughout the projected 500 year hazardous interval of the waste. The selected site must be able to meet the volume requirements predicted for the facility service life.

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APPENDIX C

ANALYSIS OF INTERIM STORAGE REQUIREMENTS AND COSTS

Basic Assumption

In addressing the problem of interim waste storage, it was postulated that the waste would be divided into three categories:

1) Unstable waste which could not be stored without treatment,
2) Stable "low-level" waste needing no additional processing or shielding,
3) Intermediate-level waste requiring external shielding (e.g., reactor resins).

The nature of the storage facilities and their costs are derived from this classification scheme and the data provided by our licensees' responses to our survey.

The following outlines: a) the structural requirements and costs for a facility storing only stable waste, b) the cost of a co-located treatment facility for biologically or chemically unstable low-level waste and c) a co-located/shielded structure capable of safely storing "intermediate-level" waste.

Low-Level Waste Storage Building

(1) Design Concept

A design similar to that described in EG&G, Idaho, Inc.'s report, "The Conceptual Report for Regional Low-Level Waste Interim Storage Site", was selected. The concept would have,

within a controlled area, a central receiving facility supporting a series of warehouses for storage of received wastes. Each warehouse is designed to accomodate the waste generated by California's licensees in a year. Such wastes are presumed to be packaged in 55 gallon drums, placed four on a pallet, and stacked three pallets high. Aisles between the stacks will be wide enough to accomodate a forklift to be used for waste handling.

It is planned that the staff will maintain surveillance over the stacked drums and be prepared to remove and repackage any containers which begin to fail.

(2) Description of Low-Level Waste Storage Buildings

The buildings would be a prefabricated steel structure bolted to a concrete base, with a half wall of concrete to limit forklift damage to the walls. In addition, this wall would contain leakage from improperly packaged drums or water which might be used in putting out a fire in a warehouse. Floor drains have been provided in each warehouse. These drains are connected to a sump where contaminated waste water could be collected and treated for packaging and storage.

The Space Management Division of the California Department of General Services has provided drawings of the proposed Interim Storage Facility (Figures 1-A, 1-B, and 1-C).

(3) Costs of Low-Level Waste Storage Building and Associated Facilities and Equipment

A five-year sheet metal facility is estimated to cost approximately $10,000,000. (If concrete buildings are used the cost will be $19,000,000). It is anticipated that the storage facilities would be built a year at a time, with no unnecessary warehousing space to be standing idle.

A summary of the total cost and a breakdown of the total cost and the incremental costs of building warehouses sequentially for five years are shown in Tables I and II. These are based on 1985 dollars.

(4) Decontamination and Decommissioning Costs

The estimated cost for cleaning the interim storage facility to a level suitable for unconditional use is $387,440.

TABLE I

Total Projected Costs for a Five Year Complete Interim Waste Storage Facility

(1)	Low-Level Waste Storage Buildings	
	a. Construction Costs	$10,095,097
	b. Equipment Costs	117,888
	c. Decontamination Costs	387,440
		$10,600,425
(2)	Intermediate-Level Waste Storage Buildings	
	a. Construction Costs	$ 5,000,000
	b. Decontamination Costs	860,000
		$ 5,860,000
(3)	Waste Incinerator	
	a. Construction Costs	$ 1,913,630
	b. Decontamination Costs	5,000
	c. Natural Gas @ $57,000/yr.	285,000
		$ 2,203,630
(4)	Special Projects Area	
	a. Construction Costs	$ 174,240
	b. Decontamination Costs	5,000
		$ 179,240
	TOTAL ESTIMATED COSTS:	$18,843,295

TABLE II

Cost Facility Breakdown

Low-Level Waste Interim Storage

(1)	Land Cost (35 acres)		$ Unknown
(2)	Road Way - @ $4.00 ft.^{2}		Unknown
(3)	General Cost		
	a. site improvements		200,000.00
	b. fence		55,000.00
	c. septic tank		10,000.00
	d. security system		130,000.00
	e. exterior lighting		10,000.00
	f. transformer		16,000.00
	g. emergency generator		10,000.00
	h. miscellaneous		10,000.00
	i. ditch and pound		20,000.00
(4)	Adm. & Receiving Bldg.		464,000.00
(5)	Equipment (forklift trucks, scale, furniture, etc.)		300,000.00
(6)	Sub-Total (#3, 4, and 5 only)		1,225,000.00
(7)	Storage Bldg. (metal bldg.) (5 total @ 96,860 sq. ft. each)		
	Build One Building Per Year		
	1st year	$1,452,900.00	
	2nd year	1,598,190.00	(10% inflation factor)
	3rd year	1,758,009.00	(10% inflation factor)
	4th year	1,933,809.00	(10% inflation factor)
	5th year	2,127,189.00	(10% inflation factor)
	Sub-Total		$ 8,870,097.00
	Total Cost (without land & roadway)		$10,095,097.00 *

* 1985 dollars.

(5) Personnel Costs

The projected personnel requirements for the facility are 14 full-time employees. The cost for staffing is $319,019 per year.

TABLE III

Personnel Costs for a Low-Level Waste Facility

State equivalents/all calculations are 1st step - 1982 salary schedule.	Annual Cost*
1. 3 forklift/crane operators Warehouse Worker $1,322 - 1,437/mo.	$ 47,592
2. 3 radiation monitors Assistant Health Physicist $1,848 - 2,226/mo.	66,528
3. 3 security personnel Security Guard $1,014 - 1,175/mo.	36,504
4. 2 laborers Skilled Laborer $1,437 - 1,572/mo.	34,488
5. 1 record keeper Office Assistant II $989 - 1,145/mo.	11,868
6. 1 secretary Secretary $1,166 - 1,372/mo.	13,992
7. 1 supervisor Health Physics Supervisor $2,814 - 3,398/mo.	33,768
14 Total	$244,740
Fringe Benefits 30.35%	74,279
Total Personnel Costs:	$319,019

* 1982

Intermediate-Level Waste Storage Building

(1) Justification

An analysis and cost estimate for a shielded storage facility as an added feature to the low-level facility has been made at the request of the waste generators. While some of these generators could probably resolve their own intermediate waste problems, a statewide facility should be considered.

(2) Description of Intermediate-Level Waste Storage Building

The facility would be designed to provide storage for waste requiring radiation shielding. The design is based closely on that developed for SMUD's Rancho Seco plant. This design is a partially buried facility which utilizes internal shielded cells for additional radiation protection.

(3) Costs for Intermediate-Level Waste Storage

The estimated costs for a basic facility capable of storing one year's waste, the waste generated by operating nuclear power plants, would be $5,000,000. This includes the cost of a special bridge crane for lifting the heavy shielded casks and internal shielding cell lids.

(4) Personnel Costs

No additional personnel are presumed needed to operate the intermediate facility if it is co-located with the basic low-level facility.

(5) Decontamination and Decommissioning Costs

These costs are difficult to predict but could be as high as $860,000. Because of the heavy concrete walls, this facility could not be easily dismantled. It could, however, be sold for use as a factory or warehouse.

Waste Incinerator

(1) Justification

In the rough classification scheme, we identified that certain wastes were considered unstable and, therefore, could not be safely stored in the low-level waste facility without treatment. The most effective treatment mode for these wastes appears to be incineration. Therefore, in order that the entire waste stream of the state be accomodated, it is necessary that an incinerator be available in support of an interim storage facility.

(2) Description of a Waste Incinerator

The incinerator is a packaged, free-standing unit not requiring an additional building. The proposed unit is a 750 pound per hour unit with automated ash ejection and stack emission control equipment.

(3) Costs for a Waste Incinerator with Stack Emission Control

The projected cost for this facility is $1,913,630 and is detailed in Table IV.

(4) Operational Costs for a Waste Incinerator

The projected costs for the personnel are $65,789 per year. The fuel cost is estimated to be $57,000 per year for natural gas.

(5) Decontamination and Decommissioning Costs

These costs cannot be estimated with any degree of accuracy. They will vary with the level of contamination. For planning purposes, a figure of $5,000 has been used.

Special Projects Area for Low-Level Waste

(1) Justification

Occasionally unusual problems are encountered by the waste generators which result in large volumes of very low activity waste not needing a protective storage structure. Decommissioning of a research laboratory could create such waste. A one acre asphalt pad will be provided on site for storage of such unanticipated very low level waste.

(2) Costs

The construction costs for the pad is estimated at $174,240.

(3) Decontamination and Decommissioning Costs

The cost of pad removal is estimated at $5,000, should it become unacceptably contaminated.

TABLE IV

Radioactive Waste Incinerator Costs

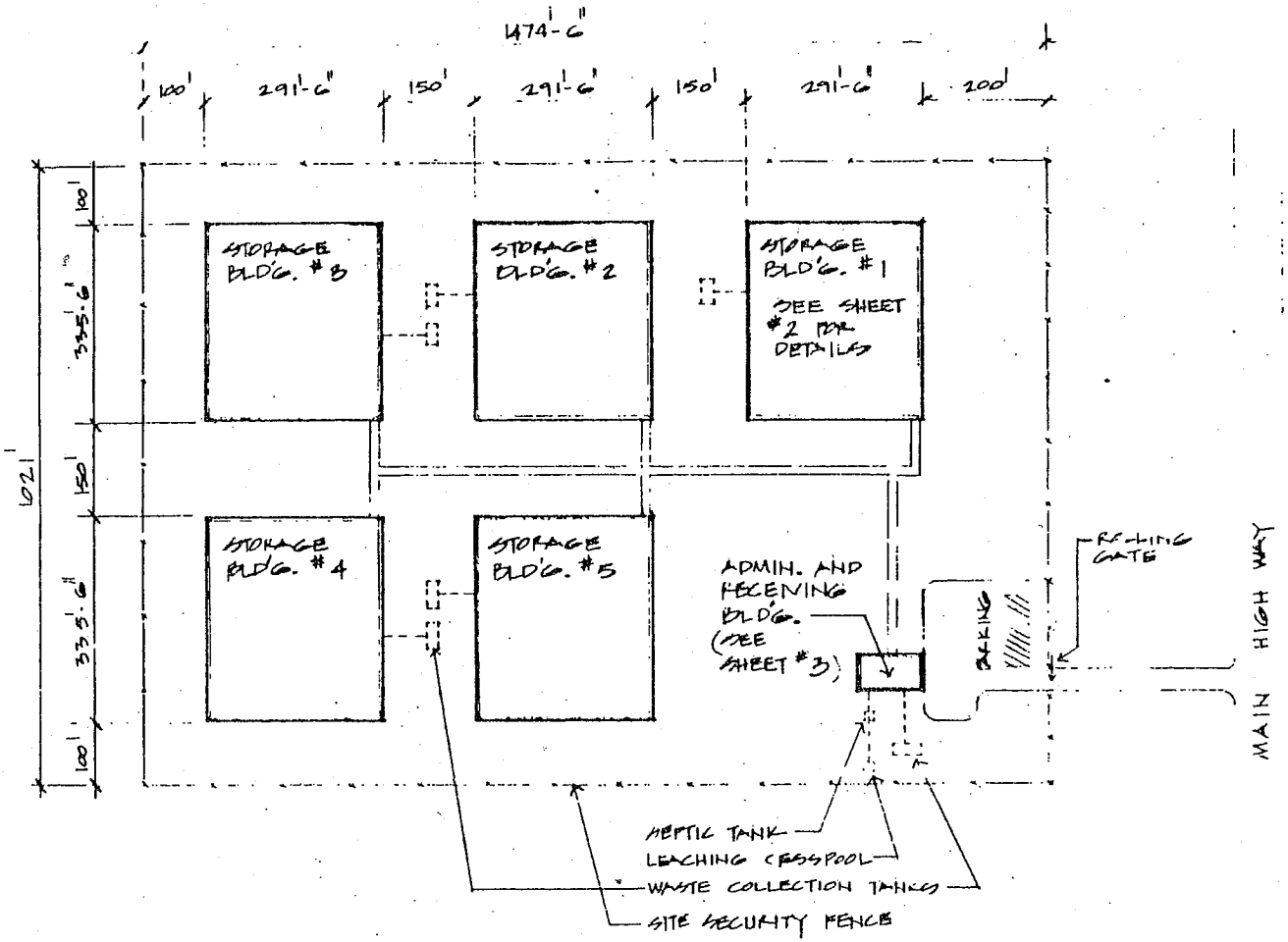
Incinerator Model 750 T Dual fuel designed	$ 82,640
Pathological waste adapted	8,095
Stack	6,035
Air and fuel modulator	4,860
Scrubber and filter	1,000,000
Special loader	22,000
Automatic wet ash removal	30,000
Waste liquid injection system	10,000
Bitumen mix system	750,000
	$1,913,630

COST TO USERS OF THE FACILITY

Radioactive waste generators are presently paying $18.15 per cubic foot for radioactive waste delivered at the Washington burial site. Since the proposed California facility is designated as an interim low-level radioactive waste storage facility, it is expected that stored radioactive waste will be transferred to a permanent burial site within seven years of commencing operation (Section 25813(f), AB 1513). Therefore, a base charge of $18.15 should be levied for each cubic foot stored. In addition to the initial charge of $18.15, a charge of $20.00 per drum of stored waste (failure fee @ $2.72/ft^3) should be levied to cover the cost for repackaging an expected 10% of the stored containers. If the waste generators are expected to cover the construction and operational costs, an additional fee of between $22.00 and $15.00 per cubic foot should be levied, depending upon the type of facility approved. The costs for decontamination and decommissioning would be expected to amount to about a dollar per cubic foot of waste stored. The estimated total cost in 1982 dollars to radioactive waste generators is:

	Per Cubic Foot Costs
Burial Fee	$18.15
Failure Fee	2.72
Operational Charge	15.56
Decommissioning Fee	1.00
TOTAL COST:	$37.33

Interim Storage Facility
Low Level Radioactive Waste



NOTES:

EACH OF THE STORAGE BLDG. WILL HAVE THE FOLLOWING ITEMS.

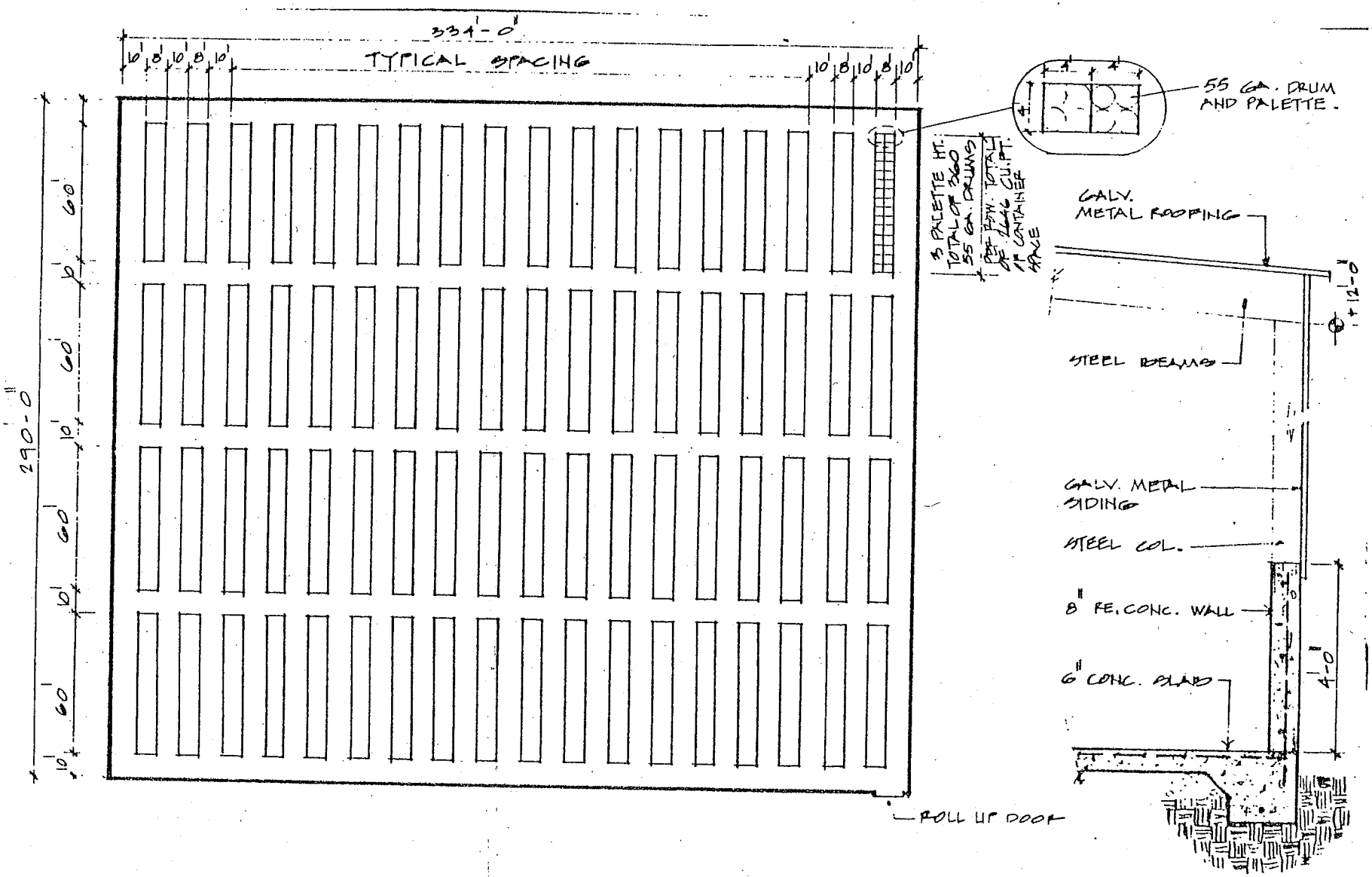
- UNISEX TOILET RM.
- SKY LIGHTS
- GRAVITY VENTS
- SMOKE ALARMS
- FIRE EXTINGUISHERS
- EXTERIOR AREA LIGHTING.
- SECURITY ALARM

PROPOSED PLOT PLAN

SCALE: 1" = 200'-0"

APPROXIMATE 35 AC. WITHIN THE FENCE AREA

Interim Storage Facility
Low Level Radioactive Waste



PROPOSED STORAGE BLD'G. FLOOR PLAN

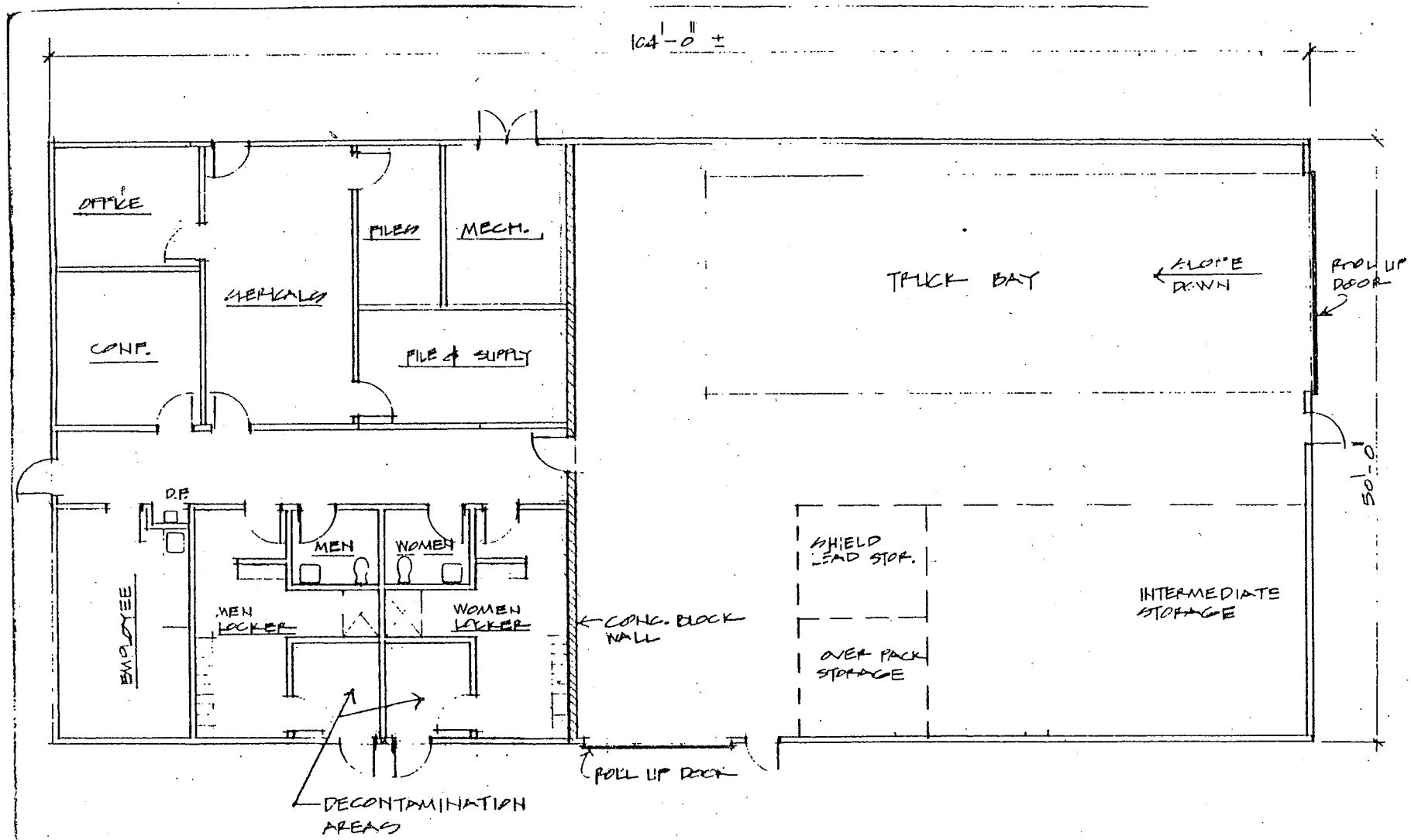
SCALE: 1" = 40'-0"

BLD'G. TOTAL 96860 SQ.FT. NET
CONTAINER STORAGE CAPACITY 110,512 CU.FT

TYP. SECTION

½" = 1'-0"

Interim Storage Facility
Low Level Radioactive Waste



PROPOSED FLOOR PLAN FOR RECEIVING AND ADMIN. BLDG.

TOTAL 5200 SQ. FT.

1/8" = 1'-0"

10 CFR 61 DRAFT 05/19/82

§61.55 WASTE CLASSIFICATION

(a) Classification of waste for near surface disposal.

(1) Considerations. Determination of the classification of radioactive waste involves two considerations. First, consideration must be given to the concentration of long-lived radionuclides (and their shorter-lived precursors) whose potential hazard will persist long after such precautions as institutional controls, improved waste form, and deeper disposal have ceased to be effective. These precautions delay the time when long-lived radionuclides could cause exposures. In addition, the magnitude of the potential dose is limited by the concentration and availability of the radionuclide at the time of exposure. Second, consideration must be given to the concentration of shorter-lived radionuclides for which requirements on institutional controls, waste form, and disposal methods are effective.

(2) Classes of waste.

(i) Class A waste is waste that is segregated from other waste classes at the disposal site. The physical form and characteristics of Class A waste must meet the minimum requirements set forth in §61.56(a). If Class A waste also meets the stability requirements set forth in §61.56(b), it is not necessary to segregate the waste for disposal.

(ii) Class B waste is waste that must meet more rigorous requirements on waste form to ensure stability after disposal. The physical form and characteristics of Class B waste must meet both the minimum and stability requirements set forth in §61.56.

(iii) Class C waste is waste that not only must meet more rigorous requirements on waste form to ensure stability but also requires additional measures at the disposal facility to protect against inadvertent intrusion. The physical form and characteristics of Class C waste must meet both the minimum and stability requirements set forth in §61.56.

(iv) Waste that is not generally acceptable for near-surface disposal is waste for which waste form and disposal methods must be different, and in general more stringent, than those specified for Class C waste. In the absence of specific requirements in this part, proposals for disposal of this waste may be submitted to the Commission for approval, pursuant to §61.58 of this part.

(3) Classification determined by long-lived radionuclides. If radioactive waste contains only radionuclides listed in Table 1, classification shall be determined as follows:

(i) If the concentration does not exceed 0.1 times the value in Table 1, the waste is Class A.

(ii) If the concentration exceeds 0.1 times the value in Table 1, the waste is Class C.

(iii) If the concentration exceeds the value in Table 1, the waste is not generally acceptable for near-surface disposal.

(iv) For wastes containing mixtures of radionuclides listed in Table 1, the total concentration shall be determined by the sum of fractions rule described in paragraph (a)(7) of this section.

TABLE 1

Radionuclide	Concentration Curies/cubic meter
C-14	8
C-14 in activated metal	80
Ni-59 in activated metal	220
Nb-94 in activated metal	0.2
Tc-99	3
I-129	0.08
Alpha emitting transuranic nuclides with half-life greater than five years	100*
Pu-241	3,500*
Cm-242	20,000*

*Units are nanocuries per gram

(4) Classification determined by short-lived radionuclides. If radioactive waste does not contain any of the radionuclides listed in Table 1, classification shall be determined based on the concentrations shown in Table 2. If a nuclide is not listed in Table 2, it does not need to be considered in determining the waste class.

(i) If the concentration does not exceed the value in Column 1, the waste is Class A.

(ii) If the concentration exceeds the value in Column 1, but does not exceed the value in Column 2, the waste is Class B.

(iii) If the concentration exceeds the value in Column 2, but does not exceed the value in Column 3, the waste is Class C.

(iv) If the concentration exceeds the value in Column 3, the waste is not generally acceptable for near-surface disposal.

(v) For wastes containing mixtures of the nuclides listed in Table 2, the total concentration shall be determined by the sum of fractions rule described in paragraph (a)(7) of this section.

TABLE 2

Radionuclide	Concentration, Curies/cubic meter Column 1	Column 2	Column 3
Total of all nuclides with less than 5 year half life	700	**	**
H-3	40	**	**
Co-60	700	**	**
Ni-63	3.5	70	700
Ni-63 in activated metal	35	700	7000
Sr-90	0.04	150	7000
Cs-137	1	44	4600

**There are no limits established for these radionuclides in Class B or C wastes. Practical considerations such as the effects of external radiation and internal heat generation on transportation, handling and disposal will limit the concentrations for these wastes. These wastes shall be Class B unless the concentrations of other nuclides in Table 2 determine the waste to be Class C independent of these nuclides.

(5) Classification determined by both long- and short-lived radionuclides. If radioactive waste contains a mixture of radionuclides some of which are listed in Table 1, and some of which are listed in Table 2, classification shall be determined as follows:

(i) If the concentration of a nuclide listed in Table 1 is less than 0.1 times the value listed in Table 1, the class shall be that determined by the concentration of nuclides in Table 2.

(ii) If the concentration of a nuclide listed in Table 1 exceeds 0.1 times the value listed in Table 1, the waste shall be Class C, provided the concentration of nuclides listed in Table 2 does not exceed the value shown in Column 3 of Table 2.

(6) Classification of wastes with radionuclides other than those listed in Tables 1 and 2. If radioactive waste does not contain any nuclides listed in either Table 1 or 2, it is Class A.

(7) The sum of the fractions rule for mixtures of radionuclides. For determining classification for waste that contains a mixture of radionuclides, it is necessary to determine the sume of fractions by dividing each nuclide's concentration by the appropriate limit and adding the resulting values. The appropriate limits must all be taken from the same column of the same table. The sum of the fractions for the column must be less than 1.0 if the waste class is to be determined by the column. Example: A waste contains Sr-90 in a concentration of 50 Ci/m^3 and Cs-137 in a concentration of 22 Ci/m^3. Since the concentrations both exceed the values in Column 1, Table 2, they must be compared to Column 2 values. For Sr-90 fraction, 50/150 = 0.33; for Cs-137 fraction, 22/44 = 0.5; the sum of the fractions = 0.83. Since the sum is less than 1.0, the waste is Class B.

(8) Determination of concentrations in wastes. The concentration of a radionuclide may be determined by indirect methods such as use of scaling factors which relate the inferred concentration of one radionuclide to another that is measured, or radionuclide material accountability, if there is reasonable assurance that the indirect methods can be correlated with actual measurements. The concentration of a radionuclide may be averaged over the volume of the waste, or weight of the waste if the units are expressed as nanocuries per gram.

§61.56 WASTE CHARACTERISTICS

(a) The following requirements are minimum requirements for all classes of waste and are intended to facilitate handling at the disposal site and provide protection of health and safety of personnel at the disposal site.

(1) Wastes must not be packaged for disposal in cardboard or fiberboard boxes.

(2) Liquid(s) waste must be packaged in sufficient absorbent material to absorb twice the volume of the liquid. §6

(3) Solid wastes containing liquid shall contain as little free-standing and noncorrosive liquid as is reasonably achievable, but in no case shall the liquid exceed 1% of the volume.

(4) Waste must not be readily capable of detonation or of explosive decomposition or reaction at normal pressures and temperatures, or of explosive reaction with water. §6

(5) Waste must not contain, or be capable of generating, quantities of toxic gases, vapors, or fumes harmful to persons transporting, handling, or disposing of the waste. This does not apply to radioactive gaseous waste packaged in accordance with paragraph (a)(7) of this section.

(6) Wastes must not be pyrophoric. Pyrophoric materials contained in wastes shall be treated, prepared, and packaged to be nonflammable.

(7) Wastes in a gaseous form must be packaged at a pressure that does not exceed 1.5 atmospheres at 20°C. Total activity must not exceed 100 curies per container.

(8) Wastes containing hazardous, biological, pathogenic, or infectious material must be treated to reduce to the maximum extent practicable the potential hazard from the non-radiological materials.

(b) The requirements in this section are intended to provide stability of the waste. Stability is intended to ensure that the waste does not degrade and affect overall stability of the site through slumping, collapse, or other failure of the disposal unit and thereby lead to water infiltration. Stability is also a factor in limiting exposure to an inadvertent intruder, since it provides a recognizable and nondispersible waste.

(1) Waste must have structural stability. A structurally stable waste form will generally maintain its physical dimensions and its form, under the expected disposal conditions such as weight of overburden and compaction equipment, the presence of moisture, and microbial activity, and internal factors such as radiation effects and chemical changes. Structural stability can be provided by the waste form itself, processing the waste to a stable form, or placing the waste in a disposal container or structure that provides stability after disposal.

(2) Notwithstanding the provisions in §§61.56(a)(2) and (3), liquid wastes, or wastes containing liquid, must be converted into a form that contains as little free-standing and noncorrosive liquid as is reasonably achievable, but in no case shall the liquid exceed 1% of the volume of the waste when the waste is in a disposal container designed to ensure stability, or 0.5% of the volume of the waste for waste processed to a stable form.

(3) Void spaces within the waste and between the waste and its package must be reduced to the extent practicable.

§61.57 LABELING

Each package of waste must be clearly labeled to identify whether it is Class A waste, Class B waste, or Class C waste, in accordance with §61.55.

§61.58 ALTERNATIVE REQUIREMENTS FOR WASTE CLASSIFICATION AND CHARACTERISTICS

The Commission may, upon request or on its own initiative, authorize other provisions for the classification and characteristics of waste on a specific basis, if, after evaluation, of the specific characteristics of the waste, disposal site, and method of disposal, it finds reasonable assurance of compliance with the performance objectives in Subpart C of this part.

Assembly Bill No. 1513

CHAPTER 95

An act to amend Section 25805 of, to add Sections 25811.5, 25813, and 25814 to, to add and repeal Section 25811.7 of, and to repeal Section 25813 of, the Health and Safety Code, relating to low-level nuclear waste, and declaring the urgency thereof, to take effect immediately.

[Approved by Governor March 2, 1982. Filed with Secretary of State March 2, 1982.]

LEGISLATIVE COUNSEL'S DIGEST

AB 1513, Torres. Radioactive waste.

(1) Under the existing Radiation Control Law, the State Department of Health Services is the designated agency responsible for the issuance of licenses and is charged with performing several functions with regard to protecting the public health and safety.

This bill would make several legislative findings with regard to the safe disposal of low-level radioactive waste, as defined; would require the department to develop an overall plan for the management, treatment, and disposal of low-level radioactive waste including, among other things, specific contingency plans to address the needs of the state for the short-term storage of low-level radioactive waste and the development of a classification scheme for separating low-level waste from other waste to facilitate its disposal; would permit the department to establish and operate, or contract for the establishment and operation of, low-level radioactive waste interim storage facilities once the department has prepared the above described contingency plans and classification scheme and the Legislature enacts enabling statutory provisions authorizing the department to establish interim storage facilities; and would require the State Director of Health Services to appoint an advisory committee to advise the department regarding such matters.

Existing law authorizes the department to adopt a schedule of fees to be paid by applicants for the licensing of radioactive materials and of devices and equipment utilizing those materials.

The bill would authorize the department to levy additional fees, not to exceed a specified amount, upon California generators of low-level radioactive waste to support various activities imposed on the department by the bill.

(2) The bill would take effect immediately as an urgency statute.

The people of the State of California do enact as follows:

SECTION 1. The Legislature finds and declares that without means for adequate, safe disposal of low-level radioactive waste,

medical, industrial, and other operations which contribute to the health and safety of the people of California as well as to the state economy, may be seriously impaired. For this reason the Legislature finds and declares that the State of California must develop plans to address the issues surrounding the long-range management, treatment, and disposal of low-level radioactive waste generated by licensed users of radioactive material within the state.

The Legislature further finds and declares that the impact of the generation and disposal of low-level radioactive waste upon the environment and the public health and safety must be minimized. To this end, the state must consider developing mechanisms to reduce the potential for adverse environmental and health effects related to low-level radioactive waste, including, but not limited to, reduction of volume, reduction of total amount produced, reactivity, and chemical and radionuclide toxicity of low-level radioactive waste.

The Legislature further finds and declares that any long-range program for the management and disposal of low-level radioactive waste must incorporate integrated efforts that collectively:

(a) Assess the potential for, and effects of, and, if feasible, recommend methods of volume and source reduction.

(b) Develop specific plans for an interim low-level radioactive waste storage facility.

(c) Develop procedures for the segregation and classification of low-level radioactive waste according to treatment and disposal options.

(d) Develop criteria for the possible siting of treatment facilities and disposal facilities within the state.

SEC. 2. Section 25805 of the Health and Safety Code is amended to read:

25805. As used in this chapter:

(a) "Secretary" means the Secretary of the Resources Agency.

(b) "Ionizing radiation" means gamma rays and X-rays; alpha and beta particles, high-speed electrons, neutrons, protons, and other nuclear particles; but not sound or radio waves, or visible, infrared, or ultraviolet light.

(c) "Person" means any individual, corporation, partnership, firm, association, trust, estate, public or private institution, group, agency, political subdivision of this state, any other state or political subdivision or agency thereof, and any legal successor, representative, agent, or agency of the foregoing, other than the United States Nuclear Regulatory Commission, the United States Department of Energy, or any successor thereto, and other than federal government agencies licensed by the United States Nuclear Regulatory Commission, under prime contract to the United States Department of Energy, or any successor thereto.

(d) "Byproduct material" means any radioactive material, except special nuclear material, yielded in or made radioactive by exposure

to the radiation incident to the process of producing or utilizing special nuclear material.

(e) "Source material" means (1) uranium, thorium, or any other material which the department declares by rule to be source material after the United States Nuclear Regulatory Commission, or any successor thereto, has determined the material to be such; or (2) ores containing one or more of the foregoing materials, in such concentration as the department declares by rule to be source material after the United States Nuclear Regulatory Commission, or any successor thereto, has determined the material in such concentration to be source material.

(f) "Special nuclear material" means (1) plutonium, uranium 233, uranium enriched in the isotope 233 or in the isotope 235, and any other material which the department declares by rule to be special nuclear material after the United States Nuclear Regulatory Commission, or any successor thereto, has determined the material to be such, but does not include source material; or (2) any material artificially enriched by any of the foregoing, but does not include source material.

(g) "General license" means a license, pursuant to regulations promulgated by the department, effective without the filing of an application, to transfer, acquire, own, possess or use quantities of, or devices or equipment utilizing, byproduct, source, or special nuclear materials or other radioactive material occurring naturally or produced artificially.

(h) "Specific license" means a license, issued after application, to use, manufacture, produce, transfer, receive, acquire, own, or possess quantities of, or devices or equipment utilizing, byproduct, source, or special nuclear materials or other radioactive material occurring naturally or produced artificially.

(i) "Registration" means the reporting of possession of a source of radiation and the furnishing of information with respect thereto, in accordance with subdivision (b) of Section 25815.

(j) "Department" means the State Department of Health Services.

(k) "Director" means the State Director of Health Services.

(*l*) "Low-level waste" means any radioactive waste except high-level radioactive waste and transuranic waste. "High-level radioactive wastes" means: (1) irradiated reactor fuel, (2) liquid waste resulting from the operation of the first cycle solvent extraction system, or equivalent, and the concentrated wastes from subsequent extraction cycles, or equivalent, in a facility for reprocessing irradiated reactor fuel, and (3) solids into which such liquid wastes have been converted. "Transuranic waste" includes any waste containing more than 10 nanocuries of transuranic elements per gram of waste material.

SEC. 3. Section 25811.5 is added to the Health and Safety Code, to read:

25811.5. In addition to the requirements imposed by Section 25811, the department shall develop an overall plan, in consultation with other state, regional, and federal agencies, for the management, treatment, and disposal of low-level radioactive waste generated within California. The plan shall contain, at a minimum, all of the following elements:

(a) Specific contingency plans to address the needs of the state for the short-term storage of low-level radioactive waste in the event of a precipitous closure of existing out-of-state commercial waste disposal facilities and to evaluate feasible alternatives for meeting the state's needs. This element of the plan shall include, but is not limited to, all of the following factors:

(1) The amount and kinds of low-level radioactive waste generated by California licensees and current disposal locations.

(2) The size and nature of an interim storage facility required to meet California's interim low-level radioactive waste disposal needs.

(3) The cost of developing and operating an interim storage site by the department or contracting organizations.

(4) Criteria for the siting of an interim storage site, including, but not limited to, all of the following:

(A) Proximity to population.

(B) Geologic stability.

(C) Proximity to ground or surface water.

(D) Availability of transportation.

(E) General public health and economic considerations.

This element of the plan shall be completed and submitted to the appropriate committees of each house of the Legislature on or before December 31, 1982.

(b) A classification scheme for the separation of low-level waste which will facilitate the management, treatment, storage, and ultimate disposal of such waste. This classification scheme shall consider such matters as possible de minimus radiation levels for specific radionuclides, the quantity and specific activity of the material, its persistence, toxicity, chemical form, reactivity, and the principal radionuclides present. The classification scheme shall also include the specifications necessary to determine which classes of waste may or may not be accepted for storage in an interim storage facility established pursuant to Section 25813, which may or may not be held by the licensee for decay to specified residual radioactivity levels and which require long-term isolation from the environment, as the case may be, for the protection of the public health and safety. The department may require as a condition of licensure the submission of information necessary to determine the total amount of waste produced in each class of the classification scheme. The department may, by regulation, adopt the classification scheme establishing which wastes may or may not be accepted at an interim storage facility or at a treatment or disposal facility.

This element of the plan shall be completed and submitted to the

appropriate committees of each house of the Legislature on or before December 31, 1982.

(c) Siting criteria for potential land burial disposal sites and treatment facilities within the state. In establishing these criteria, the department shall consider the following factors, including, but not limited to:

(1) The present and projected future uses of land, water, and natural resources.

(2) The proximity of the site to major population centers.

(3) The presence of active earthquake faults.

(4) Geologic and other natural barriers which protect against surface or groundwater contamination.

(5) The effectiveness of engineered barriers, waste treatment, and waste packaging in ensuring isolation of the waste from the environment.

(6) Transportation of radioactive materials as it relates to public health and safety.

(7) The relative economic impact of location and operation of treatment or disposal facilities.

This element of the plan shall be completed and submitted to the appropriate committees of each house of the Legislature on or before December 31, 1982.

(d) A plan of action to minimize the environmental, occupational, and public health impact of low-level radioactive waste and to protect the public health and safety by encouraging a reduction in the amount and toxicity of waste produced. This activity shall include conducting or having studies conducted which evaluate the technical and economic feasibility of (1) reducing the volume, reactivity, and chemical and radioactive hazard of such waste, and (2) substituting nonradioactive or short-lived radioactive materials for those radionuclides which require long-term isolation from the environment. The results of these studies, along with the departmental recommendations for their implementation, shall be reported by the department to the appropriate committees of the Legislature on or before December 31, 1983.

(e) Within 18 months after the department has fulfilled the requirements imposed by subdivisions (a) and (b), the department, in consultation with other state agencies, shall conduct and complete a study which identifies those regions of the state within which it is likely the criteria developed pursuant to subdivision (c) could be met.

SEC. 3.5. Section 25811.7 is added to the Health and Safety Code, to read:

25811.7. In addition to the fees authorized to be levied pursuant to Sections 25813 and 25816, the department shall set and collect fees, due and payable on July 1, 1982, and July 1, 1983, to be paid by generators in California of low-level radioactive waste in an amount sufficient to support the development and implementation of the

plans required to be prepared by Section 25811.5. The total amount of fees collected pursuant to this section shall not exceed one dollar ($1) for each cubic foot of waste prepared for disposal in a land burial disposal site or put into a retrievable surface storage facility pending ultimate disposal between July 1, 1981, and July 1, 1983, or a total of four hundred thousand dollars ($400,000), whichever is less. The amount of the annual fee shall be based on the amount of low-level radioactive waste prepared for disposal during the preceding fiscal year.

If the department contracts with any public or private entity for preparation of the plan required to be prepared pursuant to Section 25811.5, or any portion thereof, the department shall, to the extent the director determines it to be beneficial, contract with entities which are knowledgeable and experienced in the management and disposal of low-level radioactive waste. The department shall seek all available federal funds for the purposes of implementing this section.

This section shall remain in effect only until January 1, 1985, and as of such date is repealed, unless a later enacted statute, which is chaptered before January 1, 1985, deletes or extends such date.

SEC. 4. Section 25813 is added to the Health and Safety Code, to read:

25813. (a) The department is authorized, pursuant to subdivision (d), to establish and operate, or contract for the establishment and contract for operation, of one or more low-level radioactive waste interim storage facilities for the exclusive use of persons located in California who are licensed by the department or the United States Nuclear Regulatory Commission.

(b) In addition to the fees authorized to be levied pursuant to Sections 25811.7 and 25816, the department is authorized to set and collect fees, by regulation, to be paid by generators in California of low-level radioactive waste in an amount sufficient to support the development and operation of such facilities including the surveillance and repair of damaged packages, maintenance of the facilities, decontamination, decommissioning, and postclosure maintenance of these facilities, recordkeeping systems, and such other activities as the department finds necessary to ensure the safe operation of such a facility. In no event shall any fee be set in an amount which exceeds the amount reasonably necessary to implement the provisions of this section. The department is also authorized to require the operators or the users of such facilities to post bonds or possess adequate insurance, as may be reasonably necessary to protect the state against such liabilities as storage and ultimate disposal costs for abandoned waste and against claims arising out of accidents or failures of the storage facility.

(c) All users of any facility operated pursuant to this section must all meet state and federal orders, requirements, or regulations for handling and management of low-level radioactive waste including those prescribed pursuant to subdivision (b) of Section 25811.5.

(d) No low-level radioactive waste interim storage facility may be established pursuant to subdivision (a) until (1) the department has fulfilled the requirements of subdivisions (a) and (b) of Section 25811.5 and has submitted its findings to the Legislature, and the Legislature has authorized the department, by statute enacted after the effective date of this section, to establish interim storage facilities.

(e) In addition to any other grounds authorizing the department, or any person with whom it contracts, to cease the operation of a low-level radioactive waste interim storage facility, any such facility shall cease accepting low-level radioactive waste for interim storage (1) no later than five years after the date it commences operating or (2) if the director determines that an alternate disposal site is available to California licensees in the western region of the United States, whichever event occurs first.

(f) Within seven years of commencing operation of any interim storage facility all wastes stored at the facility shall be transferred to a permanent land burial disposal site or permanently disposed of by some other treatment or means of disposal and the facility shall be closed and thereafter, to the extent necessary, as determined by the department, decontaminated and decommissioned.

(g) This section shall remain in effect for a period of eight years from the date of the establishment of a low-level radioactive waste interim storage facility pursuant to this section, and as of such date is repealed. The director shall report the date the facility is established to the appropriate committees of each house of the Legislature and the Legislative Counsel Bureau.

SEC. 5. Section 25814 is added to the Health and Safety Code, to read:

25814. The director shall appoint, in consultation with the Chairperson of the Senate Rules Committee and the Speaker of the Assembly, an advisory committee to advise the department regarding methods for minimizing the environmental impact of low-level radioactive wastes, criteria for siting low-level waste treatment and burial facilities, alternatives to land burial of low-level waste, and waste classification schemes.

The committee shall include representatives from the field of medicine, and from research, industrial, environmental, and public health organizations, who have demonstrated expertise and experience with radioactive materials, waste management, the health effects of exposure to low-level radioactive waste, or the environmental impact associated with the storage of low-level radioactive waste.

SEC. 6. This act is an urgency statute necessary for the immediate preservation of the public peace, health, or safety within the meaning of Article IV of the Constitution and shall go into immediate effect. The facts constituting the necessity are:

In order to assure the continued availability of safe methods for the disposal of low-level radioactive waste generated by California's

licensees, it is necessary that this act take effect immediately.

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Public Law 96-573
96th Congress

An Act

To set forth a Federal policy for the disposal of low-level radioactive wastes, and for other purposes.

Dec. 22, 1980
[S. 2189]

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled,

Low-Level Radioactive Waste Policy Act.

SHORT TITLE

SECTION 1. This Act may be cited as the "Low-Level Radioactive Waste Policy Act".

42 USC 2021l note.

DEFINITIONS

SEC. 2. As used in this Act—

42 USC 2021l

(1) The term "disposal" means the isolation of low-level radioactive waste pursuant to requirements established by the Nuclear Regulatory Commission under applicable laws.

(2) The term "low-level radioactive waste" means radioactive waste not classified as high-level radioactive waste, transuranic waste, spent nuclear fuel, or byproduct material as defined in section 11 e. (2) of the Atomic Energy Act of 1954.

(3) The term "State" means any State of the United States, the District of Columbia, and, subject to the provisions of Public Law 96-205, the Commonwealth of Puerto Rico, the Virgin Islands, Guam, the Northern Mariana Islands, the Trust Territory of the Pacific Islands, and any other territory or possession of the United States.

(4) For purposes of this Act the term "atomic energy defense activities of the Secretary" includes those activities and facilities of the Department of Energy carrying out the function of—

(i) Naval reactors development and propulsion,

(ii) weapons activities, verification and control technology,

(iii) defense materials production,

(iv) inertial confinement fusion,

(v) defense waste management, and

(vi) defense nuclear materials security and safeguards (all as included in the Department of Energy appropriations account in any fiscal year for atomic energy defense activities).

GENERAL PROVISIONS

SEC. 3. (a) Compacts established under this Act or actions taken under such compacts shall not be applicable to the transportation, management, or disposal of low-level radioactive waste from atomic energy defense activities of the Secretary or Federal research and development activities.

42 USC 2021

(b) Any facility established or operated exclusively for the disposal of low-level radioactive waste produced by atomic energy defense activities of the Secretary or Federal research and development

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activities shall not be subject to compacts established under this Act or actions taken under such compacts.

LOW-LEVEL RADIOACTIVE WASTE DISPOSAL

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SEC. 4. (a)(1) It is the policy of the Federal Government that—

(A) each State is responsible for providing for the availability of capacity either within or outside the State for the disposal of low-level radioactive waste generated within its borders except for waste generated as a result of defense activities of the Secretary or Federal research and development activities; and

(B) low-level radioactive waste can be most safely and efficiently managed on a regional basis.

(2)(A) To carry out the policy set forth in paragraph (1), the States may enter into such compacts as may be necessary to provide for the establishment and operation of regional disposal facilities for low-level radioactive waste.

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(B) A compact entered into under subparagraph (A) shall not take effect until the Congress has by law consented to the compact. Each such compact shall provide that every 5 years after the compact has taken effect the Congress may by law withdraw its consent. After January 1, 1986, any such compact may restrict the use of the regional disposal facilities under the compact to the disposal of low-level radioactive waste generated within the region.

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es.

(b)(1) In order to assist the States in carrying out the policy set forth in subsection (a)(1), the Secretary shall prepare and submit to Congress and to each of the States within 120 days after the date of the enactment of this Act a report which—

(A) defines the disposal capacity needed for present and future low-level radioactive waste on a regional basis;

(B) defines the status of all commercial low-level radioactive waste disposal sites and includes an evaluation of the license status of each such site, the state of operation of each site, including operating history, an analysis of the adequacy of disposal technology employed at each site to contain low-level radioactive wastes for their hazardous lifetimes, and such recommendations as the Secretary considers appropriate to assure protection of the public health and safety from wastes transported to such sites;

(C) evaluates the transportation requirements on a regional basis and in comparison with performance of present transportation practices for the shipment of low-level radioactive wastes, including an inventory of types and quantities of low-level wastes, and evaluation of shipment requirements for each type of waste and an evaluation of the ability of generators, shippers, and carriers to meet such requirements; and

(D) evaluates the capability of the low-level radioactive waste disposal facilities owned and operated by the Department of Energy to provide interim storage for commercially generated low-level waste and estimates the costs associated with such interim storage.

(2) In carrying out this subsection, the Secretary shall consult with the Governors of the States, the Nuclear Regulatory Commission, the Environmental Protection Agency, the United States Geological Survey, and the Secretary of Transportation, and such other agencies and departments as he finds appropriate.

Approved December 22, 1980.

LEGISLATIVE HISTORY:

SENATE REPORT No. 96-548 (Comm. on Energy and Natural Resources).
CONGRESSIONAL RECORD, Vol. 126 (1980):
July 28-30, considered and passed Senate.
Dec. 3, H.R. 8378 considered and passed House; passage vacated and S. 2189, amended, passed in lieu.
Dec. 13, Senate agreed to the House amendment with amendments; House agreed to Senate amendments.

activities shall not be subject to compacts established under this Act or actions taken under such compacts.

(2) In carrying out this subsection, the Secretary shall consult with the Governors of the States, the Nuclear Regulatory Commission, the

APPENDIX E

GLOSSARY OF FREQUENTLY USED TERMS

ALARA:	As Low As Reasonably Achievable
HALF-LIFE:	Time required for a radioactive substance to lose half of its activity by decay. Each radionuclide has a unique half-life.
INTERIM STORAGE:	The temporary holding of wastes on or away from the generator's site when disposal is not available.
IRRADIATION:	Exposure to radiation.
MILLIREM: (mrem)	One-thousandth of a rem. A rem is the standard unit of measurement of the energy imparted by radiation to biological systems.
mR:	One thousandth of a roentgen. A roentgen (R) is the standard unit of measurement of radiation exposure in air.
NANOCURIE:	One-billionth of a curie. A curie is the standard unit for measuring radioactivity. It is equal to 37 billion nuclear transformations per second, or the radioactivity contained in 1 gram of radium.
RADIATION:	The process of emitting radiant energy in the form of waves or particles.
RADIOACTIVITY:	The property possessed by some species of atoms of spontaneously emitting half-life.
RADIONUCLIDE/RADIOISOTOPE:	Any species of atom that emits radiation and therefore has a defined half-life.
SCINTILLATION LIQUIDS:	Organic chemical solutions that produce light when bombarded with radiation. These liquids are a major component of institutional low-level waste.
SHALLOW LAND BURIAL:	The disposal of wastes in the uppermost 15 to 20 meters of the earth's surface.
SPECIFIC ACTIVITY:	Amount of radioactivity of a given radionuclide per gram of a compound or element.
TRANSURANIC	An element beyond uranium in the periodic table. (i.e., with an atomic number higher than 92)