DEVELOPMENT OF A WASTE INVENTORY FOR NEW YORK STATE

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ABSTRACT

Projecting the waste inventory for a LLRW disposal facility's operational life is a necessary preliminary step to designing the facility, conducting the performance assessment, or selecting the disposal technology. In 1990, the 500-page Source Term Report (STR) was researched and developed in-house by Paul Mayo, Kathleen McMullin, and Peter Blood of the New York State Siting Commission staff. The STR was a New York State LLRW inventory characterizing hundreds of waste streams by a dozen parameters. The projections covered two time periods (30 and 60 years), three case scenarios (an Expected, Minimum and Maximum), and included such non-routinely generated waste forms as irradiated components and decommissioning waste. This paper will outline how the inventory was developed and how it will be revised.

DEVELOPMENT OF THE PROJECTIONS

The Source Term Report characterized nearly all LLRW projected to be placed in the disposal facility. It not only projected routinely generated waste from 200 generators, but included projections of non-routinely generated waste, such as irradiated power reactor components, LWR decontamination waste, sealed sources, and decommissioning waste from nuclear power reactors, university research reactors, radiopharmaceutical reactors, and small industries. Had non-routinely generated LLRW been excluded, the inventory could have been projected by simply extrapolating from current annual generation data. This approach would have been considerably easier, albeit unrealistic. Mixed waste was purposefully excluded from the projections because adequate sources from which to project mixed waste were unavailable at the time. Mixed waste will be addressed in the revised Source Term Report, expected in early 1994.

The Commission used a building-block approach to characterize each waste stream projected to be placed in the facility during its operating life. In order to develop the disposal facility's inventory, a multi-step approach was employed.

Projection of Routinely Shipped Waste

In the first step, routinely shipped LLRW from radiopharmaceutical manufacturers, power reactors, and institutions were projected from recent historical shipping records. Institutional waste (DAW, biologicals, etc.) was projected using the State's 1987 database of LLRW generator reports (submitted annually by all generators in New York) and data from NDL, the State's largest LLRW broker. LLRW projections for "major" generators (those producing more than 5% of the State's volume or activity) relied heavily on 1987 LLRW shipping manifest data. The following sources were also used:

- Letter surveys and/or telephone inquiries of generators, waste brokers, medical and industry experts, waste processors, and State and Federal radioactive material regulators.
- On-site interviews with representatives from
  - Cintichem (a radiopharmaceutical manufacturing reactor).
  - Albany Medical Center (a major research hospital center).
  - State and Federal radioactive material regulators.
  - Nine Mile Point Unit 1, Nine Mile Point Unit 2, Ginna, Fitzpatrick, Indian Point Units 1 & 2, and Indian Point Unit 3 (all nuclear power plants in New York were visited except Shoreham. Its future at the time was ambiguous).
- The Idaho National Engineering Laboratory's National LLRW computer database and 1980-1988 State-by-State Assessments.
- The Conference of Radiation Control Program Directors 1984 Survey database.
- Available power reactor decommissioning studies.

Projection of Non-routinely Shipped Waste

In the second step, Commission staff developed projections for non-routinely generated waste streams. Non-routinely generated waste included decontamination wastes, decommissioning wastes, irradiated reactor components (IRCs), and other waste types expected to require disposal but not suitably reflected in historical data. The methodology used for projecting non-routinely shipped waste differed for each waste category. Listed below are the sources used to project non-routinely shipped wastes:

- **Research reactors and radiopharmaceutical reactors** used NUREG/CR-1756 (1) for decommissioning calculations.
- **Light Water Reactor decommissioning.** Volumes and activities were described using NUREG/CR-0672 (2) and the 1978 edition of NUREG/CR-0130 (3). Waste class was determined using the 1979 (4), 1983 (5), and 1984 (6) updates. Volumes and activities were scaled using NUREG/CR-4370 (7). Activation products were calculated using the 1983 update (5). SAFSTOR activities for Indian Point 1 were calculated using the 1984 update (6).
- **LWR Decontamination events.** Radionuclide spectra were developed using EPRI NP-5900 (8). Volume and activity were estimated using NUREG/CR-4370 (7).
- **LWR Irradiated hardware**. Volume was projected using NUREG/CR-4370 (7), Luksic (9), and utility

data. Radiological properties were developed using NUREG/CR-4370 (7), SAIC (10), and utility data.

- **LWR Spent Fuel Disassembly Hardware.** Volume was calculated using Luksic (9). Activity was estimated using SAIC (10).
- **Americium and Tritium using industries** used NUREG/CR-1754 (11) for decommissioning calculations.

Development of the Base Year

The Base Year was essentially a characterization of several hundred waste streams by certain parameters. Characterizing each waste stream by each parameter allowed the necessary data to be sought and collected, waste streams to be consistently described, and data files to be constructed and sorted. For both routinely and non-routinely generated waste categories, a Base Year was developed which characterized every waste stream by every parameter. This information was entered on a Lotus 1-2-3 spread sheet. The following parameters were used:

- Facility Category (brokered, radiopharmaceutical, BWR, etc.).
- Generator (brokered, or specific major generator).
- Physical Form (Co-60 sealed sources, biological, resin, metal, evaporator bottoms, filter cartridges, etc).
- Treatment (super-compaction, solidification, none, etc.).
- Waste Class.
- Annual volume.
- Annual activity.
- Generation start and end years.
- Container data (type/description, burial volume, annual disposal rate, full weight, and contact radiation level).
- Radionuclides (specifically identified).
- Physical and chemical description.

Adjustment of the Base Year

The development of a data base from historical sources, such as the NUREGs and 1987 shipping manifests, provided the primary source data for the development of the Base Year. However, it became evident early in the effort that such data would need to be supplemented by other sources to reflect trends in generation. Future trends and changes in waste characteristics were projected from various sources such as generator estimates, radioactive material-use projections, and decommissioning projections. The Base Year was than modified to account for any unusual aberrations in the data peculiar to 1987 in order to specifically reflect:

- Estimates of changes provided by major generators expected in demand, product mix, process, volume reduction, facility modifications, decontamination or other maintenance events, plant life extension plans, and decommissioning.
- Estimates by industry experts regarding expected trends in radioactive material usage.
- Historical trends in generation volume and activity.
- Impacts of possible variables such as economic conditions, performance, processing, and volume reduction.

Development of Assumptions and Scenarios

Projecting LLRW volumes and activities for 30 and 60 years required the use of many assumptions. Nevertheless, the Source Term Report utilized the best information available and contained what are considered to be reasonable assumptions. Some of the assumptions are reflected in the multipliers used to obtain the expected, minimum, and maximum volume and activity values from the Base Year. Multipliers were used to scale the Base Year according to a particular scenario. The multiplier of 1.0, usually used for the Expected Case, reflects the assumption that 1987 was a fairly representative year for routinely generated waste streams. For the Minimum Case, multipliers between 0 and 1 were used to obtain low volume and activity values, reflecting factors which decrease LLRW generation, such as increased utilization of compaction or improved technological efficiency. Likewise, for the Maximum Case, multipliers greater than 1 were used to obtain high volume and activity values, reflecting factors which increase in generation, such as loss of compaction services or increased use of radionuclides in therapy or diagnosis.

Thus, the Expected, Minimum, and Maximum, Case scenarios were derived by obtaining the product of the Base Year attributes and the multiplier for the particular scenario. The waste streams were projected for the number of years the generator was expected to remain operating, up to 60 years. The major assumptions which significantly impact LLRW projections are listed in Table I.

Construction of the Database

An electronic spreadsheet was constructed to allow data sorting. Both 30 and 60 year projection subtotals were developed. A 30 year projection was chosen because State regulations require that the disposal facility operate for at least 30 years. A 60 year projection was chosen because the economic advantage of not constructing a second disposal facility during the next 30 years warranted evaluation.

Utilization of Peer-Review Feedback

The document was than subjected to a peer review. Input from major generators and State officials were obtained and used to modify the projections.

Quality Assurance and Data Management

Since the inventory projections will be used to gauge the disposal facility's performance, development of the Source Term Report was a Quality activity imploring adherence to Quality Assurance plans and procedures. Decommissioning studies, shipping manifests, *generator LLRW* Report Forms, computer printouts, applicable industry studies, trip reports, calculations, documentation, and transmittal letters are maintained in hard copy files. Software files are maintained on D-Base III or Lotus 1-2-3 files.

RESULTS

The study projected that the disposal facility would receive an annual volume of about 100,000 ft^3 and 100,000 Ci in the 60 year Expected Case. The volumes (in cubic feet) and activities (in curies) projected for the six scenarios are summarized in Table II.

TABLE I
Major Assumptions in the Source Term Report

USE OF 1987 DATA	The Source Term Report employs 1987 manifest data to develop a Base Year for routine waste streams.		
	A multiplier of 1.0 was used most often.	Multipliers between 0 and 1 were used.	Multipliers between 1 and 2 were used.
NEW NUCLEAR POWER PLANTS	No new LWRs will become operational during the operational life of the disposal facility. Demand for electricity will be met by existing sources, alternative non-nuclear sources, imported electricity, and conservation.		1 new 650 MWe BWR and 2 new 650 MWe PWRs become operational.
OUT-OF-STATE TREATMENT	Some LLRW is currently shipped out-of-state to be super-compacted or incinerated before disposal. For this Case, out-of-state treatment continues at current rates (status quo).		Services cease. Scintillation fluid is placed in facility. DAW is not super-compacted
BELOW REGULATORY CONCERN	NRC proposal to land-fill or incinerate some LLRW with short half lives & low activity as non-LLRW doesn't occur.	BRC is adopted. Brokered and LWR DAW volume is reduced 90%	Same as Expected Case.
LWR ROUTINELY GENERATED WASTE	Generation of routine waste stream volumes and activities remain at current levels.	90% less DAW vol/act due to incineration, VR, and BRC. 50% less act in resin, sludge, & evaporator bottoms.	100% increase in DAW volume due to loss of volume reduction services.
NINE MILE POINT TWO	NMP2 nuclear power station became operational in 1986. As a result, 1987 manifest data, the most current available in 1990, was not adequate for projections. LLRW generation projections for NMP2 were developed utilizing manifest data from reference BWRs, scaled to NMP2's capacity.		

	EXPECTED CASE	MINIMUM CASE	MAXIMUM CASE
SHOREHAM	Shoreham Nuclear Power plant operates and ships LLRW to the facility	Shoreham does not operate.	Same as Expected Case.
REACTOR OPERATING LIFE AND DECOMMISSIONING	NMP1 & Ginna operate 40 yrs. Other LWRs operate for 50 years (10 year Plant Life Extension).	All LWRs operate 40 years.	Same as expected Case
	Ginna and NMP1 are decommissioned via immediate dismantlement (LLRW put in facility). Other LWRs undergo delayed decomm (LLRW is not put in facility).	Delayed decommissioning of all LWRs - LLRW is not placed in the facility.	All LWRs are immediately dismantled - all LLRW is placed in the facility.
	Delayed decommissioning generates LLRW identical to routinely generated waste for 2 years after operations cease.		
	Cintichem operates 55 years (15 year PLEX) and is decommissioned in 2017.	Cintichem operates 45 yrs (5 yr PLEX) and is decommissioned in 2007	Cintichem operates 60 yrs (20 yr PLEX) and is Decommissioned in 2022.
	Research reactors at SUNY Buffalo and Cornell operate 40 years.		
FLAT TREND PROJECTIONS	Although generators generally forecast increasing volumes & activities, the data has historically showed a down trend. Routine LLRW projections were conservatively assumed to remain constant.		
JANUARY 1, 1993	Operating sites will refuse to accept out-of-state waste after January 1, 1993. Regardless of when the facility actually opens, it will eventually accept waste generated after that date (even LLRW in interim storage).		

IRRADIATED COMPONENTS	Irradiated components are within Class C limits & are shipped as Class C.			
	IRCs are stored for decay for 1 fuel cycle (1½ – 2 yrs). Average PWR IRC shipments contain 1200 Ci. Average BWR IRC components contain 1600 Ci.			
	PWRs	1 shipment/yr	1 shipment/2 yrs.	3 shipments/2 yrs.
	BWRs	IRCs shipped/yr: NMP1: 20 NMP2: 30 FITZ: 20 SHOR: 20	IRCs shipped/yr: NMP1: 10 NMP2: 20 FITZ: 12 SHOR: 0	IRCs shipped/yr: NMP1: 30 NMP2: 40 FITZ: 32 SHOR: 32
	Spent Fuel Disassembly hardware exceeds Class C limitations and will not be placed in the disposal facility.			Fuel bundles are consolidated 3 yrs before fuel pool is at capacity. SFD is within Class C limits and is put in facility.
WASTE FORM, CONTAINERS	Waste forms and containers for routinely generated LLRW remain as those currently shipped to existing shallow land burial disposal facilities.			
NUCLEAR POWER PLANT DECONTAMINATION WASTE	PWRs	1 subsystem decontamination every 5 years.	1 subsystem decontamination prior to decommissioning.	Same as Expected Case.
	BWRs	a recirculating piping decontamination every 3 years.	1 subsystem decontamination prior to decommissioning.	Same as Exp Case - 1 full primary system decon

The order of magnitude difference between the Minimum and Maximum Cases reflect uncertainties regarding such issues as power reactor decommissioning or irradiated reactor component shipments.

Class A waste was estimated to account for 97% of the volume placed in the disposal facility. Class C waste was projected to account for 1% of the volume, but 94% of the activity.

Significantly less LLRW was projected to be disposed during the facility's second 30 years of operation. This occurs because, in the Expected Case, no new nuclear power plants are projected to operate and most existing plants cease to operate during this period. Nuclear power accounted for 98% of the activity (81% from irradiated components and 17% from other waste streams). Nuclear power accounted for 68% of the total volume (56% from routinely generated LLRW and 12% from decommissioning). The remaining volume was projected to come from institutions, radiopharmaceutical manufacturing and other industries, and sealed sources.

The annual activity of LLRW projected for disposal was significantly higher than the historical shipping record. Although annual State disposal rates were only a few tens-of-thousands of curies during the 1980s, the facility was projected to receive about 100,000 Curies annually. Most of this activity was projected to come from irradiated reactor components from nuclear power plants. Although IRCs had not been regularly shipped at the time, diminishing on-site spent fuel pool storage space was anticipated to result in regular IRC utility shipments in the near future.

Most of LLRW activity was projected to be comprised of radionuclides with relatively short half-lives. Co-60 and Fe-55, primarily from the irradiated reactor components, accounted for over 90% of activity shipped for disposal. Both radionuclides have half-lives of less than six years. Radionuclides with half-lives greater than 500 years were expected to account for 0.04% of the activity. The activity in IRCs are tightly bound within corrosion-resistant metals and are highly immobile. Initially they are highly radioactive, but 79% of the activity decays within 10 years.

To account for radioactive decay, a spreadsheet decay analysis was performed to approximate the residual activity in the facility at various times during operations. As a result of decay, although six million curies of LLRW were projected to be disposed in 60 years, the maximum residual curie content was projected to be less than one million curies. Even if the facility operated for 60 years, the residual activity was expected to drop rapidly during the second 30 years of operation. For the 30 year facility, this decrease occurs entirely because disposal operations have ceased. For the 60 year facility, the decrease occurred despite continued operations because the rate of radioactive decay was projected to exceed the rate of activity accumulated from disposal, due to the operation of fewer nuclear power plants.

Residual activity at closure was projected to be 904,000 curies and 421,000 curies for the 30 and 60 year facilities, respectively. At 100 years after closure, roughly 99% of the activity will have decayed, leaving about 47 thousand Curies for either a 30 or 60 year facility.

MODIFICATIONS PLANNED FOR FIRST REVISION

When published in 1990, the STR represented the State's best estimate of the LLRW expected to require disposal in the LLRW disposal facility. Better source data has become available since then. The STR will be revised and the new edition will be available by early 1994. It will use the same bottom-up projection development methodology, but will be modified to:

- simplify projection methodologies for some waste categories.
- update assumptions, such as the operating status of the Shoreham nuclear power and Cintichem radiopharmaceutical reactors.
- estimate yearly volume and activity totals during operations.
- incorporate findings from current Commission projects on waste form and container performance, container standardization, and waste form stabilization.
- estimate LLRW resulting from the normal operation and closure of the disposal facility itself.
- utilize the findings of a recent EPRI study of I-129 and Tc-99 generation rates in New York State power reactors.
- estimate a New York mixed waste inventory term based on the EPA/NRC Mixed Waste Profile and DOE Mixed Waste Management Options Study.
- utilize improved database management software.
- utilize SOUCREDK^{TM}, a now widely used radioactive decay software conceptually designed by Commission staff and developed and marketed by Grove Engineering.

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TABLE II
Total Volume and Activity Projections

	Expected Case		Minimum Case		Maximum Case	
Period	Volume (ft^3)	Activity (Ci)	Volume (ft^3)	Activity (Ci)	Volume (ft^3)	Activity (Ci)
30 YEARS:	4.04E6	4.41E6	9.95E5	1.71E6	6.63E6	7.89E6
60 YEARS:	5.79E6	6.02E6	1.40E6	1.91E6	1.37E7	1.23E7

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