A DEMONSTRATION PROGRAM TO EVALUATE CENTRALIZED LLW INCINERATION

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ABSTRACT

Dramatic increases in low level waste burial charges in the last five years have spurred interest in achieving higher volume reduction than currently achieved by compaction. Battelle has completed a planning study to demonstrate the technical and economic feasibility of central site incineration for dry active waste to service several generators within a geographical area. We initiated licensing by the USNRC and Ohio EPA and developed plans, procedures, and estimated costs for licensing, construction, operation, and decommissioning of a central site incinerator. In addition, acceptance criteria were established for incoming waste. Response from the NRC and Ohio EPA indicated that no major obstacles existed toward obtaining licenses. The economic study indicated that a commercial incineration operation lasting 20 years or more was economically advantageous over direct burial of compacted waste, assuming that burial costs continue to escalate at their current rates. However, a 5-year demonstration period was not economically advantageous because of the short period to recover the fixed capital investment.

INTRODUCTION

Compaction and shallow land burial have generally been considered the most viable method for disposing of low-level radioactive waste (LLW). However, dramatic increases in burial charges in the last half decade have spurred interest in achieving higher volume reduction through alternative methods. This increased interest has been further intensified by the Low-Level Waste Policy Act of 1980. This act, which calls for regional management of LLW, has resulted in predictions of even greater escalation of burial costs. Major generators of LLW who investigated incineration in the past have found proposed construction and operation of their own incinerator not to be cost effective. However, with the reality of regional waste management occurring in the near future, Battelle recognized the possible economic advantages of establishing regional incineration facilities to service several generators within a geographical area.

Several types of radioactive waste incineration are available or under development. In order to determine one suitable for a centralized site, several factors were considered. Primary among these was a determination of the types of waste requiring treatment. Adoption of a centralized facility would necessitate the transport of the LLW from the generators to the incinerator site. Because of regulatory restrictions on the transport of liquid waste, it was virtually mandated that only dry active waste be considered. In addition, it was decided to exclude highly radioactive wastes from consideration. We desired to use an established incinerator design with a reasonable history of successful utilization rather than a design still in the developmental stage or with little operating experience. As a result of our study, we felt that the pyrolysis incinerator developed by Kraftanlagen was best suited to our needs. Atcor Engineered Systems, who holds the rights to market this incinerator in the U.S., shared our interest in such a demonstration program and agreed to collaborate in this effort.

PROGRAM STRUCTURE

Our program was conceived as a demonstration lasting nine years (Fig. 1). This included about 6 months for planning and license application, 21 months for license receipt and construction, five years of incinerator operation, and nine months for decommissioning. We initially solicited sponsorship only for the first phase. The objective of this planning phase was to determine the technical and economic feasibility of continuing on to the remaining phases.

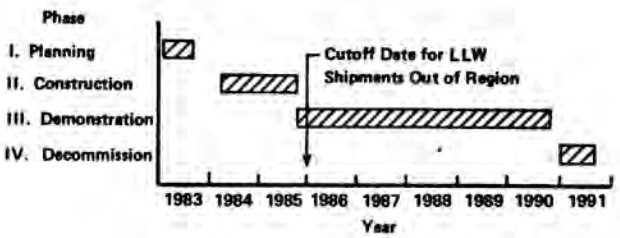

Fig. 1. Program schedule.

SPONSORSHIP

Solicitation for sponsorship in the program was initially concentrated within the State of Ohio. We identified 32 generators (or potential generators) of low level waste (LLW) within the state. These included three nuclear utilities, 6 hospitals, and 23 industrial firms. We subsequently expanded our solicitation into adjacent midwestern states who are eligible for membership in the Midwest Compact. In these states, we concentrated on contacting primarily the nuclear utilities. Our news releases were picked up throughout the country, however, and we found interest outside our region. Our final sponsorship for the Phase I effort included four utilities and one university (Table I).

Table I

Sponsors for Phase I

Toledo Edison Company
Cleveland Electric Illuminating Company
Pennsylvania Power and Light Company
Niagara Mohawk Power Corporation
Case Western Reserve University

INCINERATOR SITING

We planned to locate the incinerator at the Battelle Nuclear Sciences Area near West Jefferson, Ohio. This site, about 20 miles west of Columbus, currently includes the Battelle Hot Cell Facility and our decommissioned research reactor. Locating the incinerator there had several advantages. We would be able to license the facility as part of the existing Nuclear Sciences Area, thus significantly reducing the time required to prepare license applications. We would also be able to draw on our experienced support service groups such as health physics, quality assurance, radioactive materials transportation, and security.

PHASE I. RESULTS

The planning phase had five major thrusts as shown in Fig. 2. Licensing applications were prepared and submitted to the NRC and Ohio EPA. The program plan addressed the practical matters of construction, operating logistics, and decommissioning. Development of the contracting vehicles required scoping of the contracts between Battelle, Atcor, and the waste generators. These required careful consideration in order to protect all parties, identify rights and obligations, and define the liabilities toward other parties in the event of a default or non-compliance with the terms and conditions of the contracts. The public was kept informed by the community relations activity through news releases, meetings with community groups, civic services organizations and members of the Ohio General Assembly. The final activity assimilated the costs estimated in the planning activity and developed total program cost estimates for various funding schemes.

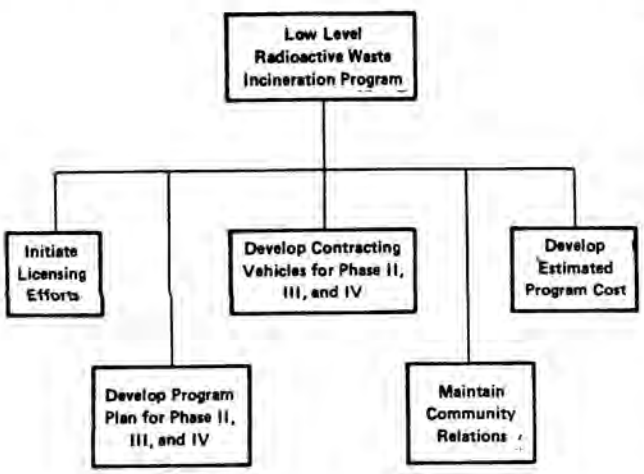

Fig. 2. Phase I activities.

Program Planning

The Planning Phase had five major tasks as shown in Fig. 3. Each of these tasks had several subtasks as indicated. The objectives of the program plan were to identify all the activities which would continue as part of Phases II, III, and IV; establish the waste acceptance criteria needed for inclusion in the contracting instruments; and identify needed manpower, procedures, space requirements, regulatory compliance data, research data, instrumentation, and decommissioning options.

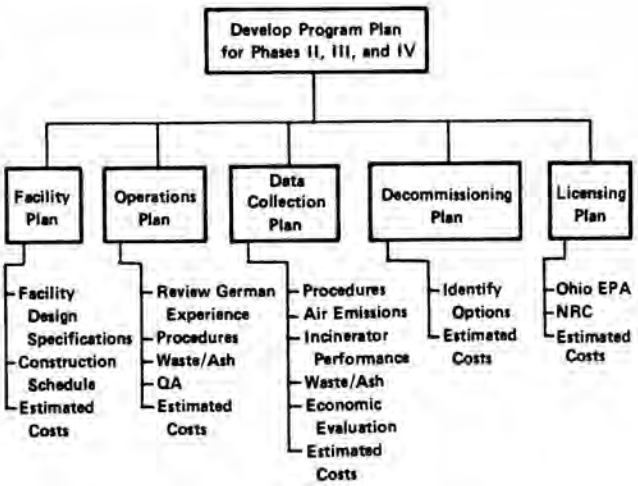

Fig. 3. Program plan subtasks.

Facility

The Volume Reduction Demonstration Facility (VRDF) consists of two adjoining buildings which share a common wall (Fig. 4). The incinerator, control room, offices, and locker rooms are found in the three story Process Building. This building is 60 ft long, 45 ft wide, and 52 ft high. Adjacent to the 60 ft side is the Waste Storage Building. This building, 80 ft long, 60 ft wide, and 12 ft high, is used to receive, monitor and store incoming waste, and to monitor, store and ship out the ash product.

The incinerator is a two-stage pyrolysis incinerator developed by Kraftanlagen and marketed in the U.S. by Atcor Engineered Systems. The combustion chambers are oriented vertically. Waste is charged at the top of the pyrolysis chamber through a waste charging chamber which provides an air lock feature. This design permits continuous feed charging, i.e., waste can be added at frequent intervals without waiting for the waste in the incinerator to be consumed. As it moves downward through the pyrolysis chamber, the waste temperature is raised until at the grates it is 800 C. The heat required to maintain decomposition and combustion normally comes from the waste itself. Auxiliary fuel is usually needed only to begin from a cold condition or if the waste has a low heat content. Gases of decomposition pass through the grates to a combustion chamber underneath, where they are burned with excess air at 900 C. Ash is collected in the bottom of the combustion chamber. The combustion gases pass through a dry off-gas system where particulates are collected. The off-gas system includes a ceramic hot

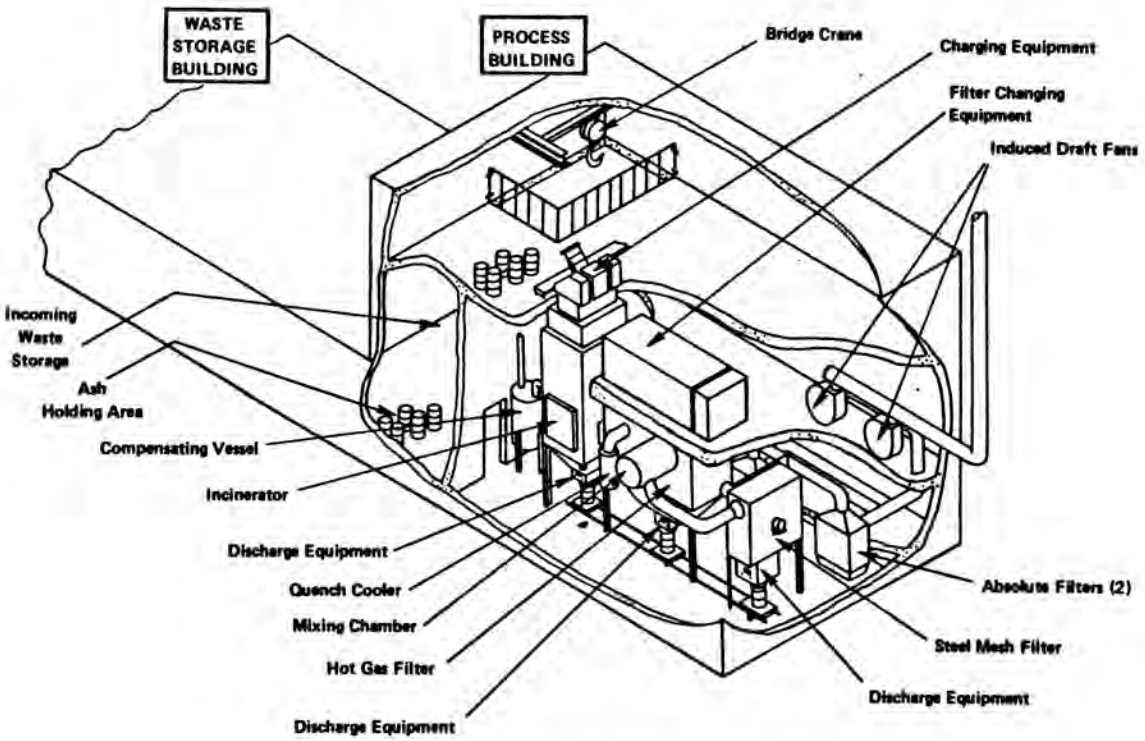

Fig. 4. Volume reduction demonstration facility.

gas filter, a steel mesh filter and spark arrester, and a final, two-stage high efficiency air particulate filter.

Operations Plan

The objective of the operations plan was to identify all the procedures which needed to be prepared prior to start up. These included staff qualifications and training, waste receipt and interim storage, waste and ash handling, waste and ash shipping logistics, quality assurance, health physics, start-up tests, and emergency plans. A key effort of this subtask was to develop waste acceptance criteria and to consider methods which might be used for waste and ash characterization.

It is of prime importance that all outgoing ash meet the regulatory transportation and burial requirements as well as the site specific requirements stipulated by the burial site operators. Thus, characterization of the ash, specifically of the isotopic curie content, is an important element of the facility operation. In addition, the volume reduction will concentrate the radioactivity of the incoming waste in the ash product. Thus it is imperative that the character of the incoming waste is also well known. Since we would be receiving a variety of waste from the participating generators, we decided that it is necessary to use a drum counter or similar assay device for characterizing both the waste and the ash. Several types have been identified but final selection will made during Phase II after more in-depth study.

In order to control the character of the incoming waste we developed Waste Acceptance Criteria. They were developed to meet the following goals:

(1) Adhere strictly to all applicable NRC and DOT regulations

(2) Minimize radiation exposure of incinerator operators

(3) Accept waste in packages as similar as possible to those now utilized by the program's participants

(4) Maximize operating efficiency by optimizing throughput and minimizing costs.

In accordance with these goals, the acceptance criteria have been divided into two categories, inflexible criteria and flexible criteria. The inflexible criteria, Table II, shall be strictly adhered to by all generators sending waste to the VRDF. These criteria address the regulatory requirements and the types of materials and activity levels for which the incinerator is not designed. They also specify the documentation required to facilitate the logistics of managing diverse waste types from several sources. The flexible criteria, Table III, are those which we consider desirable to ensure safe and effective waste management. These criteria are subject to change as justifiable needs arise and are negotiable with the program group clients.

Data Collection

Several types of data will be collected during operation of the facility. Some are related to operation, such as waste receipt and inventory, identification of waste (and ash) by generator, waste receipt and ash shipment logistics, and incinerator operation parameters. Others, such as emission or ash curie content, are related to assuring that regulatory requirements are met. Finally, others are related to

research activities such as the effect of various waste types on filter life. In addition, this subtask was charged with developing an economics evaluation plan to determine detailed cost data for the incineration of LLW in the Volume Reduction Demonstration Facility and to compare the economics of incineration to those of other LLW management schemes.

Table II

Inflexible Acceptance Criteria
For Incoming Waste

1. Full compliance with NRC and DOT packaging and transportation regulations.
2. No explosive materials.
3. No polychlorinated biphenyl materials (PCB's).
4. No pyrophoric materials.
5. Transuranics <10 nCi/gm.
6. Only combustible absorbants for liquids (ground corn cobs, wood chips, saw dust, etc.).
7. No shielded shipping casks or drums.
8. Documentation

   - Compliance with all applicable NRC and DOT regulations
   - Prior notification (7 days minimum)

     -- description of containers
     -- approximate number of containers
     -- approximate composition
     -- approximate waste density or total waste weight
     -- approximate arrival date
     -- carrier

   - With shipment

     -- identification of waste as prescribed on the Radioactive Waste Shipment forms.

Decommissioning Plan

At the end of its useful life, the facility must be decontaminated and decommissioned in accordance with NRC regulations in effect at that time. The function of this subtask was to evaluate alternative methods consistent with the desires of Battelle corporate management and the participating radioactive waste generators.

Several decommissioning alternatives for the low level incinerator were identified. These include:

(1) Mothballing--Shutting down the facility and placing it in safe storage

(2) Sale and Transfer--Sale and transfer of the equipment to another location

(3) Inplace Entombment--Removal of loose contamination and exclusion of persons from the remainder

(4) Decontamination--Complete removal of all contamination and contaminated equipment but building left intact

(5) Complete Dismantlement--Removal of all contamination and contaminated equipment; disassembly of building and site restoration.

Licensing

The application for an amendment to our NRC license was submitted near the end of Phase I. We held informal discussions with the NRC prior to submittal of the amendment application. The application itself contained general conditions and administrative procedures to assure health and safety controls, and descriptive information about the facility. It was accompanied by two supporting documents: an environmental assessment and a report on safety related information. The environmental assessment addressed the impact of the incinerator operation on the ecology of the site and on surrounding areas. The report on safety related information addressed in detail the facility and incinerator construction, process systems, radioactive material confinement, radiation protection, operation procedures, accident analyses and the quality assurance program. In December, 1983, we received a list of 20 questions, many of them asking clarification or noting inconsistencies in statements among different parts of the application. Preparation of a response to the questions is in progress.

Application for a Permit to Install (PTI) was also made to the Ohio EPA near the end of Phase I. The application included descriptive information of the facility, type of waste to be processed, predicted emissions, effect on air quality, planned monitoring, and a construction schedule. Prior to this submittal, we had several informal communications with the EPA to inform them of our intentions and to ascertain any problem areas. Their review resulted in only one question regarding chlorine emissions. This question was satisfactorily answered when we confirmed that measurement of chloride emissions was planned and we agreed to accept that as a condition of the permit.

Program Costs

Upon completion of the program plan, life cycle costs were estimated. For purposes of evaluation, we divided them into fixed costs and operating costs, as shown in Table IV.

These costs need to be recovered over the 5-year operation period of the incinerator in order for the program to break even. Figure 5 shows the average incinerator fee that would have to be charged as a function of LLW incinerated in order to recover these costs over a 5-year period. At a 70 percent capacity factor, considered readily achievable, the cost of incineration is about $1.96/lb. In order to place this cost into a true perspective with alternative methods, the cost of burial must be included.

Historically, the cost of burial at Barnwell has been increasing at about $3.00/yr since 1978 (Fig. 6) and in excess of $4.00/yr at Hanford prior to a reduction in 1983. Using the data in Fig. 6, we developed the comparison shown in Fig. 7 for the cost of compaction and direct burial with incineration for 5-yr and 20-yr cost recovery periods. We used January 1986 as the starting date for the comparison since this is about the time the facility was scheduled to be fully operational. For calculating the burial cost of compacted waste, we assumed a volume reduction of 3 (compacted waste density = 24 pcf), and assigned the perpetuity and

Table III

Flexible acceptance criteria for incoming waste

1. Container surface dose rate, mr/hr

	Uncompacted	Compacted
Maximum average all drums	5	15
Maximum single drum*	100	100

*May be lower during early months of operation.

2. Acceptable Container types

- 55-gallon drums
  - -- uncompacted
  - -- compacted, ~24 PCF
  - -- no compacting discs
- Fiberboard boxes
- Cubic metal boxes or reuseable wooden boxes (waste sealed in 5-10 gallon trash bags

3. Container weight

- 55 gallon drum: 500 lb maximum
- Fiberboard boxes: 50 lb maximum
- Cubic metal boxes (LSA containers): 3000 lb maximum
- Reusable wooden boxes: 2000 lb maximum

4. Loose or Palletized Drums Acceptable

5. Requirements for Palletized Drums

- Open pallets (not enclosed)
- Six (6) drums/pallet maximum
- Banded
- Drums single layered
- Pallet gross weight--3000 lb maximum

6. Free Water: 0.5% by volume

7. Polyvinyl chloride (PVC) and other chlorine containing materials: <10% by volume of shipment

8. Non-combustibles content

- Uncompacted: <5% by volume
- Compacted: <2% by volume
- Scintillation vials: As low as reasonably possible, No specific limit
- No large, heavy or bulky items

Table IV

Summary of Estimated Cost for 5-Year Demonstration Program

Fixed Costs	Operating Expense[a]
Planning	Supplies and Parts
Licensing	Utilities
Incinerator Facility	Services
Ancillary Equipment	Labor
Data Collection Equipment	Insurance and Taxes
Procedures Preparation	Data Collection/Analysis
Personnel Training	Economic Evaluation
Start Up Tests	Nuclear Services (HP, QA, Transp. Mgt., etc.)
Decommissioning	
Subtotal[b]: $9,923M	$9,877M/5 yr
Total: $19.800M	

(a) An annual inflation rate of 7% was assumed in determining the operator expense.

(b) A large number of funding methods, interest rates, and tax advantages are available. Thus, to facilitate comparison, they are not included in these estimated costs.

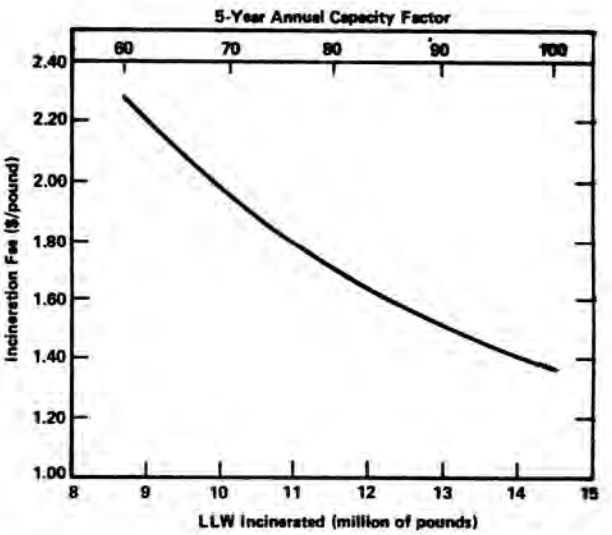

Fig. 5. Incineration costs for 5-yr program.

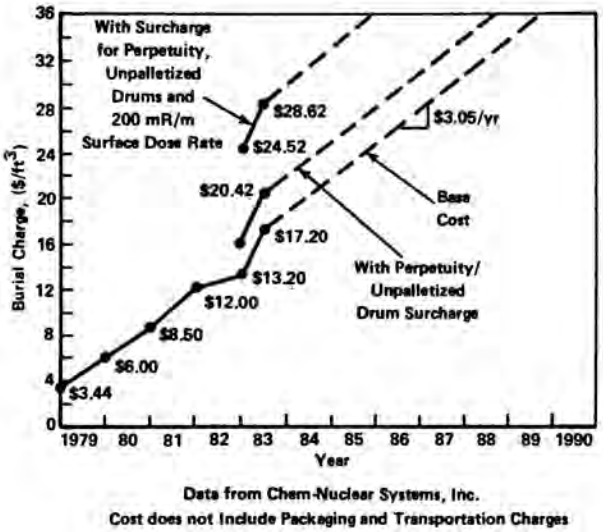

Fig. 6. LLW burial costs

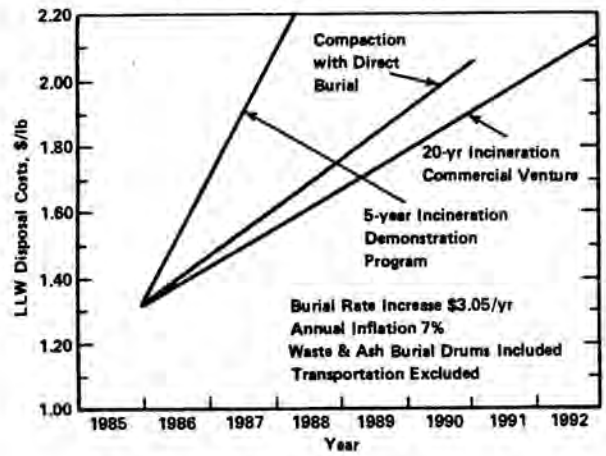

Fig. 7. Comparison of LLW management Alternatives

unpalletized drum charge. We assumed an annual escalation of the burial costs of $3.05/cuft. For the incinerated waste, we assumed a volume reduction of 20 from uncompacted waste (160 lb waste produces 1-cuft of solidified ash). In addition to the perpetuity and unpalletized surcharge, we also applied a burial surcharge for waste drum radioactivity, and assumed an annual 7 percent inflation rate. We assumed that at the beginning of full time operation of the facility in 1986, we would adjust our charges to the user so that the total disposal costs would be the same as for the compaction/direct burial option. (Transportation costs were not included but we determined that these usually impact about 2 to 6 percent of total costs.) Figure 7 indicates that for the short 5-yr pay off the demonstration program incineration is not a viable alternative to compaction and direct burial. However, if a more realistic 20-yr life is considered, the use of incineration will result in a significant savings over compaction/burial. It should also be remembered that Fig. 7 assumes that burial costs will increase at their historic rate. If, as many predict, the rate increases dramatically before the end of the decade, incineration becomes more competitive. This is illustrated in Fig. 8 which presents a curve of the break-even cost between incineration rates and burial rates. Thus, for example, if the rates for burial should escalate to $50/cuft, incineration is a viable alternative at rates up to $2.00/lb of waste processed.

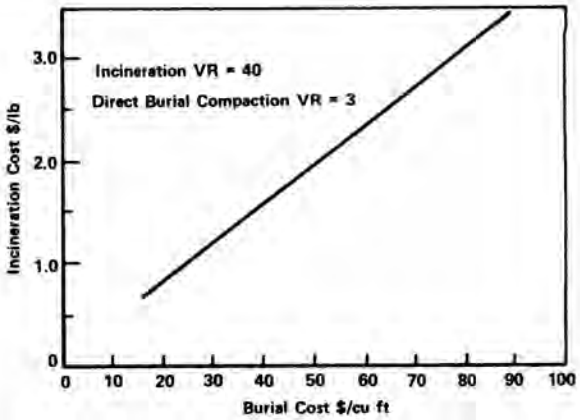

Fig. 8. Break-even curve for incineration vs. direct burial.

COMMUNITY RELATIONS

During the period of proposal issuance in the fall of 1982, Battelle issued a press release indicating our intentions. We received several immediate inquiries from citizens, from a civic organization for a housing development within 1/2 mile of the West Jefferson Nuclear Science Area, and from a service organization in the City of West Jefferson, Ohio, about 2 miles distant. Battelle responded by meeting with these groups on several occasions and by inviting them to visit the site of the proposed facility. We received favorable comments from several sources, including the Mayor of West Jefferson and a county commissioner. The opposition of the more vocal persons was quieted although it was clear that they were still not in favor of the program. One of the more positive factors was Battelle's excellent history of safe operation in the area. Another was the plan to operate the facility only for 5 years, at which time it would be decommissioned. In this same time period early in Phase I, we were also asked to present our plan to several members of the State Legislature.

After this initial activity, there were no more inquiries from the public until near the end of Phase I. A news reporter following up the story from near the start of Phase I called Battelle and asked for a status report. His story, which was very factual and unemotional, renewed public interest in the program. We responded to all inquiries and offered additional meetings. However, the sudden interest almost as suddenly disappeared. As noted below, the program has been suspended until a more favorable economic climate exists.

SUMMARY

The results of the first phase of the program indicated that for the planned 5-yr term of the demonstration program, a central site incinerator is not a cost-effective alternative to compaction with direct burial at the present burial rate escalation. For a normal plant life of 20 years, incineration as a method for waste management is more cost effective than direct burial. If burial rates should increase dramatically, even a 5-yr demonstration period could be cost competitive.