# INNOVATIONS AND THEIR SIGNIFICANCE TO LOW-LEVEL RADIOACTIVE WASTE MANAGEMENT IN THE U.S.

H. W. (Bud) Arrowsmith
RWE NUKEM Corporation
800 Oak Ridge Turnpike, Suite 701, Oak Ridge, TN, 37830

## ABSTRACT

H.W. (Bud) Arrowsmith is the 2003 recipient of the distinguished Richard S. Hodes, M.D. Honor Lecture Award from the Southeast Compact Commission in recognition of his implementation of numerous innovations in low-level radioactive waste management in the United States.

Mr. Arrowsmith was the founder and served as the President and CEO of the Scientific Ecology Group. He and the company played a significant role in solving waste management problems in the United States by providing critical new technology, facilities, and resources for the nuclear industry.

The innovative technologies to be discussed during the presentation include compaction, decontamination, incineration, recycling, and survey and release.

Mr. Arrowsmith will also share his views on the need for continued innovation in the low-level waste management field. Points to be discussed include:

- The need for continued innovation in waste characterization and processing technology;
- Concerns about continuing access to existing disposal facilities; and
- The absence of progress among interstate compacts to site low-level waste disposal facilities.

## INTRODUCTION

This paper describes the implementation of a business strategy which relied on large scale, advanced waste processing technology to reduce the volume of radioactive waste being produced by the U.S. commercial nuclear power plant industry. The development and implementation of the business strategy depended on correctly anticipating the impact of the Low-Level Radioactive Waste Policy Amendments Act of 1985 on the management of U.S. low-level radioactive waste. The Amendment placed waste volume limits and waste disposal price increases on waste from nonperforming Compact regions.

This paper also discusses the difficult situation that is being created by the U.S. failure to develop new low-level waste disposal sites.

### U.S. Radioactive Waste History

The generation of nuclear wastes began during World War II as a result of federal efforts to develop atomic weapons. The Atomic Energy Act (AEA) of 1954 permitted commercial entities to possess, own, and use radioactive materials. A 1959 amendment to the AEA authorized qualified states to assume regulatory oversight for the possession, use, and disposal of many kinds of radioactive materials, including the disposal of commercially generated low-level wastes. In 1960, the Atomic Energy Commission (AEC) announced that it would phase out the use of its facilities for disposing of commercial

low-level wastes. Instead, AEC or "agreement states" would license privately operated disposal facilities for these wastes.

From 1962 through 1971, six commercial disposal facilities located in Illinois, Kentucky, Nevada, New York, South Carolina, and Washington State were licensed to operate. By 1979, however, the disposal facilities in Illinois, Kentucky, and New York were permanently closed for a variety of reasons. Only the sites in Nevada, South Carolina, and Washington remained open to serve commercial generators of low-level radioactive wastes.

The need for the Low-Level Radioactive Waste Policy Act of 1980 was created as a result of the following actions:

- July 1979, the Governor of Nevada ordered the disposal facility for commercially generated low-level radioactive waste in that state shut down temporarily because a number of waste shipments to the facility were found to have leaking containers.

- October 1979, the Governor of Washington ordered that state's disposal facility, which is located about 20 miles from the city of Richland on DOE's Hanford site, to shut down after similar deficiencies were found in waste shipments bound for the facility.

- The Governor of South Carolina said that the Barnwell disposal facility in that state was receiving up to 90 percent of all commercially generated low-level radioactive wastes in the United States.

By the end of that year, Washington and Nevada had allowed their disposal facilities to reopen and Congress promised to act on the problem. A task force convened by the National Governors' Association recommended that the states be responsible for the development, as well as the regulation, of disposal facilities for commercially generated low-level radioactive wastes.

Late in 1980, Congress enacted the Low-Level Radioactive Waste Policy Act of 1980. The Policy Act encouraged states to form regional compacts to meet their collective disposal needs, minimize the number of new disposal sites, and more equitably distribute the responsibility for the management of low-level radioactive wastes among the states. As an inducement to states to form compacts and develop disposal facilities, the act stated that, beginning January 1, 1986, compacts could, under certain conditions, restrict the use of their disposal facilities to low-level radioactive wastes generated within their respective regions.

By the end of 1983, nearly 40 states had formed seven compacts, and it had become clear that no new disposal facilities would be ready for at least another 5 years. In 1986, Congress passed the Low-Level Radioactive Waste Policy Amendments Act of 1985. This Act represented a compromise.

Waste generators in states that were relying on the Barnwell, Beatty, and Richland disposal facilities got a 7-year extension (until the end of 1992) of the period during which they could ship wastes to those facilities. The Act also provided the following:

- States must enact compact or state legislation to prove their intent to develop their disposal site by 1986;

- Regional compacts without sites for disposal facilities must designate a host state by 1988;

- Regional compacts must file a license application by 1990;

- Regional compacts or states must file a license application for a disposal facility or pay a penalty surcharge by 1992;

- Regional compacts must provide for disposal of LLW or forfeit surcharge rebates by 1993; and

- Regional compacts and unaffiliated states without disposal facilities must provide for disposal of all low-level radioactive waste generated within their borders after January 1996.

The three states hosting the existing disposal facilities—Nevada, South Carolina, and Washington—received additional assurances that other states or compacts would develop their own disposal facilities.

As a result of the Compact process failure to develop new sites, the three operating burial sites took the following actions:

- The Governor of Nevada issued an executive order prohibiting the storage and/or disposal of additional low-level radioactive wastes on state-owned land (such as the Beatty facility) after December 31, 1992;

- South Carolina agreed to permit waste generators located within and outside of that Compact to continue shipping low-level radioactive wastes to the Barnwell disposal facility in that state until June 30, 1994. From then until mid-1995, access to the Barnwell facility was restricted to waste generators within the Southeast Compact region. During this 1-year period, waste generators in 33 states did not have access to facilities for disposing of their low-level radioactive wastes. In July 1995, however, South Carolina withdrew from the Southeast Compact and reopened access to the Barnwell facility to waste generators in all states except North Carolina. South Carolina prohibited the disposal of low-level wastes generated in North Carolina because of what it regarded as North Carolina's lack of satisfactory progress in developing a new disposal facility for the Southeast Compact; and

- Washington continued to permit the Richland disposal facility to operate. The state, however, restricted the use of the facility to waste generators within the eight member states of the Northwest Compact (of which Washington was a member) and, by contract, within the three states that comprised the Rocky Mountain Compact.

In the early 1990s, a new facility for disposing of certain types of low-level radioactive wastes and mixed low-level wastes was licensed and developed in Utah. In March 1991, Envirocare applied for and received a state license to dispose of Class A low-level radioactive wastes limited to the specific radionuclides and maximum concentrations of radioactivity stated in the license.

**U.S. Waste Disposal Cost History**

Since the late 1960s when the first five commercial nuclear power plants, including Dresden 1, Yankee Roe, Big Rock Point, Indian Point 1, and Humbolt Bay 3, were commissioned, each nuclear power plant has processed its own radioactive waste. When the plants were first built, waste disposal was not a major factor in the cost of operation. From 1962 through 1971, six commercial disposal facilities located in Illinois, Kentucky, Nevada, New York, South Carolina, and Washington State were licensed to operate. Each of these facilities was initially designed to use a relatively simple approach called "shallow land burial," in which wastes are placed into excavated trenches. By 1979, however, the disposal facilities in Illinois, Kentucky, and New York were permanently closed for a variety of reasons and the cost of radioactive waste disposal began to increase.

As illustrated in Fig. 1., by 1986, the cost of waste was $25 per cubic foot and would over time rise to almost $300 per cubic foot, driven by the following factors, which are described in more detail in the history section of this paper:

- Decreasing burial site availability;
- Surcharges imposed as a result of the 1985 Act; and
- Price increases imposed by the burial sites to maintain profit margins.

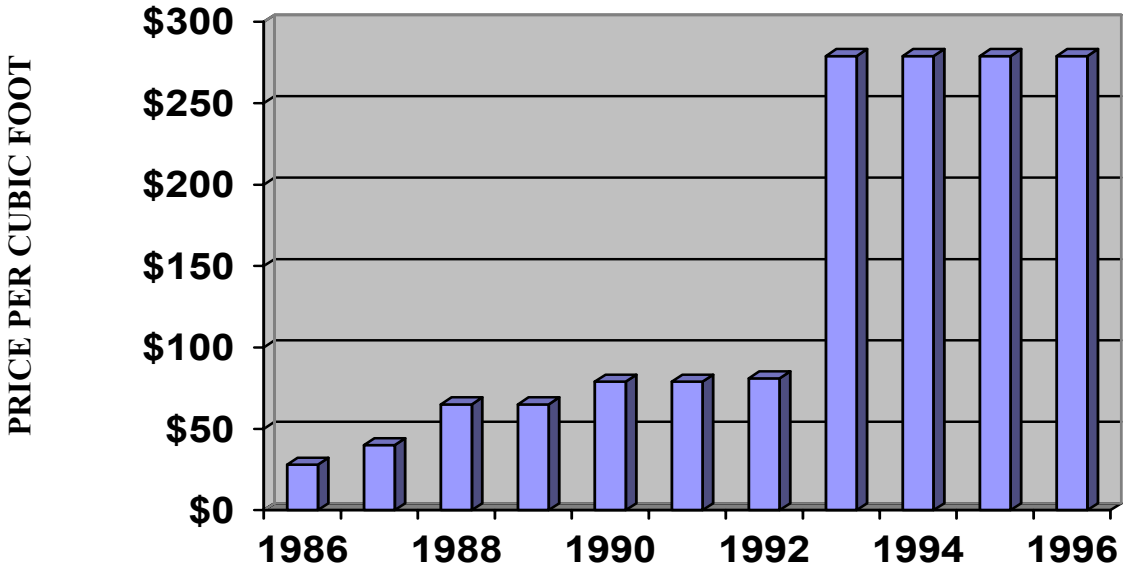


Fig. 1 The price per cubic foot to dispose of LLW rose dramatically from 1986 to 1996.

**Historical Waste Disposal Volumes and Operating Nuclear Plants**

Waste volumes that required disposal dropped during the period from 1986 to 1996 even though 11 new nuclear reactors became operational (see Fig. 2.). This drop can be attributed to the increased cost of waste disposal and the excellent results produced by the development of the Scientific Ecology Group's Centralized Radioactive Waste Processing Plant.

**HISTORICAL U. S. LLW DISPOSAL VOLUME**

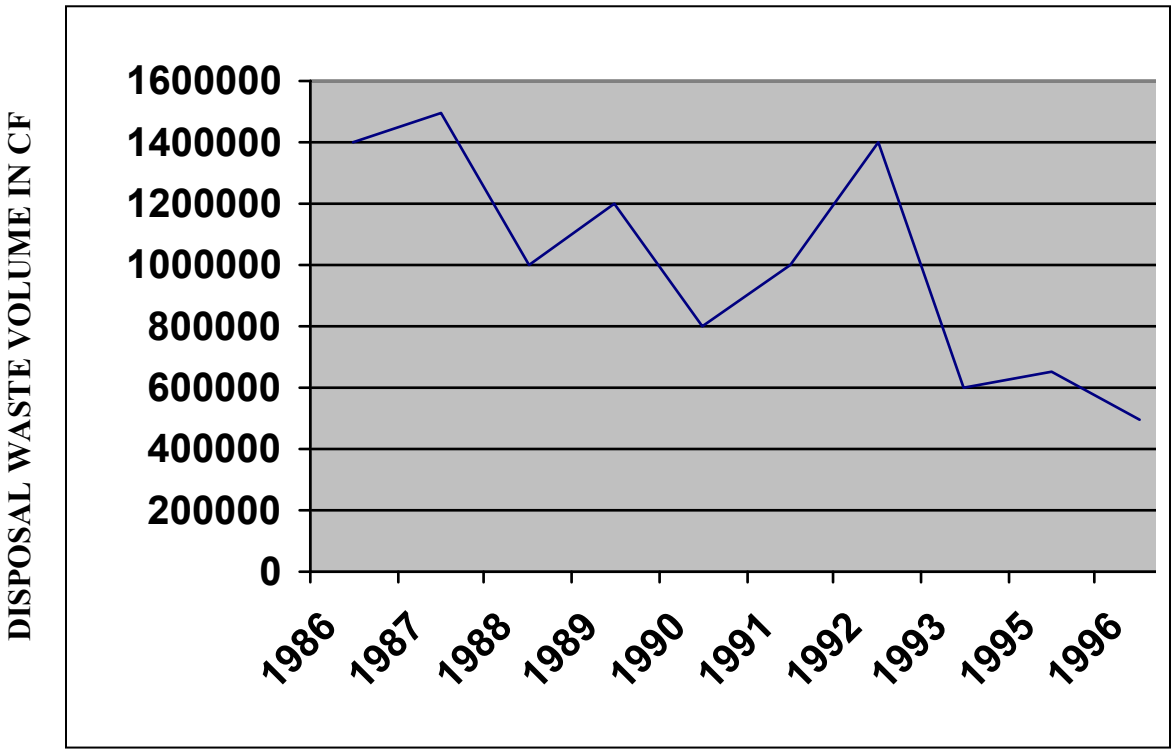


Fig. 2 During the late 1980's, 11 new nuclear plants were added and contributed operational radioactive waste to the U.S. waste totals.

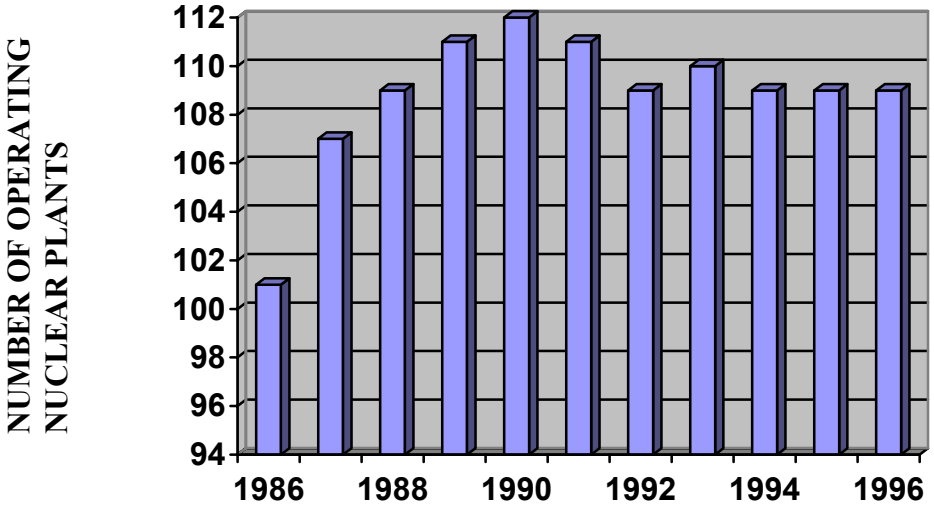


Fig. 3 The number of operating nuclear plants in the U. S. increased during the period.

**DESCRIPTION OF SEG'S CENTRALIZED LLW PROCESSING CENTER**

In 1985, with an expectation that Congress would amend the 1980 Low-Level Radioactive Waste Policy Act, a business strategy was developed. The Scientific Ecology Group (SEG) was formed with the purpose of developing a centralized radioactive waste process center which would address and solve the radioactive waste challenges faced by the commercial nuclear power industry as described above. The challenges included:

- Waste volume caps imposed on selected waste generators;
- Significantly higher waste disposal costs; and
- Emphasis on reducing radiation exposure to power plant workers

SEG's business strategy relied on the fact that waste volume limits and price increases would quickly force power plants to enhance their own waste processing capability or send their waste to a well-equipped central waste processing center for waste volume reduction and shipment of the resulting waste to one of the low-level waste disposal sites.

To prepare for this business opportunity, SEG conceptualized, designed, planned, licensed, and built a $5 million waste processing plant in Oak Ridge, Tennessee. Initially the plant was equipped with a capability to receive and compact radioactive waste in a 5,000 ton Ultra-compactor™. The Ultracompactor™ was designed by the SEG engineering staff, and it was unique because it could compact 38 cubic foot boxes of waste compared to previous supercompactors, which compacted waste in 7.5 cubic foot drums. The size and efficiency of compacting waste in larger size containers made the operational cost of the SEG facility lower than the cost of its competitors. Carolina Power & Light and New York Power were the first customers to sign long term contracts with SEG. When SEG began processing waste in late 1986, waste disposal costs were in the high $20's per cubic foot. With the cost advantage, SEG gained market share and began to grow.

By 1989, the waste disposal market price had risen to over $60 per cubic foot, which provided SEG with the opportunity to enhance its waste processing systems. In order to finance the next step in SEG's development, its founders sold the business to the Westinghouse Corporation to obtain the capital necessary to build the first commercial waste incinerator. With the sale completed, SEG installed a previously licensed waste sorting capability and the first commercial radioactive waste incinerator in the U.S. The cost of the waste sorting capability and incineration capacity was approximately $15 million. The incinerator was capable of burning 800 pounds of radioactive waste. Radioactive oil and radioactive water was used for temperature control in the primary chamber. With the addition of the waste sorting and incinerator, the volume reduction ratio SEG could attain immediately increased from an average of 3.8 to 6.6, based on the 75:1 volume reduction obtained through the incineration of the combustible fraction of the LLW waste stream. The increased processing efficiency removed a significant amount of waste from the nation's waste stream and enhanced SEG's competitive position even further.

By 1992, SEG's market position supported the installation of a second incinerator and a metal recycling plant. The $20 million metal recycling plant was the first metal recycling plant in the nation to be equipped with a decontamination and metal melting capacity. The metal recycling plant processed between 2,000 and 6,000 tons of contaminated metal per year. For the metal that could not be decontaminated, a 20-ton induction furnace was used to cast the contaminated metal into 5 and 10-ton shield blocks which were used by DOE to enhance the safety at its high energy facilities at Los Alamos,

Brookhaven, and Argon Laboratory Facilities. In 1992, SEG received 2.2 million cubic feet of waste and achieved a 10:1 volume reduction ratio on that waste.

The impact of the waste surcharges for non-performing Compact Regions and the continuing volume reduction improvements by SEG drove the burial site operators to increase prices. As the burial site operators increased prices, SEG developed new, even more efficient waste processing technologies that permitted the company to boost its profit margin despite the burial cost hikes.

One of the final major waste processing strategies implemented by SEG was a "green is clean" waste processing program. In this strategy, waste generators shipped waste to SEG for monitoring. Waste that could be free released was disposed of as municipal waste. Waste that was very slightly contaminated was disposed of in a licensed industrial landfill. Radioactively contaminated waste was processed using SEG waste sorting, Ultracompaction™, incineration, decontamination, and metal melting technologies.

## IMPACT OF THE SEG CENTRALIZED LLW PROCESSING CENTER

The implementation of the variety of technologies discussed above had a dramatic impact on the U.S. radioactive waste stream. The table below demonstrates that impact:

**Performance and Impact Estimate for SEG Advanced LLW Processing Technology on the U. S. Disposal Volumes**

| Years | Year | Received Volume | Volume Reduction Ratio | Volume Requiring Disposal | Estmated Burial Price | Estimated Savings compared To Direct Burial (1) |
|---|---|---|---|---|---|---|
| 1 | 1987 | 325,000 | 3.3 | 98,485 | $40 | $2,265,152 |
| 2 | 1988 | 830,000 | 3.5 | 237,143 | $65 | $9,633,929 |
| 3 | 1989 | 961,000 | 3.8 | 252,895 | $65 | $11,506,711 |
| 4 | 1990 | 1,200,000 | 6.6 | 181,818 | $79 | $20,109,091 |
| 5 | 1991 | 1,700,000 | 9.1 | 186,813 | $79 | $29,885,440 |
| 6 | 1992 | 2,200,000 | 10.1 | 217,822 | $81 | $40,139,109 |
| 7 | 1993 | 2,600,000 | 12.1 | 214,876 | $279 | $166,362,397 |
| 8 | 1994 | 3,000,000 | 13.1 | 229,008 | $279 | $193,276,718 |
| 9 | 1995 | 2,800,000 | 13.3 | 210,526 | $279 | $180,615,789 |
| 10 | 1996 | 2,600,000 | 13.3 | 195,489 | $279 | $167,714,662 |
| | | 18,216,000 | | 1,829,386 | | |
| 10 Yr. Burial Ground Volume Savings ($ft^3$) | | | | 16,386,614 | | |
| 10 Yr. Reduction in Truck Trips to Burial | | | | 8193 | | |
| 10 Yr. Saving to SEG Customers (Min) | | | | | | $821,508,995 |
| 1 Note Saving equals volume savings X burial price X 25% | | | | | | |

SEG received more than 18 million cubic feet of waste over ten years and buried less than 2 million cubic feet of waste over the same period. SEG's operation resulted in the elimination of 16 million cubic feet requiring disposal. That volume of waste would more than fill the Barnwell burial site to its capacity during the 10-year period.

In addition to the volume saving, SEG eliminated more than 8,000 truck trips to the burial site over the ten-year period and significantly reduced radiation exposure to workers at the commer-cial nuclear plant sites because they handled significantly less waste after SEG introduced its waste processing services.

**INNOVATION IN THE FIELD OF LOW-LEVEL WASTE IS STILL NEEDED**

States, acting alone or within Compacts of two or more, have collectively spent almost $600 million over the last 18 years attempting to find and develop about ten sites for disposing of commercially generated low-level radioactive wastes.

Commercial generators of low-level radioactive wastes throughout the nation generally have access to one or more of the three existing disposal facilities. Waste generators in the 11 states that make up the Northwest and Rocky Mountain Compacts use the Richland facility.

No state is actively attempting to develop a disposal facility (except perhaps Texas). After years of effort and multi-million dollar expenditures, all of the states that had started programs to identify candidate sites for facilities and to license and develop these sites have essentially stopped their programs.

Currently, the Barnwell, Richland, and Envirocare disposal facilities collectively serve 10 compacts made up of 44 states as well as the 8 states (the Low-Level Radioactive Waste Policy Act defines the District of Columbia and Puerto Rico as states) that are not affiliated with a compact. The following is the current situation in the states with burial sites:

South Carolina: Barnwell is slated to close to waste generated outside the state by mid-2008.

Washington State: Washington continues to permit the Richland disposal facility to operate. The state, however, restricted the use of the facility to waste generators within the eight member states of the Northwest Compact (of which Washington was a member) and, by contract, within the three states that comprised the Rocky Mountain Compact.

Utah: Envirocare obtained a state license authorizing the company to use the site to dispose of naturally occurring radioactive materials. The license for the Envirocare facility has been amended to authorize the disposal of most Class A low-level radioactive wastes. Envirocare has received regulatory approval of a license for Type B and C waste, but has suspended its efforts for legislative approval based on resistance to the higher activity waste.

Texas: On May 7, 2003 the Texas Senate passed HB 1567, the nuclear waste bill that, if finally permitted, will enable the creation of not one but two private nuclear waste storage facilities, most likely at Waste Control Specialists' sites in Andrews Co.

The uncertainty of the disposal site operations and the volume of low-level radioactive waste expected to be generated over 40 years of operation is estimated to be approximately 18,000 cubic feet for a pressurized water reactor and approximately 56,000 cubic feet for a boiling water reactor. The resulting total volume from operations and decommissioning is on the order of 30 million cubic feet. In addition, volumes of contaminated soil at fuel cycle sites and sites managed under NRC's Site Decommissioning Management Plan are less well known, but could be on the order of 18 million cubic feet of waste. Consequently, although the estimates carry considerable uncertainty, it is clear that there is a significant volume of low-level waste for which a disposal site or sites will be needed.

Sufficient disposal capacity currently exists to handle today's disposal needs. Particularly in light of the trend towards license renewal of civilian nuclear power plants, however, the future disposal situation is increasingly uncertain. With the eventual closure of the Barnwell disposal facility to states outside the

Atlantic Compact in 2008, the absence of progress in other Compacts to site low-level waste disposal facilities, and few other disposal options, access to facilities for the disposal of low-level waste is increasingly constrained.

Most of the nation is going to depend on Utah to dispose of low-level radioactive waste after Barnwell closes its doors to states outside the Atlantic Compact in 2008. If the State of Utah changes it position on accepting LLW, most of the U.S. could be without access to a low level waste burial site before we know it.

It is time for further innovation in the LLW disposal industry. We must find a way to develop and permanently operate a few sites in the U.S for the disposal of LLW so that the U.S. nuclear industry is not dependent on the political will of any state.