PRELIMINARY STUDY ON THE DISPOSAL OF LOW LEVEL RADIOACTIVE WASTE GENERATED IN ILLINOIS

A Report to the
Honorable James R. Thompson,
Governor of the State of Illinois

by

The Ad-Hoc Committee
on Low Level Radioactive Waste,
Illinois Commission on Atomic Energy

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PREFACE

Since the closing of the low-level radioactive waste (LLW) disposal site at Sheffield, IL, all LLW generated within Illinois has been shipped to out-of-state disposal sites. The recently imposed restrictions on the use of these out-of-state disposal facilities (including temporary closing) has underlined the urgent need for a long-term and dependable solution for the safe disposal of LLW generated within Illinois.

At the request of Governor James R. Thompson, an Ad Hoc Committee was appointed by Representative George Ray Hudson, Chairman of the Illinois Commission on Atomic Energy (ICAE). This Ad Hoc Committee, which was charged with performing a preliminary study on the subject of LLW disposal and making preliminary recommendations, consisted of the following members:

Philip F. Gustafson, Chairman of the Ad Hoc LLW Committee, Vice Chairman ICAE, and Director Division of Environmental Impact Studies, Argonne National Laboratory,

Gerald R. Day, Executive Director ICAE,

Donald T. Eggen, Consultant ICAE, Professor of Nuclear Engineering, Northwestern University,

Jan B. van Erp, Member ICAE, Nuclear Safety Research Engineer, Argonne National Laboratory

J. Howard Kittel, Manager, Office of Waste Management Programs, Argonne National Laboratory

The Ad Hoc Committee received strong support and considerable input from the following resource persons:

Donald R. Howard, Senior Engineer, Commonwealth Edison Company

Jacques Ovadia, Chairman, Department of Medical Physics, Michael Reese Hospital, and Professor of Radiology, University of Chicago

Gary W. Wright, Chief, Nuclear Safety Section, Illinois Department of Public Health

The LLW disposal problem has many facets, some of which are of a technical nature, but most of which are of an organizational, institutional, legal and/or political nature. In the limited time available, and because of other parallel commitments of the members of the Ad Hoc Committee, it was not possible to address all facets to the depth necessary to reach final conclusions. For this reason some of the recommendations given are of a preliminary nature, requiring more study, and above all a greater interchange of ideas with the various parties involved, in order to reach a greater level of definition. It is therefore recommended that this first (preliminary) study be followed by a second-phase (engineering) study, not exceeding a period of approximately six months, aimed primarily at scoping the magnitude of the required program and at reaching a better definition of the various engineering tasks and subtasks involved. It is recommended that the State of Illinois make available appropriate funding for this purpose.

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I. SUMMARY

The people of Illinois receive many valuable and essential services involving radioactive materials which in turn require the availability of facilities for the safe disposal of low-level radioactive waste (LLW). Some of these services involve the direct use of radioactive isotopes in hospitals for diagnosis and treatment, and for research. Other services are associated with the use of electric energy, approximately 24% of which was generated in 1978 in Illinois by means of nuclear power plants (75% in the Chicago area).

The closure of the LLW disposal site at Sheffield, IL, the recent temporary interruption, and announced reduction, in the services provided by out-of-state LLW disposal sites in South Carolina, Nevada, and Washington, as well as the recent discontinuation of LLW treatment services rendered by the Todd Shipyard in Texas, may well cause the people of Illinois to be deprived of the essential services described above if alternative solutions to the problem of LLW disposal are not made available on a timely basis.

LLW derives its hazardous nature from the presence of radioactive isotopes, which are subject to nuclear decay, transforming them into relatively harmless non-radioactive materials (this decay is particularly rapid for isotopes with short half-lives). On the other hand, many industrial and agricultural wastes, being chemically stable and often non-biodegradable, remain in the biosphere for extended periods. Inasmuch as the State of Illinois does not rely on the out-of-state disposal for its chemical waste, there appears to exist no good reason why it should rely on out-of-state disposal for LLW.

It is therefore recommended that the State of Illinois urgently embark on a program to put in place a comprehensive LLW disposal program, meeting stringent requirements relative to the protection of the public health and safety, as well as the environment. The main characteristics of this proposed program are outlined in a number of recommendations (see Chapter VI), including that the State of Illinois:

(a) seek to acquire as soon as possible NRC-agreement status (Recommendation 2);

(b) acquire facilities and site(s) for the appropriate disposal of LLW (Recommendation 4);

(c) establish the function of Director for LLW Disposal within the Illinois Department of Public Health (Recommendation 5);

(d) operate the disposal facilities and site(s) through contractors on a fully self-supporting basis (Recommendations 4, 6, and 7), while maintaining stringent controls (Recommendations 3, 5, and 22);

(e) explore the avenues for cooperation with Federal Agencies such as DOE, NRC, EPA, etc. (Recommendation 9);

(f) adopt a three-phase strategy for (i) emergency disposal, (ii) interim (retrievable) disposal, and (iii) permanent disposal of LLW (Recommendations 11, 12, 13, and 14);

(g) adopt appropriate methods for volume reduction, immobilization and packaging of LLW (Recommendations 15, 16, 17, 18, and 19);

(h) make available funding to the amount of $200,000 for more detailed engineering studies relative to the various LLW disposal options, including conceptual design studies and

engineering cost estimates for an engineered interim (retrievable) LLW storage facility. These studies will involve contracts with engineering firms having expertise in the area of LLW disposal (Recommendation 10).

II. BACKGROUND INFORMATION ON LOW LEVEL RADIOACTIVE WASTE IN ILLINOIS

The State of Illinois is a major producer of low-level radioactive waste (LLW). This waste comes from several sources which include: The generation of nuclear energy, the use of radioisotopes in medical and academic institutions, the industrial application of radioactive materials, and the research activities at Argonne and Fermi National Laboratories. In addition, there are a number of inactive nuclear sites within the State which are contaminated with radioactivity to such a degree that appropriate cleanup measures are required before being returned to unrestricted use. Illinois is strongly dependent on nuclear electric power. At present, there are seven nuclear plants in operation, which provided 24 percent of state-wide electrical needs in 1978, and 45 percent in the northern, more heavily populated portion of the State. Another eight nuclear plants are currently under construction. By volume, two-thirds of the LLW produced in Illinois comes from nuclear power production, and in terms of radioactive content, about 90 percent comes from this source.

In 1963, Illinois, recognizing the need to provide for the responsible disposal of LLW, passed the Radioactive Wastes Act which directed the Illinois Department of Public Health to provide for State ownership of an LLW site, and to operate the site directly or by subcontract. A suitable site for an LLW burial ground was selected at Sheffield (in Bureau County), Illinois. Twenty acres, owned by the State, were licensed by the AEC (predecessor agency to the Nuclear Regulatory Commission (NRC)). Burial of LLW on a commercial basis commenced in 1967. Application for license renewal involving the use of a cut-and-fill method for future operation was made in the mid-1970's. Sheffield closed in 1978, pending positive licensing action, because all the licensed trenches were filled. Its present status is in limbo. During its operational

period, over three million cubic feet of waste were buried at Sheffield, some 70 percent of it produced in Illinois.

At present, all Illinois generated LLW must be shipped to one of the three commercial burial sites which remain in operation, although the continued availability of this disposal option is highly uncertain. In 1978, 235,000 cubic feet of LLW, containing over 7000 curies of radioactivity, were generated in Illinois. The annual production of LLW will increase over time. One-half to two-thirds of this volume, however, can be significantly reduced by physical compaction or incineration.

Due largely to the tenuous future of out-of-state LLW disposal, in December 1979, Governor Thompson requested the Illinois Commission on Atomic Energy to examine the LLW situation in the State and to make recommendations regarding the various options available to the State for the management of the LLW produced within its borders. The Commission has actively involved members of the waste-generating community in this study, and has consulted with NRC and DOE in regard to putting in place a comprehensive LLW management plan which will be conducted as a demonstration of feasibility and practicality for other states who may face a similar situation in the future. Although not finalized at this time, the Commission regards a form of engineered, retrievable storage on state-owned property as the method of choice for an interim time period. Incineration and/or other forms of compaction and solidification are seriously being considered to reduce the volume and immobilize radioactivity migration. Currently, Commonwealth Edison is building temporary storage facilities at Zion and Quad Cities nuclear power sites which will provide on-site storage for six months, if required. Hence, to meet all eventualities, any state-managed LLW plan must be in place within six months or very soon thereafter.

In order to accomplish this goal the active participation and cooperation of NRC, DOE, key State agencies, and individual LLW producers is absolutely essential.

It is noted that the programs recommended above will fit within the responsibility of the Department of Nuclear Safety, created by Executive Order No. 3 (April 1, 1980), issued by Governor James R. Thompson of Illinois.

III. PRESENT STATE OF TECHNOLOGY FOR DISPOSAL OF LOW LEVEL RADIOACTIVE WASTE

III.1 Origin and Type of LLW

Radioactive materials are characterized by the fact that they spontaneously emit ionizing radiation.* Hospitals, and institutions using radioactive materials for medical treatment and research, as well as nuclear power plants, generate low-level radioactive materials as waste.

Typical Radioactive Waste

	Nuclear Power	Hospital	Research Institution
Paper, Rags, Wood (compacted or loose)	X	X	X
Rubber, Plastics	X	X	X
Toluene, Xylene (scintillation vials)	X	X	X
Bitumen, Asphalts	X		
Oil	X		X
Ion Exchange Resins, Detergents	X		
Animal Carcasses		X	X
Glass	X	X	X

In 1978 approximately 235,000 cubic feet of radioactive waste was generated in Illinois and buried at commercial burial sites (Barnwell, SC; Beatty, NV; or Richland, WA).

*Materials in which the estimated specific activity is no greater than 0.002 microcuries per gram of material, and in which the radioactivity is essentially uniformly distributed, are not considered to be radioactive materials.

Two general categories of low-level waste are considered, namely (1) institutional waste, originating at hospitals, medical research laboratories, university laboratories, and similar institutions; and (2) industrial wastes, originating principally at nuclear power stations, pharmaceutical laboratories, and possibly industrial processors of radioactive materials such as thorium or tritium.

Institutional radioactive wastes arise mainly from the medical practice and from biomedical and other scientific research. Most, if not all, of these are short-lived radioisotopes such as: phosphorus-32, sulfur-35, chromium-51, gallium-67, technetium-99 m, iodine-125 and iodine-131 which have half-lives less than 60 days. The waste and general trash developed in conjunction with the use of these short-lived radioisotopes can be separated from waste containing longer lived isotopes such as tritium (H-3) and carbon-14. Then it would be practical to allow the short-lived waste to decay for about 10 half-lives and to subsequently dispose of them as regular trash.

The long lived radioisotopes used in medical and biological research are normally contained in liquid scintillation vials, organic and aqueous liquids, and biological wastes (animal carcasses). These should be disposed of in suitable facilities which can accommodate their special character. Institutions, generally do not have facilities for effective volume reduction. Normally wastes are collected in three categories: dry compactible wastes are collected in plastic-lined drums; biological wastes are preserved in freezers until shipment, and shipped in plastic-lined drums; and liquids and vials are packed in absorbent materials in plastic-lined drums. These must be unpacked and solidified by some process. An alternate method of disposal of scintillation liquids

is by incineration. One possibility is to add the scintillation fluid to the fuel of heating plants where appropriate facilities exist.

The industrial waste, principally composed of filters, resins and dry trash, has an annual volume (1978) of 4360 m^3 and a total activity of 7179 Ci. Most of the activity is due to corrosion products (from steel reactor structure) removed in the water polishing filters. The breakdown of utility wastes is:

Spent resins, filters, sludges, etc.	2308 m^3/yr	5621 Ci/yr
Dry waste and contaminated equipment	1851	151
Irradiated components	201	1407

In addition to the utility wastes, there are low-activity wastes from 283 users of sealed radioisotopes (about 775 m^3/yr of dry wastes and spent irradiators) and 420 m^3/yr of dry solid wastes from two government laboratories with a total activity of about 646 Ci/yr.

Generally, the utilities have facilities, or plan to have available facilities, for compaction, solidification, and possibly incineration of the wastes generated at their sites.

III.2 Processing of LLW

Compaction of compressible materials, incineration of combustible materials, drying to produce solids, evaporation and/or crystallization for liquids containing salts and suspended solids are commonly applied processing techniques for radioactive waste. Incinerator ash, dried solids and concentrated liquids are then encapsulated in cement, bitumen or asphalt in the packaging container. Waste shipment and burial packaging containers vary widely in size and shape,

but usually are well constructed and meet the standards and criteria of the Federal Department of Transportation, Nuclear Regulatory Commission, and various burial sites.

A vitrification process is in existence, though it is still in the development stage, that will incinerate all combustible waste types and immobilize the ashes in glass in a single operation (a prototype has been constructed and is operational). The asphalt process is a liquid handling process that drives off the water and immobilizes the remaining particulates and dissolved solids in asphalt.

Cement immobilization is accomplished by merely adding concentrated liquid waste to dry cement and thoroughly mixing. Chemical immobilization or solidification of liquids or dry solids utilizes commercially available plastics (modified vinyl ester resins, or polyethylene, or polypropylene, etc.) as a binder to form a stable mixture.

IV. OPTIONS FOR LOW LEVEL WASTE DISPOSAL

Considerable operating experience has been gained from the Sheffield low-level radioactive waste disposal site in Illinois and from other hazardous chemical waste and radioactive waste disposal sites in humid climates. The experience is in both technical and public relations areas.

The technical experience shows the necessity of improved methods for excluding the effects of ground and surface water on waste contained in shallow land burial sites. Improvements in this area can be achieved by (1) greater attention to the hydrologic characteristics of the candidate sites, and (2) provision of engineered barriers preventing the movement of water into and out of the buried waste. These improvements are particularly desirable for waste containing tritium, for which soil ion-exchange mechanisms are insufficient to materially reduce migration rates.

The experience gained in public relations areas has shown that the mere detection of trace radioactivity moving from a burial site can be perceived by the public as a cause for alarm, even though the levels may be far below those considered potentially harmful to human health or to the environment. Even poorly informed public opinion in the area of nuclear waste management appears to weigh heavily in the decision-making process. It is therfore all the more essential that future low-level waste disposal facilities in at least the eastern half of the United States be located and engineered in such a manner as to virtually guarantee no measurable waste migration into the surrounding soil for the period of interest, e.g., 100 to 150 years.

It is assumed throughout this section that shallow land burial, with improvements to be discussed, is the most economically feasible method that will also satisfy health and environmental concerns.

IV.1 Temporary Storage

The lack of a low-level waste disposal site in Illinois is a serious problem for both institutions (defined as hospitals, research laboratories, etc.) and the nuclear power utilities. It would appear that, for the institutions, much of their problem could be alleviated if (1) the waste is segregated to separate out material containing relatively short-lived activities from waste containing long-lived activities, (2) both types of waste are subjected to more effective volume-reduction procedures, (3) the waste containing short-lived activities is stored on-site or in other temporary storage facilities until the waste is qualified for disposal in a sanitary landfill or incineration, and (4) the long-lived waste is shipped to the same low-level disposal facility to be designated for nuclear power plant wastes, which are also normally long-lived.

The long-lived and mixed wastes from the power industry and institutions could be stored temporarily on isolated utility or government controlled property while the improved retrievable intermediate storage facility described in Section IV.2 is being designed and constructed. Temporary storage in ground-level tornado-resistant structures could be acceptable for contact-handled containers. Remote-handled containers should be stored temporarily in dry below-grade structures, such as concrete caissons. Consideration should be given to use land and facilities already designated for waste disposal. Provision for decommissioning the temporary storage facility must be made in order to return it to its normal use.

IV.2 Interim Retrievable Storage

A facility is required at which grading, sorting, compaction, temporary and retrievable storage can be accomplished. The facility could be located at a site already dedicated to nuclear activities or adjacent to them. The facility could be considered as an interim facility (5 to 7 years) to be used until permanent state owned or regional burial sites are available. On the other hand, the facility could be considered as a staging area for the control, compaction and proper packaging of LLW to be later shipped to and disposed of in a permanent burial site.

The facility could be solely an engineered, retrievable storage facility intended to store on an interim basis compacted and properly packaged LLW from institutions and industrial waste generators; or it could serve an additional purpose and service of compacting, immobilizing, and packaging LLW as well.

As a retrievable storage facility, an engineered structure, probably located below grade and hardened against tornados, seismic events, and flooding could be constructed in modular fashion to provide storage of packages of compacted and immobilized LLW. Suitable means of moving wastes into, about, and out of the storage facility would be provided by fork-lift or mobile crane equipment.

Assuming compaction of LLW it would be expected that the equivalent of 5,000-10,000 cubic yards of interim storage will be required (about 15,000 to 30,000 square feet) per year. The first modular storage space would be about 40,000 square feet and additional units would be built, every two or three years, as required. Potentially five such modules would be required at the site to meet a ten year interim storage requirement. Estimated cost is about

$200,000 for preliminary engineering and three to four million dollars per module.

It would seem practical to locate a facility to compact or incinerate, immobilize the radioactivity, and package bulk low level wastes (discussed in the previous chapter) at the same site as the interim storage facility. This facility is expected to be necessary to reduce the volume of institutional wastes and that from small industrial operators.

After the period of required interim storage - prior to the availability of a state or required permanent burial site - the interim facility and volume reduction equipment could be used as a staging site intermediate to shipping to the burial site.

IV.3 Permanent Burial

Permanent burial, presumed to be shallow burial, will be required in the longer term to isolate the LLW stored at the interim site, or generated and reduced in volume by the utility industry. This facility may be the regional facility presently considered in Federal planning, or it may be state-owned and operated. Since it is conceived to be operational for a long period (100 years), a sizeable area (160 to 250 acres) will be required both for the burial and for security and isolation. Site criteria are enumerated in Chapter V.

The disposal facility could consist of trenches, each typically 60 ft wide, 25 ft deep, and 750 ft long, that are lined on the sides and bottom with reinforced concrete. The bottom of the trench would slope to the center and to one end. At this end a sump would be placed to catch any water entering the trench for sampling and disposal. The filled trenches would be covered with mounded earth 6 to 10 ft deep and an impermeable replaceable cover such as stainless

steel or aluminum sheet, concrete, asphalt composite, compacted clay, an earth-covered heavy plastic membrane, etc.

An alternate would provide a deeper earth cover which is stabilized by vegetation or other means against significant erosion for a period of at least 100 years.

As another alternative, exploratory studies should be enlarged on possible use of the extensive abandoned mine workings in Illinois for permanent disposal of long-lived remote-handled waste. If such facilities can be made usable, it may be desirable to place long-lived remote-handled waste in mine workings directly, without intermediate retrievable storage in a retrievable near-surface facility such as that described above.

A fourth alternative is to construct trenches similar to that described under the first alternative, but at greater depths to permit a final earth cover 25 to 50 ft deep. A concrete lining is again specified, but in this case only to provide an engineered barrier rather than to also facilitate container retrieval.

V. SITE SELECTION CRITERIA

In selecting a site for retrievable storage of radioactive material, one is not as constrained as one would be under the prevailing restrictions for permanent disposal. However, there are several criteria that one must consider. This chapter will specify some of them in general. Until a decision on site specifics can be made, the following factors would be considered.

V.1 Health and Safety of the Public and On-site Personnel

Any site selection should as the first priority include consideration of the health implications of the site on the population in the immediate vicinity, including the individuals employed on site. A complete study would have to be undertaken to determine any health impact after a specific site was selected. This study would be made based on the present and potential future population in the region and should include consideration of present and projected future uses of land, water, and natural resources in the region of the site.

V.2 Geology

Although not a key issue in the selection of a temporary site for interim storage, the geology must be considered in the selection of any site. Any site chosen for temporary or permanent disposal should be located on land that has low permeability and is not subject to flooding or high ground water problems. The geology should be studied to determine other potential problems such as dislocation due to earth tremors, or mine subsidence.

V.3 Geographical Considerations

Sites selection for interim storage facilities should involve consideration of several elements as regards geography. The site should be located as centrally as possible to the bulk of the users so no licensee has to transport long distances, the location should be easily accessible by major highways or by rail, and routing of shipments should be possible without transporting through large populated areas. The site should not contain natural resources of future potential interest. In planning for a site consideration must be given to an area large enough so that a buffer zone (State or Federally owned) can be established and maintained.

V.4 Topography

Sites should be chosen in areas that have good drainage of surface water from the site and when surface or sub-surface storage is planned, weather elements such as tornados and high winds will cause no disturbance of the site or facility.

V.5 Decommissioning

Sites should be selected in areas that may be decommissioned with the least impact on the environment. In the case of temporary storage, contamination, if any, would be very small so sites should be chosen that could be put to other uses upon completion of decommissioning.

V.6 Ultimate Disposal

If the State should opt for permanent disposal, all the above should be considered. In addition, the State would have to conform to those site selection criteria of applicable federal and state regulations.

VI. RECOMMENDATIONS

VI.1 General and Organizational Aspects

1. It is recommended that the State of Illinois seek solutions to the disposal of low-level radioactive waste (LLW) generated within the State to replace the current practice of shipping Illinois' LLW over long distances to Barnwell, SC, or Hanford, WA, or Beatty, NV. Such solutions are needed in view of (a) the announced intent of the States operating disposal sites (SC, WA, and NV) to no longer accept unlimited quantities of LLW from other States, and (b) the rising cost of long-distance shipping.

2. It is recommended that Illinois seek to acquire the status of NRC Agreement State at the earliest possible date, as a means to expedite the licensing process for LLW disposal facilities.

3. It is recommended that the Illinois Department of Public Health (IDPH) continue to perform an independent monitoring and enforcement function to guard against the inadvertent dispersal of radioactive isotopes from the disposal site(s). It is furthermore recommended that the IDPH assume such regulatory functions associated with the disposal of LLW as may be in conformance with the NRC Agreement-State status.

4. It is recommended that the State of Illinois acquire facilities and site(s) for the appropriate disposal of LLW. It is further recommended that these facilities and site(s) be operated for the State, and under supervision of the State, by (a) commercial contractor(s).

5. It is recommended that the State of Illinois establish within the IDPH the position of Director for LLW Disposal, having overall responsibility for

the administration and management, as well as the monitoring and enforcement activities pertaining to the disposal of LLW.

This Director shall, by training and experience, be well qualified to deal with the problems related to the disposal of radioactive waste, be it from hospitals, laboratories, or nuclear power plants.

It is suggested that, within the IDPH, the functions of administration and management of the LLW disposal operations be performed in a section separate from the section responsible for the monitoring and enforcement functions, both sections reporting to the Director for LLW Disposal.

6. It is recommended that the IDPH, through its contractor(s), operate the disposal facilities and site(s) on a fully self-supporting basis, except for an initial period necessary for attaining commercial operation. Capital to cover the initial costs related to the acquisition of disposal facilities and site(s), preparation of the site(s), etc., is to be raised on the capital market, or may be provided by future users or the State, and is to be repaid in accordance with normal established commercial practices (possibly in users' return-credits).

7. It is recommended that the IDPH be entitled to charge the users of the disposal facilities a fee, based on the volume and radioactivity of the waste, to cover the overall costs of the disposal operation, including the cost of the site, the cost of the civil-engineering structures on the site, the operation and management of the disposal facilities, the monitoring of the site, as well as the retrieval and re-disposal of the waste in case of non-permanent disposal facility, including facility decommissioning or perpetual surveillance

if necessary. Furthermore, it is recommended that the fee include a contingency margin of sufficient magnitude to guard against unforeseen circumstances.

8. It is recommended that the Director for LLW Disposal be assisted by an Advisory Committee, consisting of individuals, not employed by the same State Agency, who are well qualified to deal with specific areas (disciplines) related to radioactive waste disposal, including health physics, hydrology, waste treatment and packaging, etc. Such individuals shall serve without remuneration, except for reimbursement of expenses, and shall be appointed for periods of three (3) years (staggered to provide continuity). The composition of this Advisory Committee shall include, in addition to fully independent individuals, representatives of the different types of users of the disposal facilities and site(s).

9. It is recommended that the State of Illinois explore potential avenues for cooperation with Federal Agencies (DOE, NRC, EPA, etc.). In particular, it is recommended that the State of Illinois explore the possibility of obtaining Federal funding in the framework of a demonstration project.

10. It is recommended that, prior to the appointment of the Director for LLW Disposal, the study of the various options for the disposal of LLW generated in Illinois be continued by a Project Planning Review Committee under the responsibility of the Illinois Commission on Atomic Energy. This Review Committee is to continue the work started by the Ad Hoc Committee, proceeding with in-depth studies supported by (relatively-small) consulting contracts with firms having expertise in the area of LLW disposal (NUS, Gilbert/Commonwealth, Sargent & Lundy, etc.) this study, which is urgently needed before any definite decisions can be made and before any major contracts can be placed, shall address the following points:

(a) evaluation of the feasibility of the various emergency options (see recommendation 12);

(b) conceptual design, site selection, and engineering cost estimate for an interim (retrievable) storage facility (see recommendation 13);

(c) establishment of regulatory requirements and site selection criteria for a permanent disposal site (see recommendation 14);

(d) consultation with the US-DOE as to the possibility and nature of a cooperative program;

(e) consultation in greater detail with US-NRC as to the implications of becoming an Agreement State, and definition of potential areas of cooperation;

(f) consultation with other Federal and State Agencies involved in LLW disposal;

(g) consultation with a greater spectrum of potential users of disposal facilities and site(s) as to the nature of their needs.

It is recommended that the State of Illinois make available an amount of $200,000 for this study.

VI.2 Disposal Strategies

11. It is recommended that the State of Illinois adopt a three-phase strategy for the disposal of LLW generated within the State, covering three distinct time periods, namely (a) the immediate future, (b) an interim time period (five to seven years), and (c) the long-term. It is expected that the

solutions for the above-mentioned periods (a) and (b) will be limited to the State of Illinois, whereas that the long-term (c) may have a regional character.

12. It is recommended that the LLW disposal options to be adopted for the immediate future be primarily aimed at providing emergency disposal capability within the State in case of near-term closure of out-of-state disposal sites. The following possible options may be considered in this connection: (a) use of an existing site or facility, (b) use of a site which has already been used for such purposes, (c) use of State lands or abandoned Federal or State facilities (such as warehouses or underground sites, etc.), preferably located outside of regions of frequent tornado activity or areas prone to floods. To the extent possible, the solutions adopted shall have a temporary and retrievable character. Rules and procedures shall be established to assure a minimum risk of contaminating the site, and provisions shall be made for decontamination at the end of use.

13. It is recommended that the LLW disposal options to be adopted for the interim time period (five to seven years) be of the retrievable type, and include the installation and operation of appropriate facilities for volume reduction (compaction or incineration), immobilization (vitrification, or mixing with concrete or bitumen), and packaging. It is further recommended that these facilities be designed to continue to serve, subsequent to their initial use as interim storage facility, as a staging area and volume reduction facility intermediate to permanent disposal, if necessary.

14. It is recommended that the LLW disposal options to be adopted for the long term be of a permanent (i.e., non-retrievable) nature. Among the many aspects that would need to be considered are site selection, disposal methods (e.g., shallow land burial, deep land burial, etc.), methods for immobilization

and packaging of the waste, interface with Federal Agencies, etc. In view of the relatively short time period available (~ five years), it is recommended to proceed with due urgency with the study of the various aspects; it is further recommended that appropriate funding be made available for this purpose.

VI.3 Volume Reduction, Immobilization and Packaging of LLW

15. It is recommended that LLW generated by nuclear power plants be compacted, immobilized, and packaged by the utility, and be inspected by the State, at the location of origin, and be subsequently shipped to a State-owned site for interim storage or permanent disposal.

16. It is recommended that long-lived LLW generated by institutions (hospitals, universities, etc.), industries, and other organizations (national laboratories, etc.) be shipped to a State-owned site for volume reduction, immobilization, and packaging, and for interim storage or permanent disposal.

17. It is recommended that among the methods for volume reduction of LLW be considered physical compression, controlled incineration and controlled evaporation.

18. It is recommended that among the methods for immobilization of LLW be considered (a) mixing with concrete, (b) coextrusion with bitumen or other suitable materials (e.g., plastics), (c) vitrification, i.e., dissolution in molten glass and subsequent solidification.

19. It is recommended that the volume-reduced and immobilized LLW be cast or packed into steel containers which are sealed against penetration by water or other (possibly corrosive) liquids. It is recommended that a number of standard types and sizes be established for these containers, to meet the needs of specific applications.

VI.4 Transportation of LLW

20. It is recommended that the transportation of LLW from the location of origin to the site of interim storage or permanent disposal be performed in conformance with the relevant Federal regulations, standards, and criteria.

21. It is recommended that the Illinois Department of Transportation, The Illinois State Police, and the IDPH be jointly responsible for enforcing regulations, standards, and criteria applicable to transportation of LLW.

VI.5 Site Management

22. It is recommended that the State of Illinois, through the IDPH, carry overall responsibility for the LLW disposal operations. The IDPH shall contract for the actual physical waste disposal operations, but shall retain all controls necessary to guarantee a safe and economically viable operation, having minimal environmental impact. Such controls shall include monitoring and enforcement, establishing of users' fees, site security, etc.

VII. CONCLUSION

The people of Illinois receive many essential services, which require the safe disposal of low-level radioactive waste. Among these services are nuclear medicine and electric power derived from nuclear power plants. The State is furthermore endowed with some of the world's leading research institutions in medicine, engineering and science, whose continued activity depends to a considerable extent on the availability of appropriate disposal facilities for low-level radioactive waste. The people of Illinois, in order to continue to receive these essential services and the benefits derived from the presence of research institutions and industries, should accept the responsibility for the safe disposal of the low-level radioactive waste generated within the State's borders.

Low-level radioactive waste is in many instances less hazardous than chemical waste. The technology for the safe disposal of low level radioactive waste is available, including suitable methods for volume reduction, immobilization, and packaging. It is therefore recommended that the State of Illinois proceed with due urgency to put in place a comprehensive program for the safe disposal of low-level radioactive waste.

GLOSSARY OF TERMS

Radiation: Radiation is energy traveling in the form of waves, particles, or bundles of energy called photons. Some everyday examples are microwaves used to cook food, radio waves for radio and television, radar for location and tracking of vehicles, X-rays used in medicine and dentistry, and sunlight.

Radioactivity, Radioactive Decay Radioactivity is a property of some materials, and is characterized by a natural and spontaneous process by which the unstable atoms of an element emit or radiate the excess energy of their nuclei as particles or photons and change (or decay) to atoms of a different element or to a lower energy form of the original element.

Alpha (α), Beta (β), and Gamma (γ) Radiation: There are three types of radiation associated with radioactivity that ordinarily affect humans: alpha, beta, and gamma radiation. Alpha particles are the nuclei of helium atoms (two protons and two neutrons), and are readily stopped by even a thin layer of material such as a sheet of paper. Beta particles (or rays) are high-speed electrons. Gamma radiation, like medical X-rays, is composed of photons except that gamma radiation is emitted from the nucleus of atoms.

Radiation Dose: The most meaningful units for measuring radiation dose to humans are the rem and millirem (1/1000 or a rem, abbreviated mrem). These units of measurement take into account the effect on living tissue (biological effectiveness) of the three types of radiation.

Curie: A Curie is a measure for radioactivity, defined as the amount of a given radioactive substance which undergoes 3.7×10^{10} (i.e., 370 billion) radioactive transformations per second. It is noted that the Curie is not a measure for biological effectiveness of the radiation given off, inasmuch as 1 Curie of a given isotope may be many times more hazardous than 1 Curie of another isotope.

Isotope: A given chemical element is, with a few exceptions, a mixture of atoms, called isotopes, which have the same atomic number and hence the same chemical properties, but which differ in nuclear mass. Different isotopes of the same chemical element may be either stable or radioactive.

Half-life: This is the time it takes for radioactivity to decrease to half its starting level. Each radioactive nuclide has a unique half-life, in the range from millionths of a second to billions of years.

Fission Process, Fission Product:	In the fission process, uranium splits into two, or more, new (and lighter) atoms. These are called fission products. Many of the fission products are stable (nonradioactive), but others are highly radioactive. Only the radioactive atoms are hazardous. The fission products build up in the fuel during its use and are retained there until the fuel is removed from the reactor for reprocessing.
Activation:	Under activation is understood the process whereby stable isotopes are transformed into radioactive isotopes due to irradiation with neutrons.
Proton, Neutron:	Elementary particles which constitute the building blocks of the nuclei of atoms.
Electron:	Carrier of the elementary electric charge, constituting part of the periphery of atoms.
Tritium:	Tritium is a radioactive form of hydrogen. Because it can become part of water molecules and because of its relatively long half-life (12.3 years), tritium is a potential biological hazard.
Carbon-14:	Carbon-14 is a radioactive form of carbon. Because it can be taken up by plants, and because it has a long half-life (5730 years), it is a potential biological hazard.

NEWS

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GOVERNOR

FOR IMMEDIATE RELEASE ENVIRONMENTAL IMPACT STUDIES 217-782-7355

SPRINGFIELD, Ill., April 1--Governor James R. Thompson announced the creation by executive order Tuesday of a Department of Nuclear Safety to safeguard the public from the hazards of radiation exposure, effective October 1.

Thompson emphasized: "This new department will not be concentrating its efforts on nuclear plants alone. The reorganization also is aimed at making certain that both physicians and their patients will be afforded a comprehensive program of protection from unnecessary radiation exposure.

"Use of radiation by the medical profession in hospitals, doctors' offices and at other health facilities also will be scrutinized by the department."

Spelling out the need for the new department, the Governor said: "We have had ample demonstration in other states of the need for a single agency which is responsible for the watchdog effort our citizens must have," the Governor said.

"We are the number one nuclear state in the nation and we must be number one as well in our safety efforts and number one in emergency preparedness.

"Illinois citizens must be free from accidental or unnecessary exposure to potentially deadly radiation. A single department, combining functions from diverse agencies, will have the sole responsibility for management of our radioactive waste and will give us one agency to monitor nuclear power plants and warn us in the event an emergency response is needed."

The new department will assume the powers of regulation of energy use now assigned to the Department of Public Health, the Environmental Protection Agency and the Office of the State Fire Marshal.

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Programs of inspection and licensing of radioactive materials in Illinois likewise will be moved to the new Department.

"Centralization of these functions will result in better accountability to the Governor and to the people of the state toward insuring safer operation of nuclear facilities and safer handling of radiological materials," Thompson said in the order.

Further benefits of the reorganization will be to provide a single source of communication in the nuclear area with the federal government in its role in regulating radioactive materials usage.

The executive order also provides that the Department of Nuclear Safety will:

*Work in all area of radiation protection, including unnecessary exposure of individuals in the medical and industrial fields. Recent estimates hold that 87 Illinois residents die each year from cancer caused by unnecessary exposure to radiation. An estimated 1.29 per cent of all illness in Illinois, involving about 140,000 persons, is due to unnecessary radiation exposure.

*Assume regulation of radioactive waste storage sites in Illinois.

*Be headed by a Director appointed by the Governor.

*Include about 50 personnel previously assigned to carry out the functions transferred from Public Health and about 6 from the Fire Marshal. Their rights under the personnel code, collective bargaining agreement, pension, retirement or annuity plan will not be affected. No personnel from the Environmental Protection Agency will be reassigned to the new Department. The plan calls for consolidation of the Division of Radiation Protection and the Division of Nuclear Safety in the Department of Public Health, the Boiler Safety Inspection Division of the Office of the State Fire Marshal to the extent that it relates to nuclear reactors and select substantive provisions of the Environmental Protection Act related to radiation hazards.

"Illinois depends on nuclear energy for more than 30 per cent of its electricity needs and for a minimum of 50 per cent of its electricity needs in the Chicago area," the Governor stressed.

"We cannot pull the plug on nuclear power, but we can take forceful and significant steps to insure that its production is safe for our citizens."

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STATE OF ILLINOIS

EXECUTIVE DEPARTMENT

SPRINGFIELD, ILLINOIS

EXECUTIVE ORDER NUMBER 3 (1980)

AN EXECUTIVE ORDER CREATING THE DEPARTMENT OF NUCLEAR SAFETY AND TRANSFERRING TO IT CERTAIN POWERS AND DUTIES RELATING TO THE REGULATION OF THE SOURCES OF RADIATION FROM THE DEPARTMENT OF PUBLIC HEALTH, THE ENVIRONMENTAL PROTECTION AGENCY AND THE OFFICE OF THE STATE FIRE MARSHAL

Article V, Section 11 of the 1970 Constitution authorizes the Governor to reassign functions among executive agencies which are directly responsible to him in order to simplify the organizational structure of the Executive Branch, to improve accountability, to increase accessibility, and to achieve efficiency and effectiveness in operation.

This Executive Order creates the Department of Nuclear Safety and transfers to it various rights, powers, duties and functions of the Department of Public Health, the Environmental Protection Agency and the Office of the State Fire Marshal. This action will consolidate inspection and licensing programs for radioactive materials in the State of Illinois. Centralization of these functions will result in better accountability to the Governor and the people of the state and insure the safer operation of nuclear facilities and the safer handling of radiological materials. In addition, the creation of such an entity will foster expertise in the development of nuclear policy and attract individuals with technical competence to state employment in this area. The creation of the agency will provide reliable management of our

radioactive waste and effective emergency response. The Department will also coordinate programs relating to the transport of radiological materials. Finally, the creation of such an agency will permit clear communication in the nuclear area with the federal government which plays a significant role in the regulation of the uses of radioactive materials.

Therefore, in the exercise of power vested in me by Article V, Section 11 of the 1970 Constitution, I hereby order:

I. CREATION OF DEPARTMENT

A. There shall be a Department of Nuclear Safety.

B. The Department of Nuclear Safety shall have as its head a Director.

Appointments to this office shall be made by the Governor, by and with the advice and consent of the Senate. Acting Directors shall be appointed and vacancies filled in accordance with Section 12 of the "Civil Administrative Code of Illinois", approved March 7, 1917, as amended, and the oath and bond requirements set forth in Sections 14 and 15 of that Code shall be applicable.

The Director of the Department of Nuclear Safety shall hold office from the date of appointment following the effective date of this Executive Order, until January 19, 1981, and until his successor is appointed and qualified. Thereafter, Section 13 of "The Civil Administrative Code of Illinois" shall control the terms of office.

II. TRANSFER OF POWERS

A. From the Department of Public Health to the Department of Nuclear Safety.

1. All the rights, powers and duties vested in the Department of Public Health by the following named Acts or Sections thereof:

a. "An Act to require the registration of radiation installations as herein defined, to investigate and inspect all radiation installations in this state, to provide injunctive relief and penalties for violations of this Act, and to make an appropriation therefor", approved July 5, 1957, as amended. (Ill. Rev. Stat. ch. 111½, para. 194 et seq.)

b. "Radiation Protection Act," approved July 17, 1959 as amended. (Ill. Rev. Stat. ch. 111½, para. 211 et seq.)

c. "An Act to authorize the Director of Public Health to purchase, lease, accept, or acquire suitable sites for the concentration and storage of radioactive waste, to provide for supervision of the operation of such sites and to authorize the Department of Public Health to prepare and enforce regulations pertaining to the use and operation of such sites", approved August 16, 1963, as amended. (Ill. Rev. Stat. ch. 111½, para. 230.1 et seq.)

d. "An Act to require employers to provide a type of personnel radiation monitoring service acceptable to the Department of Public Health for those employees subject to radiation monitoring and to report the personnel radiation exposure records furnished by such service to the Department of Public Health; and to prohibit the operation of personnel radiation monitoring service without approval of the Department of Public Health", approved August 16, 1963, as amended. (Ill. Rev. Stat. ch. 111½, para. 230.11 et seq.)

e. "An Act to require registration of laser systems as herein defined, to authorize the Department of Public Health to investigate and inspect all laser systems in the State, to require reporting of any accidental injuries sustained by such laser systems and provide injunctive relief and penalties for violations of this Act", approved August 11, 1967, as amended. (Ill. Rev. Stat. ch. 111½, para. 701 et seq.)

f. The "Illinois Nuclear Safety Preparedness Act", approved September 14, 1979. (Ill. Rev. Stat. ch. 111½, para. 4301 et seq.)

g. Sections 55.32 and 55.34 of the "Civil Administrative Code of Illinois", approved March 7, 1917, as amended. (Ill. Rev. Stat. ch. 127, para. 55.32, 55.34)

2. All the rights, powers and duties vested in the Director of Public Health by "An Act to create the Illinois Commission on Atomic Energy, defining the powers and duties of the Commission, and making an appropriation therefor," effective September 10, 1971, as amended, (Ill. Rev. Stat. ch. 127, para. 541 et seq.) are transferred to the Director of Nuclear Safety. The Director of Nuclear Safety, after the date this Executive Order becomes effective, shall serve as an ex officio member of the Illinois Commission on Atomic Energy in the place and stead of the Director of Public Health.

B. From the Office of the State Fire Marshal to the Department of Nuclear Safety.

1. All the rights, powers and duties vested in the Office of the State Fire Marshal by the "Boiler and Pressure Vessel Safety Act", approved August 7, 1951, as amended, to the extent such rights, powers and duties relate to nuclear steam-generating facilities, are transferred to the Department of Nuclear Safety. (Ill. Rev. Stat. ch. 111½, para. 3201 et seq.)

2. All rights, powers and duties relating to nuclear steam-generating facilities vested in the Board of Boiler and Pressure Vessel Rules by the "Boiler and Pressure Vessel Safety Act", approved August 7, 1951, as amended, which include but are not limited to the formulation of definitions, rules and regulations for the safe and proper construction, installation, repair, use and operation of nuclear steam-generating facilities, the adoption of rules for already installed nuclear steam-generating facilities, the adoption of rules for accidents in nuclear steam-generating facilities, the examination for or suspension of inspectors' licenses of such facilities and the hearing of appeals from decisions relating to such facilities are transferred to the Department of Nuclear Safety and shall be exercised by the Director of Nuclear Safety. (Ill. Rev. Stat. ch. 111½, para. 3201 et seq.)

3. All the rights, powers and duties relating to nuclear steam-generating facilities vested in the State Fire Marshal or the Chief Inspector by the "Boiler and Pressure Vessel Safety Act", approved August 7, 1951, as amended, which include but are not limited to the employment of inspectors of nuclear steam-generating facilities, issuance or suspension of their commissions, prosecution of the Act or rules promulgated thereunder for violations by nuclear steam-generating facilities, maintenance of inspection records of all such facilities, publication of rules relating to such facilities, having free access to such facilities, issuance of inspection certificates of such facilities and the furnishing of bonds conditioned upon the faithful performance of their duties are transferred to the Department of Nuclear Safety. The Director may designate a Chief Inspector, or such other inspectors, as he deems necessary to perform the functions transferred by this paragraph 3. (Ill. Rev. Stat. ch. 111½, para. 3201 et seq.)

4. The transfer of rights, powers and duties specified in paragraphs 1, 2, and 3 is limited to the program transferred by this Executive Order and shall not be deemed to abolish or diminish the exercise of those same rights, powers and duties by the Office of the State Fire Marshal, the Board of Boiler

and Pressure Vessel Rules, the State Fire Marshal, or the Chief Inspector with respect to programs retained by the Office of the State Fire Marshal.

C. From the Environmental Protection Agency to the Department of Nuclear Safety.

1. All the rights, powers and duties vested in the Environmental Protection Agency by paragraphs a,b,c,d,e,f,h, i,k,l,n,o,p,q, and r of Section 4 and Sections 30-45 inclusive of "An Act to protect the environment of the State and repeal certain Acts therein named," approved July 1, 1970, as amended, to the extent that such powers relate to standards of the Pollution Control Board adopted pursuant to Section 25a of that Act, are transferred to the Department of Nuclear Safety. (Ill. Rev. Stat. ch. 111½, para. 1004, 1030-1045)

2. The transfer of rights, powers and duties specified in paragraph 1 is limited to the program transferred by this Executive Order and shall not be deemed to abolish or diminish the exercise of those same rights, powers and duties by the Environmental Protection Agency with respect to programs retained by the Environmental Protection Agency.

III. EFFECT OF TRANSFER

A. Personnel previously assigned to the programs transferred from the Department of Public Health and the Office of the State Fire Marshal are transferred to the Department of Nuclear Safety. However, the rights of the employees, the State and executive agencies under the Personnel Code or any collective bargaining agreement, or under any pension, retirement or annuity plan shall not be affected by this Executive Order.

B. All books, records, papers, documents, property (real or personal), unexpended appropriations and pending business in any way pertaining to the rights, powers and duties transferred by this Executive Order shall be delivered and transferred to the Department of Nuclear Safety.

IV. SAVINGS PROVISIONS

A. The rights, powers and duties transferred by this Executive Order to the Department of Nuclear Safety shall be vested in and shall be exercised by that Department subject to the provisions of this Order. Each act done in the exercise of such rights, powers and duties shall have the same legal effect as if done by the former departments, divisions, officers, or employees thereof.

B. Every person or corporation shall be subject to the same obligations and duties and any penalties, civil or criminal, arising therefrom, and shall have the same rights arising from the exercise of such rights, powers and duties as if such rights, powers and duties had been exercised by the former department, division or officer or employee thereof.

C. Every officer and employee of the Department of Nuclear Safety shall, for any offense, be subject to the same penalty or penalties, civil or criminal, as are prescribed by existing law for the same offense by any officer or employee whose powers or duties were transferred to him by this Executive Order.

D. Whenever reports or notices are now required to be made or given or paper or documents furnished or served by any person to or upon the departments and offices transferred by this Executive Order, the same shall be made, given, furnished or served in the same manner to or upon the Department of Nuclear Safety.

E. This Executive Order shall not affect any act done, ratified or cancelled or any right occurring or established or any action or proceeding had or commenced in an administrative, civil, or criminal cause before this Executive Order takes effect; but such actions or proceedings may be prosecuted and continued by the Department of Nuclear Safety.

F. No rule or regulation promulgated by the Department of Public Health or the Office of the State Fire Marshal pursuant to an exercise of a right, power or duty which has been transferred to the Department of Nuclear Safety shall be affected by this Executive Order. These rules and regulations shall become the rules and regulations of the Department of Nuclear Safety.

V. SEVERABILITY

If any provision of this Executive Order or its application to any person or circumstances is held invalid by any court of competent jurisdiction, this invalidity does not affect any other provision or applications of this Executive Order which can be given effect without the invalid provision or application. To achieve this purpose, the provisions of the Executive Order are declared to be severable.

VI. EFFECTIVE DATE

This Executive Order shall become effective October 1, 1980.

James R. Thompson
GOVERNOR

Dated: April 1, 1980