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Waste Management Facilities Cost Information Report

Fred Feizollahi
David Shropshire

EG&G Idaho

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Waste Management Facilities Cost Information Report

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ABSTRACT

The Waste Management Facility Cost Information (WMFCI) Report, commissioned by the U.S. Department of Energy (DOE), develops planning life-cycle cost (PLCC) estimates for treatment, storage, and disposal facilities. This report contains PLCC estimates versus capacity for 26 different facility cost modules. A procedure to guide DOE and its contractor personnel in the use of estimating data is also provided. Estimates in the report apply to five distinctive waste streams: low-level waste, low-level mixed waste alpha contaminated low-level waste, alpha contaminated low-level mixed waste, and transuranic waste. The report addresses five different treatment types: incineration, metal/melting and recovery, shredder/compaction, solidification, and vitrification. Data in this report allow the user to develop PLCC estimates for various waste management options.

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ACRONYMS

alpha-LLMW	Alpha contaminated low-level mixed waste
alpha-LLW	Alpha contaminated low-level waste
B&W	Babcock & Wilcox
BWSDS	Buried Waste System Design Study
D&D	Decontamination and Decommissioning
DOE	U.S. Department of Energy
DOE-ID	U.S. Department of Energy Idaho Field Office
EIS	Environmental Impact Statement
F&OR	Functional and operational requirement
FAST	Freiman Analysis of System Technique
FTE	Full time equivalent
GOCO	Government owned and contractor operated
HDPE	High-density polyethylene
INEL	Idaho National Engineering Laboratory
LDR	land disposal restriction
LICP	Line Item Construction Project
LLRWPAA	Low-Level Radioactive Waste Policy Amendment Act
LLW	low-level waste
LLMW	low-level mixed waste
MCC	Motor Control Center
MK	Morrison Knudsen Corporation, Environmental Services Division
NEPA	National Environmental Policy Act of 1969
NRC	Nuclear Regulatory Commission

O&M	Operations and Maintenance
ORNL	Oak Ridge National Laboratory
PAN	Passive/active neutron
PEIS	Programmatic Environmental Impact Statement
PFD	Process functional diagram
PLCC	Planning life-cycle cost
RCRA	Resource Conservation and Recovery Act
RHMMS	Radiological and Hazardous Material Measurement System
RI/FS	Remedial Investigation/Feasibility Study
ROM	Rough order of Magnitude
RTR	Real-time radiography
RWMC	Radioactive Waste Management Complex
SEG	Scientific Ecology Group, Oak Ridge
SGS	Segmented Gamma Scanning
SSL	Scoping Study Layout
SWSDS	Stored Waste System Design Study
TRAMPAC	transportation package
TDS	Treatment, storage, and disposal
TRU	transuranic
TRUW	transuranic waste
TSCA	Toxic Substance Control Act
WIPP	Waste Isolation Pilot Plant
WMFCI	Waste Management Facility Cost Information

Waste Management Facilities Cost Information

1. INTRODUCTION AND SUMMARY

1.1 Background

The Waste Management Facility Cost Information (WMFCI) report describes the results of a task commissioned by the U.S. Department of Energy (DOE) to develop cost information for the treatment, storage, and disposal (TSD) facilities that will support DOE's multisite waste management facility siting strategy. The report is intended to provide planning level life-cycle cost (PLCC) estimates for TSD facilities that will be needed for DOE in the preparation of the Programmatic Environmental Impact Statement (PEIS). The estimates are based on a set of facility cost modules, each of which may be used alone or combined. All facilities are assumed to be government owned and contractor operated (GOCO).

The scope of this report includes cost estimates for facilities that manage low-level waste (LLW), low-level mixed waste (LLMW), alpha low-level wastes (alpha-LLW), alpha low-level mixed waste (alpha-LLMW), and transuranic waste (TRUW). Estimates are provided for TSD facilities with a wide range of size and throughput capacities for all waste types except the TRUW. Since the current DOE strategy is to dispose of TRUW in the Waste Isolation Pilot Plant (WIPP), only interim storage and disposal facilities are estimated for this type of waste. Facilities do not include TSDs for greater than Class C waste. Cost information in this report is based on the best available knowledge about waste processing requirements, technology availability, and cost data. The information in this report may have to be updated when more knowledge is gained in these areas.

1.2 "WMFCI" Task Participants

The WMFCI task was completed by a project team from EG&G Idaho, Inc. and the Environmental Services Division of Morrison Knudsen Corporation (MK). EG&G Idaho and MK were selected for this task because of their combined expertise in design and construction of waste management TSD facilities for DOE sites and for the nuclear industry (e.g., Waste Characterization Facility at INEL and the Illinois Low-Level Radioactive Waste Disposal Facility). EG&G Idaho has also prepared a buried waste system design study (BWSDS)[1] and a stored waste system design study (SWSDS)[2] with the support of MK and other engineering firms, to evaluate treatment system concepts. The treatment system design concepts and planning level cost estimates addressed in BWSDS and SWSDS are directly applicable to the WMFCI task.

EG&G Idaho provided the overall project management and technical guidance for the study and coordinated preparation of the final report. MK developed preconceptual design packages and prepared PLCC estimates for the facilities.

1.3 Cost Modules and Unit Operations

Each type of TSD facility (common support treatment through final disposal) is referred to as a cost module. There are a total of 26 cost modules (labelled A through S), shown in Figure 1-1. These cost modules can be assembled in various ways to create different types of TSD scenarios. As shown, treatment cost modules are provided for two general categories of waste: LLW/LLMW and alpha-LLW/LLMW. Cost modules for storage and disposal include LLW, LLMW, alpha-LLW/LLMW, and TRUW facilities.

Each facility is broken down into several distinct functions, referred to as unit operations. Unit operations assume inclusion of all buildings, equipment, and accessories needed to accomplish the given function.

1.4 Facility Cost Estimating Methodology

Details of the approach used for developing PLCC estimates in this report are presented in Appendix A. Figure 1-2 shows a block diagram of the steps used in the estimating process. Initially, a capacity range for each type of facility was established by studying the stored and newly generated wastes at various DOE sites. The capacities were based on the total mass or volumes of waste to be processed during a 20-year period. Data from the study defined baseline capacities for three different facility sizes: small, medium, and large. Whenever possible, the baseline capacities were selected to be the same as an existing facility. For example, the medium baseline capacity for incineration is the same as the nominal capacity of the Toxic Substance Control Act (TSCA) incinerator that is currently operating at the Oak Ridge National Laboratory (ORNL). This approach, referred to as "anchoring,"[a] provided a reference point that could be used as the basis for estimating the various cost components. Furthermore, anchoring facilitated comparison of the estimates in this report with either the actual costs incurred by an operating facility or estimates of facilities that are in an advanced design and construction stage.

Using the three capacities for each facility, preconceptual design packages were developed for each facility and used as the basis for PLCC cost estimates. Each preconceptual design package included a process functional diagram (PFD) with mass flow rates, a scoping study layout (SSL), and a summary functional and operational requirements (F&OR). The PFD and SSL drawings were developed to the individual unit operations level. After unit operations were defined, major equipment lists and building square footage requirements were established for each unit operation. The design packages utilized as much of the data from existing or planned commercial and DOE

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a. In this report, "anchor" facilities denote reference facilities that are either in operation or in advanced design and construction stage. "Anchoring" denotes using technical data and capital, operating, and maintenance costs incurred by an anchor facility as a measuring stick in development of the PLCC estimates. Before adopting costs from an anchor facility, they were adjusted to account for any differences in technical requirements and cost escalation. Major anchor facilities are TSCA incinerator at ORNL, Scientific Ecology Group (SEG) waste management facility (incinerator and metal-melting) in Oak Ridge, Simplekemp metal melting facility in Germany, Babcock and Wilcox (B&W) compaction facility in Lynchburgh, and Illinois radioactive waste disposal facility.

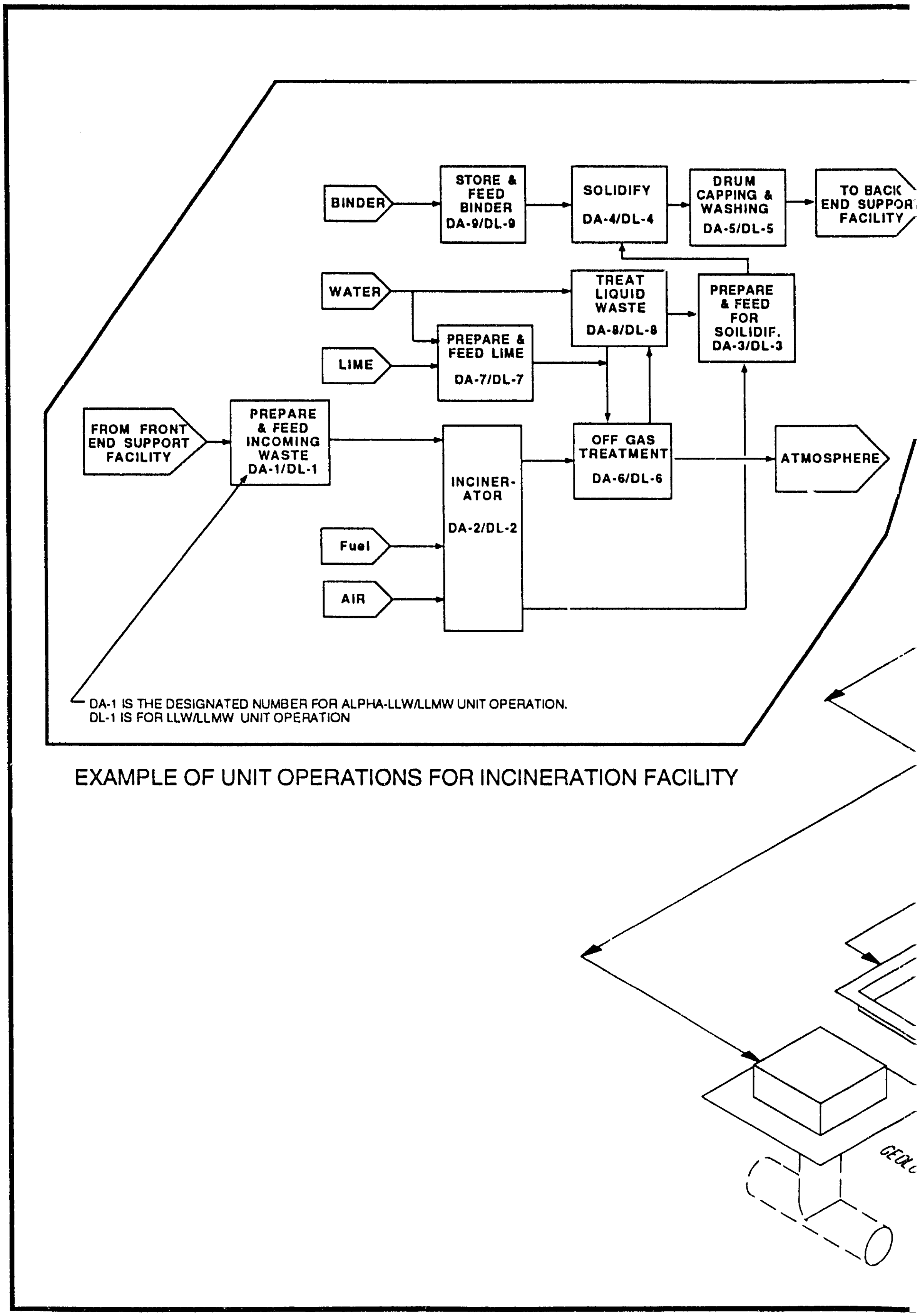
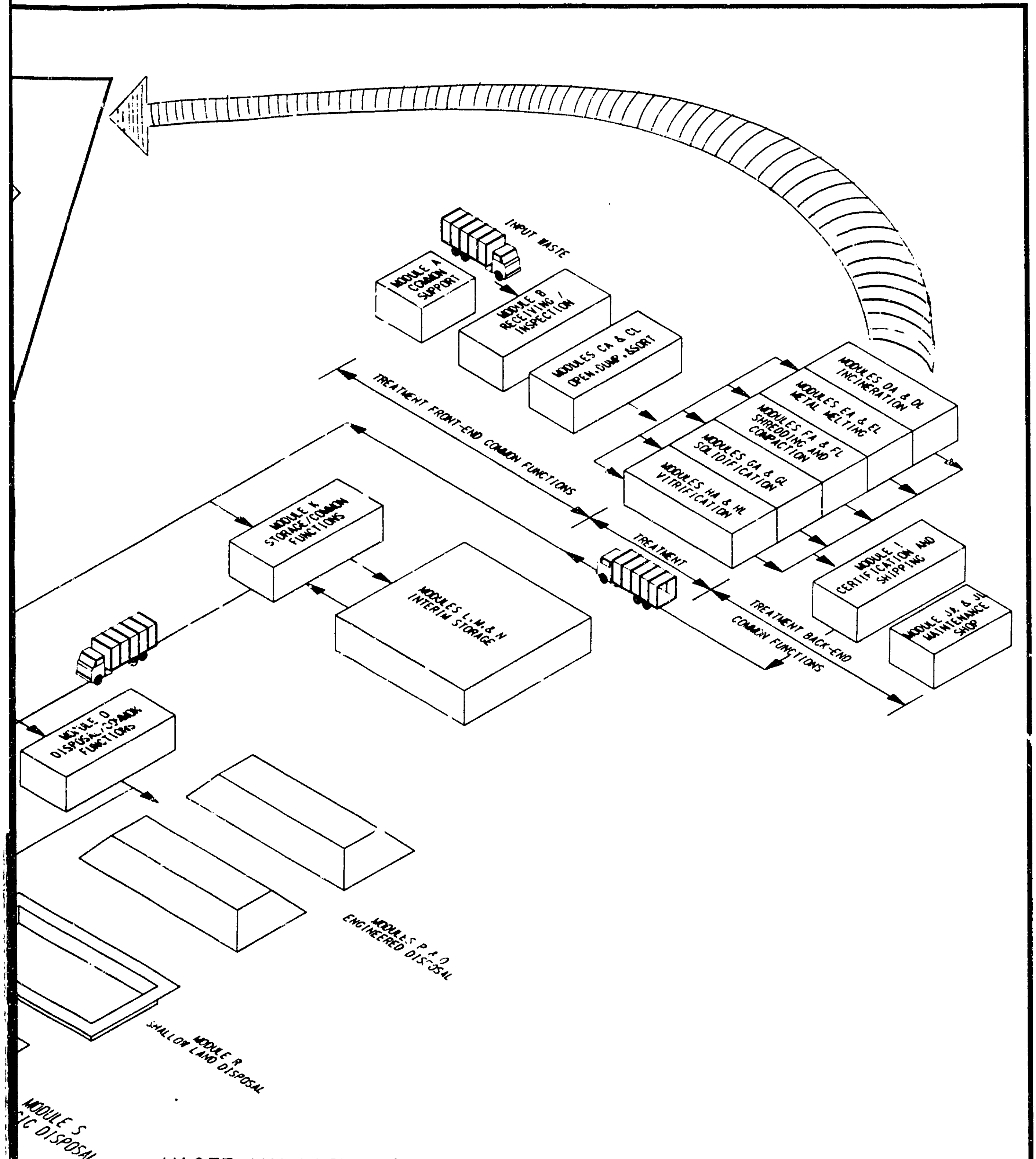


Figure 1-1. Waste management facility cost modules.



WASTE MANAGEMENT FACILITY COST MODULES

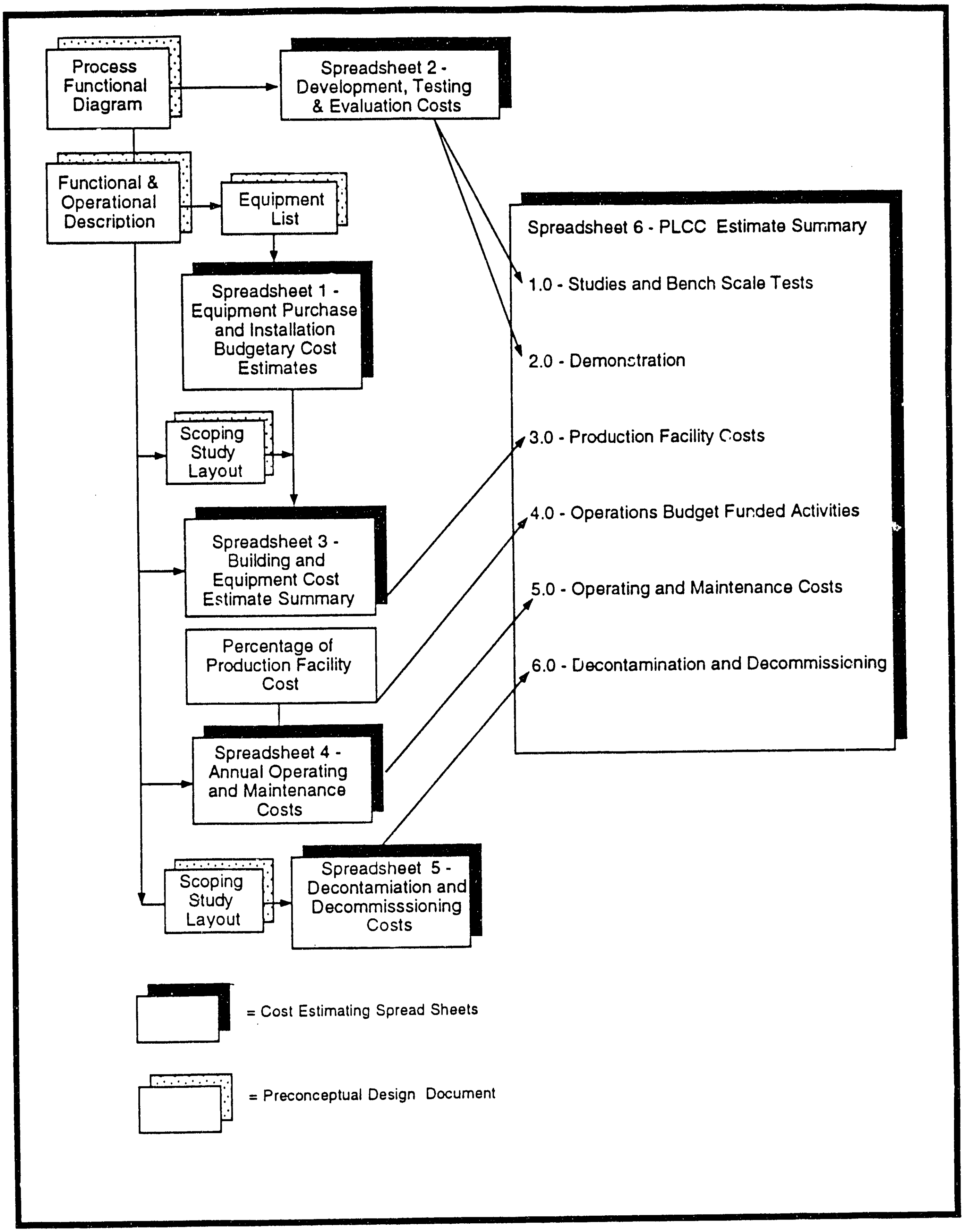


Figure 1-2. PLCC cost estimating steps.

(anchor) facilities as possible. New designs were generated only if existing data were not available.

PLCC cost for each facility was divided into six components (see Figure 1-2), each of which were estimated separately. Cost for the first and second cost components, (studies and bench scale tests, and demonstration) were estimated by obtaining research manpower and equipment estimates from the Stored Waste System Design Study (SWSDS) report.[2] The third cost component, production facility construction costs, consists of two key subcomponents, equipment and building cost. The major equipment lists were used to obtain cost estimates either from another similar or anchor facility, soliciting budgetary costs from the suppliers, or making engineering judgements. Building costs were estimated by multiplying building unit costs by the space square footage allocated to each unit operation in the SSLs.

Once the equipment and building costs were estimated for each facility, they were totalled and multiplied by a percentage to allow for the construction contractor indirect costs. The sum of the equipment, building, and indirect costs were further multiplied by appropriate factors to allow for design, inspection, construction management, and project management costs. Allowances were also included for management reserve and contingencies.

The fourth cost component, operations budget funded activities, includes conceptual design, safety assurance, National Environmental Policy Act of 1969 (NEPA) and permitting, preparation for operation, and project management costs. The NEPA and permitting activities costs were estimated at $6 million for a full NEPA, an environmental impact statement (EIS) process, and $1 million for an environmental assessment process. All other subcomponents of the operations budget funded activities cost were estimated as a percentage of the construction cost.

The fifth cost component, operating and maintenance (O&M) costs consists of operating labor, utilities, materials, maintenance parts and equipment, and maintenance labor costs. The first three sub-components, operating labor, utilities, and consumable materials were estimated based on analyzing the requirements of each facility at the unit operations level. The remaining two sub-components, maintenance equipment and labor costs, were estimated as a percent of the original equipment installed at the facility. The sixth cost component, decontamination and decommissioning (facility closure), was estimated by multiplying a decontamination and decommissioning (D&D) unit rate by the facility square footage. For disposal facilities, long-term maintenance and monitoring costs were also added to the D&D cost. The facility total PLCC estimates were obtained by adding the six cost components.

To facilitate cost estimating flexibility, the front-end and back-end functions (e.g., receiving, staging, and storage, incoming waste assay and inspection, incoming waste open, dump, and sort, outgoing waste assay and certification, and support facilities such as administration, maintenance shop, analytical laboratory) of each treatment, storage, and disposal facility are estimated as separate cost modules. This approach allows consideration of scenarios that involve existing facilities where some or all of the front-end and back-end functions are already in place.

1.5 Waste Management Scenario Costing Procedure

To guide the DOE and its subcontractors in the use of this report, a procedure for developing cost estimates was established. The procedure allows the user to easily project the overall cost of a given waste TSD alternative. The procedure (Figure 1-3) is based on seven basic steps, summarized below, to obtain the PLCC estimates:

1. Define the overall waste management TSD alternative.

2. Define parameters including type of waste, waste volumes, locations of waste, and combination of TSD facilities.

3. Select the required treatment cost modules, and if appropriate, front-end and back-end support cost modules, and obtain the corresponding PLCC estimates by selecting one of the cost modules closest to the required capacity from the cost/capacity graphs or tables in Sections 2 through 11 of this report.

4. Select the required storage cost modules and, if applicable, front-end/back-end support module and obtain the corresponding PLCC estimates by selecting one of the cost modules closest to the required capacity from cost/capacity graphs or tables in Sections 12 and 13 of this report.

5. Select the required disposal cost modules and, if applicable, front-end support module and obtain the corresponding PLCC estimates by selecting one of the cost modules closest to the required capacity from cost/capacity graphs or tables in Sections 14 and 15 of the report, unless shallow land disposal or deep geological repository is required. In such cases, refer to Sections 16 and 17 where cost estimates may be applied.

6. Calculate transportation costs using data given in Section 18 of the report.

7. Add items 3 through 6 to yield the total PLCC estimates for the given waste management alternative.

A detailed description of the procedure is presented in Section 18.

1.6 Cost Assessment Activities

To the extent possible, major equipment costs in each cost module were compared with data from anchor facilities to establish a cost confidence level within the boundaries established for the PLCC estimates. Both the DOE and the commercial nuclear industry are now planning or operating similar facilities. These facilities were surveyed to obtain capacity, cost data, and other information needed to support the WMFCI data. Before using these costs, the data was adjusted to account for capacity differences and escalation.

Additional assessment activities included a review of applicable cost models that could be used to analyze and verify the cost estimates from this study. Various cost estimating models are currently available or under development for potential use in a DOE report.[3] Table 1-1 summarizes the review of 11 cost models and the relevant areas of applicability to this study. The majority of these cost models were developed for estimating environmental restoration and construction costs. The primary applicability of these models are front-end/back-end support facilities, commercially available (nonradioactive) equipment, and unit costs for hazardous waste treatment. None of the models

Table 1-1. Cost models summary.

Cost model	Developer	Application area(s)	Currently available/$	Recommendation
Computer Gold MCACES Gold	U.S. Army	Construction nonhazard	Yes-free	Common support areas (offices, labs, utilities)
CCMAS TRACES ENVEST	U.S. Air Force	Construction/life cycle costs, primarily for RI/FS[a]	Yes-$?	Common support (O&M)
CORA	EPA	Remedial actions	Yes-$250	Treatments (no RAD)
COSTPRO	Commercial	Environmental programs	Yes-$?	Treatment/disposal MW
FAST-E FAST-C FAST-Co FAST-F	DOE	Equipment construction cost-of-ownership funding profiles	Yes-free (need training)	High applicability to equipment, and facility cost estimates; need historical information to run model
HAZRISK	AMOCO Oil	Waste clean-up	Yes-$35,000	NA[b]
MEPAS	DOE	Health risks	Yes-$?	NA[b]
RAAS	DOE	RI/FS	No-free	NA[b]—no cost data
RACER	U.S. Air Force	RI/FS	No-$?	NA[b]
RACES	EPA	Remedial actions	Yes-free	Treatment unit costs
SCEES	EPA	RI/FS	No-$1,000	N/A[b]

a. Remedial Investigation/Feasibility Study

b. NA—Not applicable

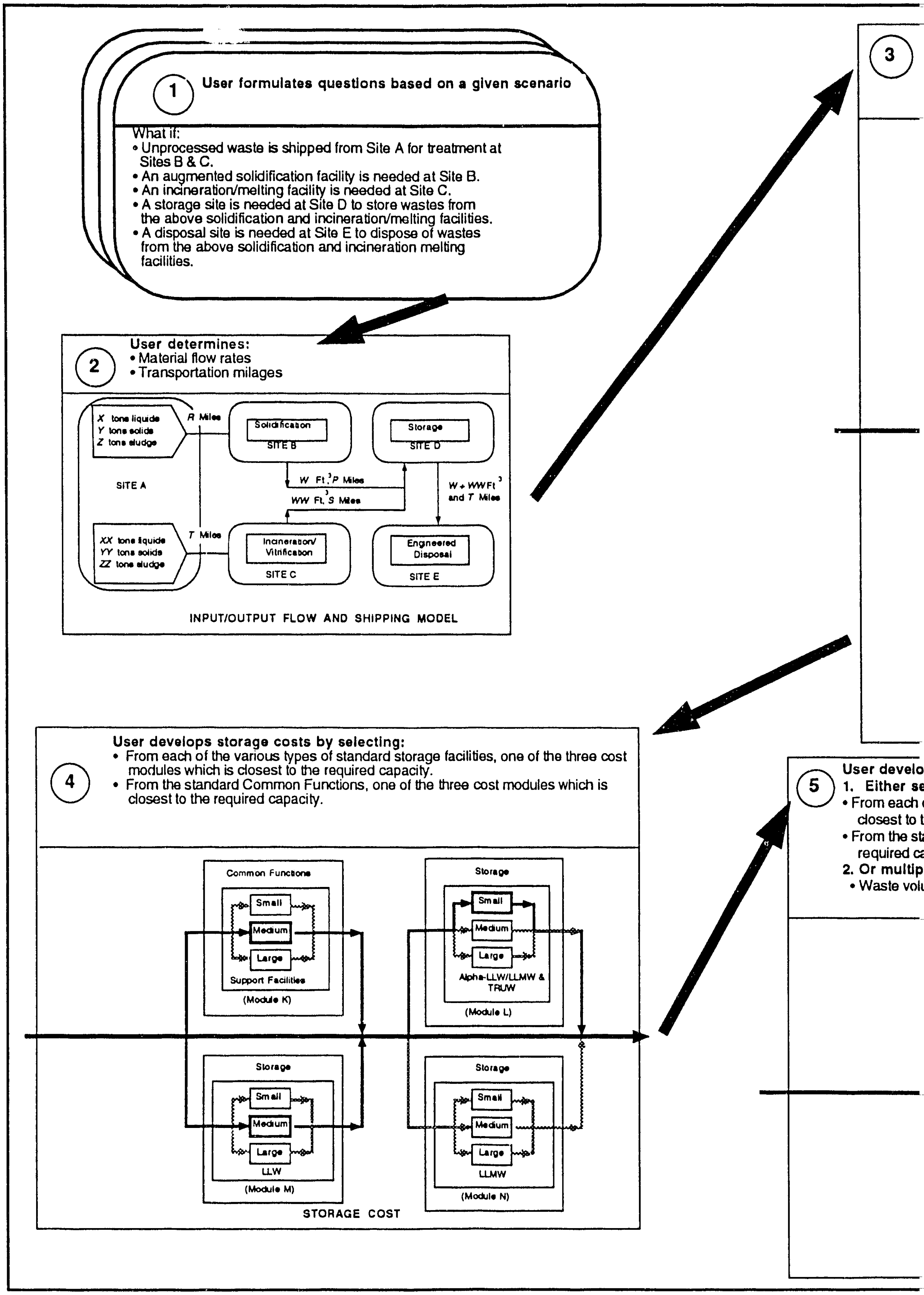
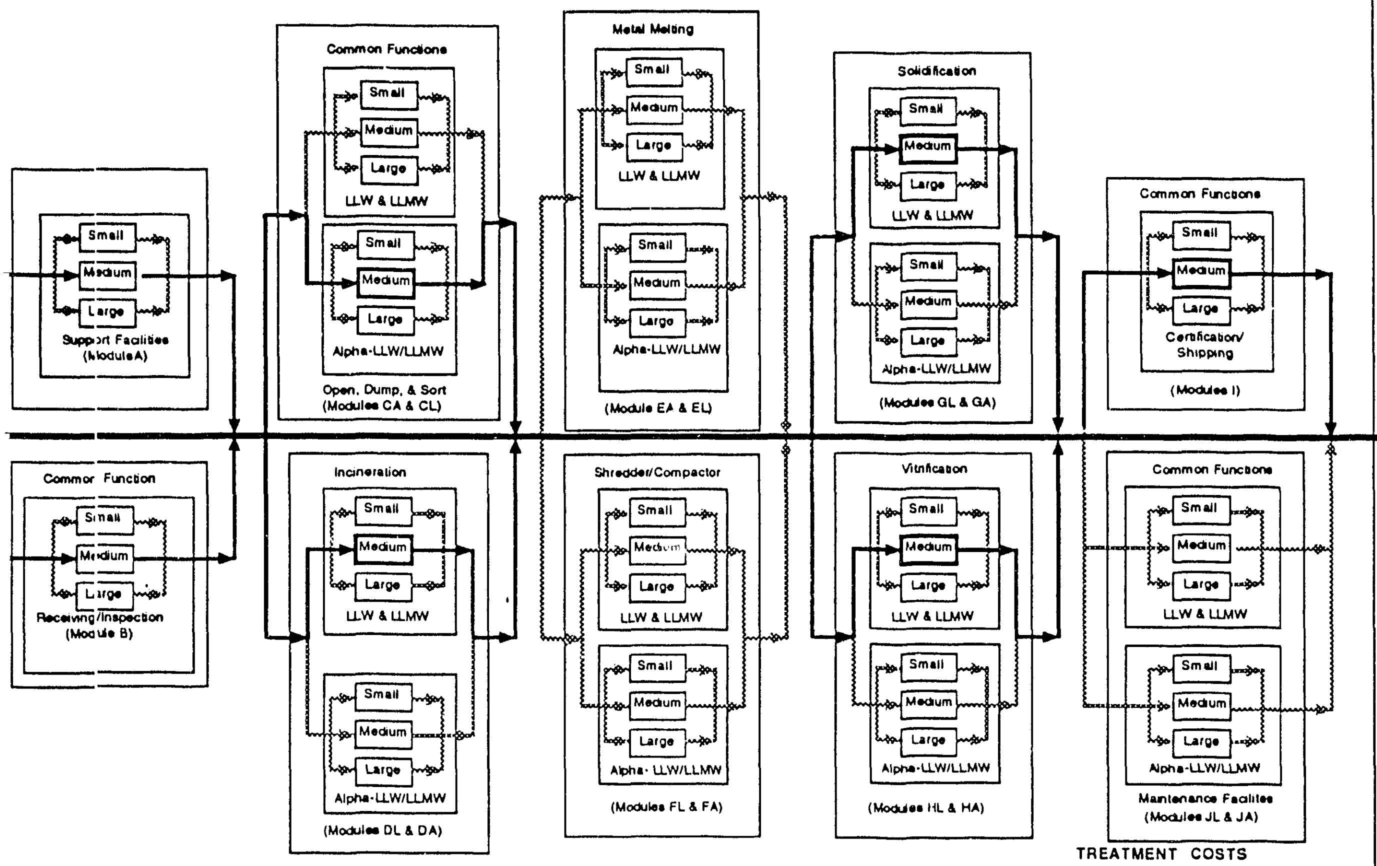
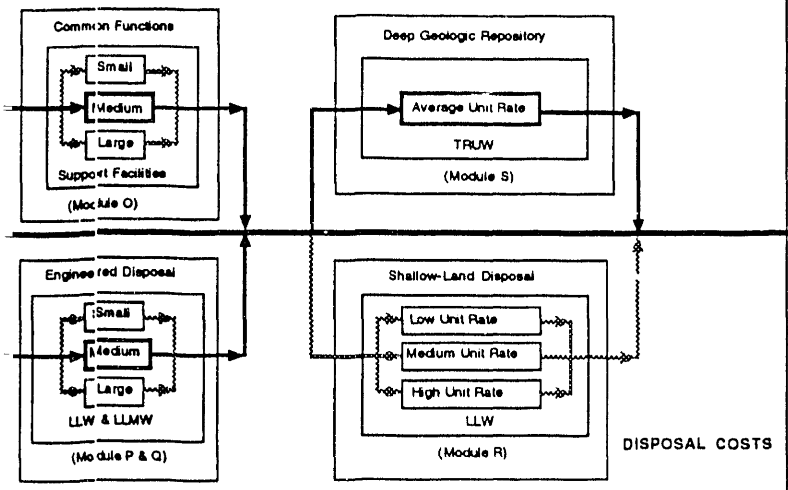


Figure 1-3. Procedure for developing cost estimates from the WMFCI report.

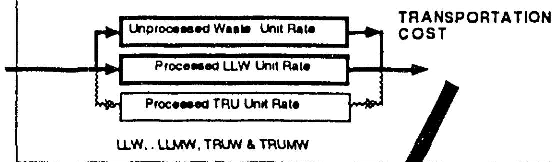
ser develops treatment costs by selecting:
From the standard solidification facilities, one of the three cost modules which is closest to the required capacity.
From the standard incineration facilities, one of the three cost modules which is closest to the required capacity.
From the standard vitrification facilities, one of the three cost modules which is closest to the required capacity.
From each of the various types of standard common functions, one of the three cost modules which is closest to the required capacity.



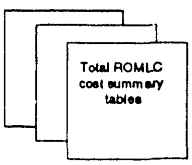
disposal costs by:
cting:
he various types of standard disposal facilities, one of the three cost modules which is required capacity.
dard Common Functions, one of the three cost modules for which is closest to the city.
ng:
s by the standard disposal unit rates.



6 **User develops transportation costs by multiplying :**
- Waste volumes by the standard transportation unit rates and the milage.



7 **User develops PLCC by adding:**
- Treatment cost modules
- Storage cost modules
- Disposal cost modules
- Transportation costs



currently address costs of equipment and construction in LLW/LLMW, or alpha environments for the WMFCI treatment, storage, or disposal facilities.

The most applicable cost models from this study are the Freiman Analysis of Systems Technique (FAST) Models C, E, and CO. With FAST the data from this study can be used to develop parametric cost relationships that could be highly valuable in the future for specific cost studies. Potential applications include (a) validation of the WMFCI cost/capacity curves based on intermediate capacities, (b) validation of existing cost estimates, (c) utilization for new facility cost estimates, and (d) use for other DOE-HQ initiatives. The information generated by the WMFCI study could be readily incorporated into the FAST model for future use by DOE.

1.7 Report Organization

Section 1 of this report contains background and summary information of the PLCC estimates. The cost estimating methodology, general assumptions, and basis used in developing PLCC estimates are presented in Appendix A.

Sections 2 through 17 summarize each TSD cost module. Sections 2 through 17 provide only a description of activities and assumptions that apply to the specific process in each section. Additional general assumptions and cost bases that apply to most or all cost modules are included in Appendix A.

Section 18 presents procedures and summary cost and capacity information for costing various waste management scenarios. PLCC estimate backup information is included in EG&G Idaho report.[4] A scenario costing worksheet is provided in Appendix B to aid the user of this report in the preparation of PLCC estimates for a specific scenario. A scenario costng worksheet is provided in Appendix B to aid the user of this report in the preparation of PLCC estimates for a specific scenario.

1.8 Limitations

Section 18 and Appendix A of this report must be consulted regarding limitations and qualifications that apply to development of PLCC estimates for various waste management options. To apply cost data from this report, at a minimum, the reader must ensure that the cost of front-end and back-end support facilities is incorporated. Front-end and back-end cost modules generally include PLCC estimates associated with functions such as waste receiving/inspection, container opening, dumping and sorting, certification and shipping of the packaged waste, analytical laboratory, maintenance shop, and facility administration, environmental and health compliance, security, and related activities.

Data extrapolation from PLCC estimate histograms given in Sections 2 through 17 should be done with caution (the reader should note that this task developed estimates only for those capacities shown as the estimate points on the histograms). Most of the cost components (such as facility capital and operating laobr cost) do not change significantly within a given capacity range. Only a minor portion of the cost (components such as power consumption, consumable materials, and maintenance costs) has direct relationship with the quantity of the waste process by the facility.

Figure 1-4 shows three different ways that can be used to estimate PLCC for a facility having a capacity not the same as an estimate point. The first method, straight line, is extrapolating data from a straight line drawn between two estimate points. The second method, most probable PLCC capital estimate, is adding the fixed costs (those that are believed to be fixed within a given capacity range) to the variable costs (those that vary with the capacity). The third method, the histogram, is selecting an estimate point closest to the required capacity. The following conclusions are reached when the three methods are used to get PLCC estimates for an alpha incineration facility with a required capacity at mid-point between the small and medium estimate points.

1. The added cost uncertainty is greatest at a mid-point between two estimate points.

2. If a histogram method is used, the estimated PLCC is about 11% more or less than the most probable cost method.

3. If a straight line method is used, the estimated PLCC is 12% more or less than the most probable cost method.

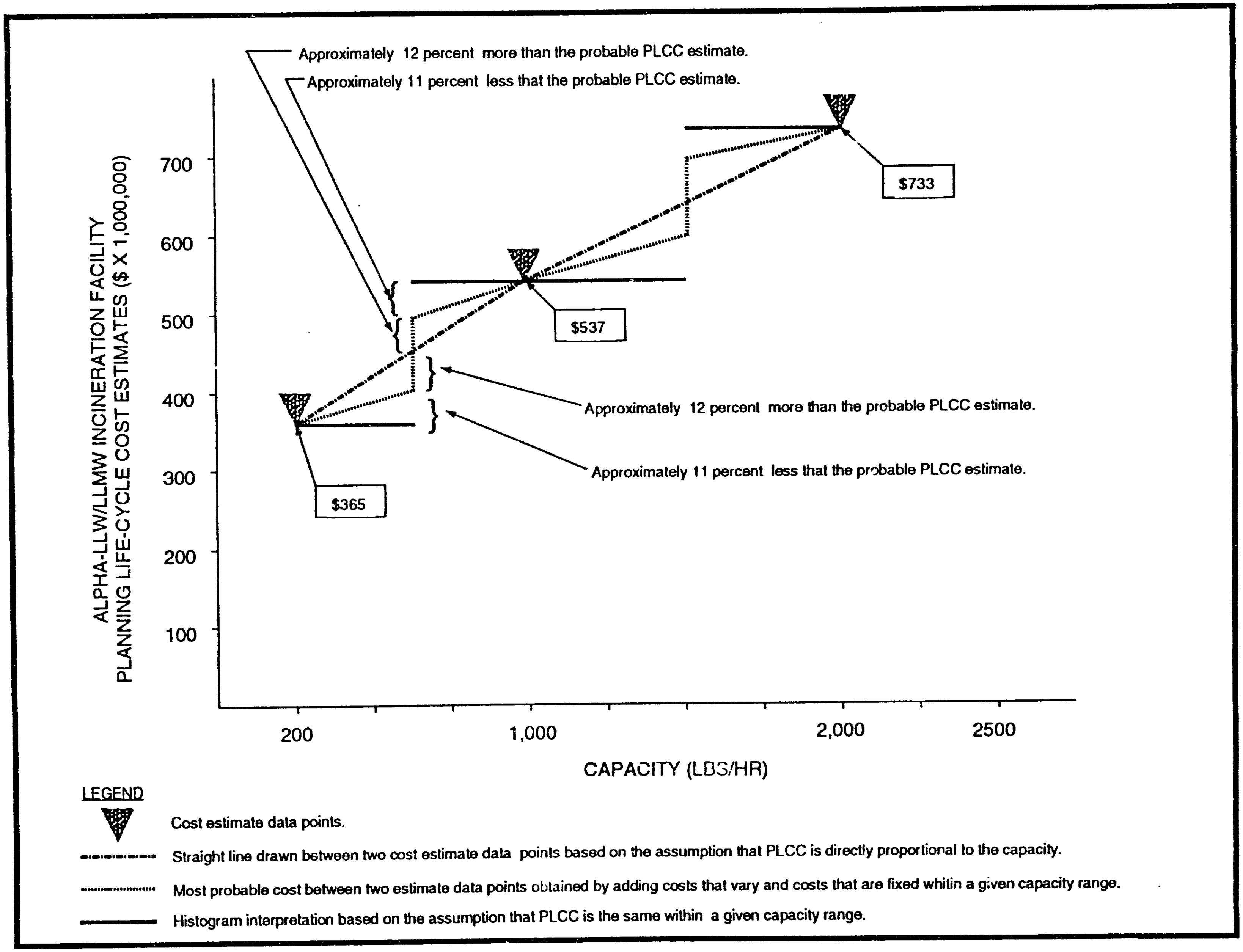


Figure 1-4. Comparison of three methods to obtain PLCC data between two cost estimate points.

2. TREATMENT FRONT-END SUPPORT FACILITY (COST MODULE A)

2.1 Basic Information

Front-end support facilities include all administrative and laboratory buildings required for the waste management support functions. The front-end support facilities are essentially the same for all treatment cost modules. Any differences will depend on the type of equipment needed for different waste management activities within the facility and will not change the general layout. Front-end support facilities, whether for treatment, storage, or disposal, should be used whenever a new facility is planned. Unit operations are shown in Figure 2-1.

2.2 Technical Bases and Requirements

All front-end support cost modules incorporate all support functions needed to manage the operation of a waste management facility. These functions include security, personnel decontamination (radioactive and hazardous), maintenance of noncontaminated areas/equipment, health physics/radiation badges/facility access control, sanitary facilities, work control/personnel support, internal and external (public relations) communications, spill or emergency response provisions (hazardous and radioactive), analytical laboratory, environmental field sampling, environmental regulatory reporting, and records management.

2.3 Cost Bases, Assumption, Assessments

The treatment facility front-end support module is the same for both LLW/LLMW and alpha-LLW/LLMW waste types. General cost bases and assumptions are given in Appendix A. Facility specific items are discussed below.

- Major equipment capital cost items are laboratory analytical equipment. For a small common support facility, $1 million allowance is made for analytical instruments and components needed for a mixed waste laboratory.

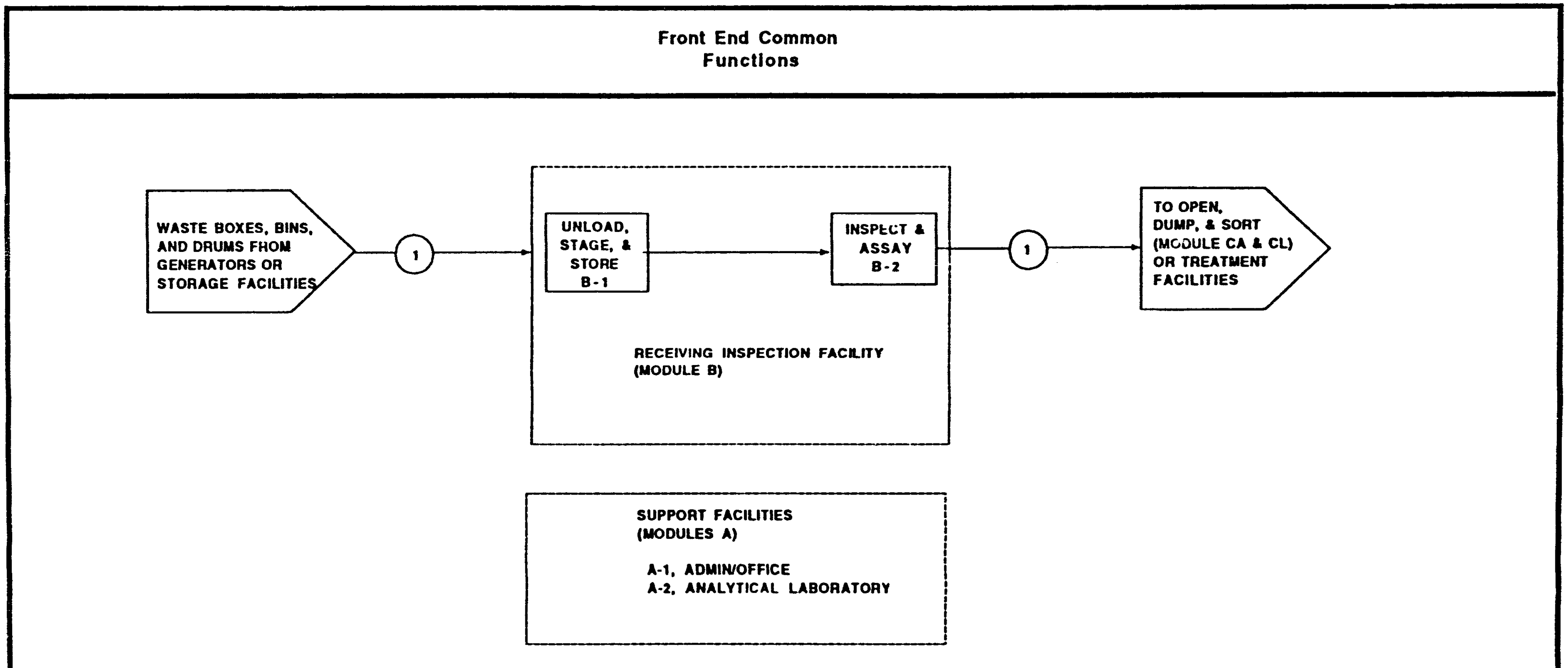
- Estimating operating staff is shown in Table 2-1.

- Mixed waste laboratory vendors have been consulted to ensure that the laboratory allowance is adequate.

- Small, medium, and large facility capacities and unit costs are shown in Table 2-2.

2.4 Cost Summaries

Cost summary for the front-end support facility is shown in Table 2-3. A histogram of cost versus capacity is shown in Figure 2-2.



FLOWRATES (LB/HR)

Node	1
Facility Size	Input Waste
Small	200
Medium	5600
Large	12500

Figure 2-1. Front-end support facility process functional diagram.

Table 2-1. Estimated operating staff for front-end support (module A).

Unit Operation	Description	Small (FTE)[a]	Medium (FTE)	Large (FTE)
A-1	Administration office:			
	Accountant	1	3	4
	Secretarial/clerk	2	5	10
	Document control	2	4	7
	Manager-dayshifts	2	5	9
	Technical personnel	1	4	8
	Communications	1	2	3
	Environmental manager	1	4	9
	Oper. support/mgmnt.	1	4	9
	Quality control technicians	1	4	9
	Security guard	4	7	13
	Health physics tech.	4	7	13
A-2	Testing laboratory	7	12	18
	Total	27	61	112

a. Full time equivalent

Table 2-2. Capacity and cost information for front-end support facility (cost module A).[a]

Mod.	Module Description	Facility	Life Cycle Cost ($x1000)	Capacity (lbs/hr)	Unit Cost ($/lb)	Capacity (ft3/hr)	Cap(Tot Vol) (ft3x1000)	Unit Cost ($/ft3)
A	Treatment Support	Small	$128,897	200	$7.99	6	461	$279.72
A	Treatment Support	Medium	$290,158	5,600	$0.64	160	12,902	$22.49
A	Treatment Support	Large	$530,763	12,500	$0.53	357	28,800	$18.43

a. Average density used is 35 lbs/ft.[3]

Table 2-3. PLCC estimate summary for treatment front-end support facility (cost module A).

Cost component	Cost Items				Cost ($ x 1000) Small	Medium	Large
1.0	**Studies and bench scale test costs**						
	1.1 Manpower costs during research				$0	$0	$0
	1.2 Equipment costs				$0	$0	$0
	1.3 Installation costs				$0	$0	$0
	1.4 Project management before title I			(10 % of 1.1 through 1.3)	$0	$0	$0
	1.5 Contingency			(25 % of 1.1 through 1.4)	$0	$0	$0
	Subtotal 1.0				$0	$0	$0
2.0	**Demonstration costs**						
	2.1 Manpower costs during demonstration				$0	$0	$0
	2.2 Design cost			(30 % of 2.5)	$0	$0	$0
	2.3 Inspection cost			(7 % of 2.5)	$0	$0	$0
	2.4 Project management			(10 % of 2.5)	$0	$0	$0
	2.5 Construction cost						
		2.5.1	Building structure costs		$0	$0	$0
		2.5.2	Equipment costs		$0	$0	$0
		2.5.3	Indirect	(29 % of 2.5.1 & 2.5.2)	$0	$0	$0
	Subtotal of 2.5				$0	$0	$0
	2.6 Construction management costs			(17.1 % of 2.5)	$0	$0	$0
	2.7 Management Reserve			(10 % of 2.5)	$0	$0	$0
	2.8 Contingency			(25 % of 2.1 through 2.7)	$0	$0	$0
	Subtotal 2.0				$0	$0	$0
3.0	**Production facility construction costs**						
	3.1 Design cost			(18 % of 3.4)	$845	$1,572	$2,683
	3.2 Inspection cost			(7 % of 3.4)	$329	$612	$1,043
	3.3 Project management			(10 % of 3.4)	$469	$874	$1,491
	3.4 Construction cost						
		3.4.1	Building structure costs		$1,350	$3,024	$5,904
		3.4.2	Equipment costs		$2,288	$3,748	$5,650
		3.4.3	Indirect	(29 % of 3.4.1 & 3.4.2)	$1,055	$1,964	$3,351
	Subtotal of 3.4				$4,693	$8,736	$14,905
	3.5 Construction management			(17.1 % of 3.4)	$803	$1,494	$2,549
	3.6 Management Reserve			(10 % of 3.4)	$469	$874	$1,491
	3.7 Contingency			(25 % of 3.1 through 3.5)	$1,785	$3,322	$5,668
	Subtotal 3.0				$9,393	$17,484	$29,830
4.0	**Operations Budget Funded Activities (See Sect. 7)**						
	4.1 Conceptual design			(1.5 % of 3.0)	$141	$262	$447
	4.2 Safety assurance			(1 % of 3.0)	$94	$175	$298
	4.3 NEPA permitting ($ 6 Mill for EIS, $1 Mill for EA)				$1,000	$1,000	$1,000
	4.4 Preparation for operations			(100 % of 5.0)	$5,514	$12,639	$23,249
	4.5 Project Management			(10 % of 4.1 through 4.4)	$675	$1,408	$2,499
	Subtotal 4.0				$7,424	$15,484	$27,493
	Total Initial Cost (1.0,2.0,3.0 & 4.0)				$16,817	$32,968	$57,323
5.0	**Operating and maintainence costs**						
	5.1 Annual operating costs				$3,780	$8,540	$15,680
	5.2 Annual utility costs				$5	$11	$64
	5.3 Annual material costs				$164	$800	$1,700
	5.4 Annual maintainence costs				$462	$760	$1,155
	5.5 Contingency			(25 % of 5.1 through 5.4)	$1,103	$2,528	$4,650
	Subtotal 5.0				$5,514	$12,639	$23,249
	Total 20 year O & M cost (20 times Subtotal 5.0)				$110,280	$252,780	$464,980
6.0	**Decontamination & Decommissioning**				$1,800	$4,410	$8,460
7.0	**ROM Life cycle costs (20 years operation)**				$128,897	$290,158	$530,763

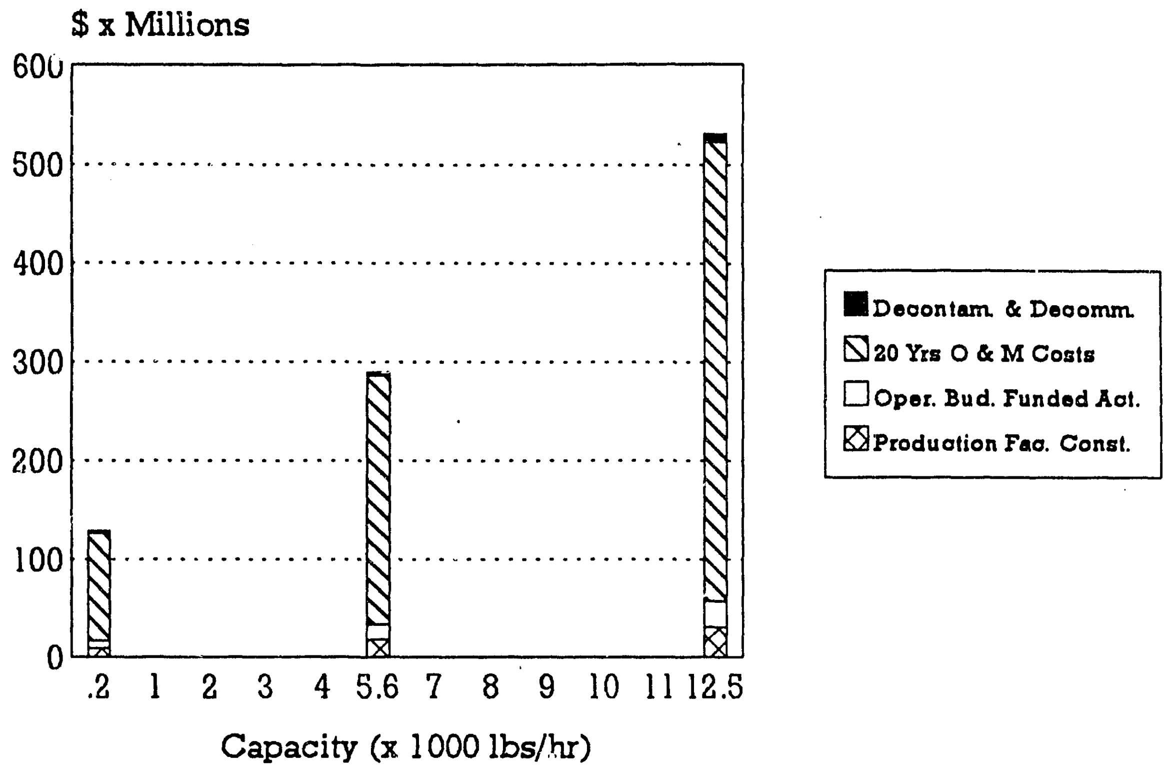


Figure 2-2. Cost versus capacity histogram for front-end treatment support facility.

3. TREATMENT RECEIVING AND INSPECTION FACILITY (COST MODULE B)

The receiving and inspection facility is effectively the same for LLW/LLMW and alpha-LLW/LLMW waste types. There are minor differences in the assay/inspection equipment that are negligible at a PLCC estimate level. Unit operations are given in Figure 2-1.

3.1 Basic Information

The receiving and inspection facility is intended to be contiguous with the container open, dump, sort, and the waste treatment facilities. It consists of two unit operations: unload/stage and inspect/assay. The waste containers (drums, boxes and metal bins) arrive at the receiving and inspection facility on a transport vehicle. Containers are removed from the transport vehicle and placed in a staging/storage area. The containers are visually examined, labeled, logged, recorded, and sent to inspection and assay.

The purpose of the inspect/assay unit operation is to physically and radiologically characterize the waste to allow segregation of the containers. Based on the inspection and assay results, the waste containers are grouped according to their processing needs. The inspection and assay unit operation also identifies a special waste category that applies to any containerized waste requiring special processing operations.

The receiving and unloading area is equipped with a 20-ton bridge crane and a 5-ton forklift truck. It is designed to receive and unload containers from flat-bed trailers or van trucks. Containers brought in large overpacks [e.g., transportation package (TRUPAC II type containers)] can also be unloaded.

3.2 Technical Bases and Assumptions

3.2.1 Functional and Operational Description

Transportation vehicles are used to ship the containers (in overpacks if necessary) from the generators to the receiving and inspection facility. These vehicles are not included in the cost module. In the unloading and staging unit operation the transportation vehicles are unloaded, and containers are placed in the staging area. Surge storage is also provided. Containers may be moved within the unloading, staging, and surge storage areas and transported to and from the various interfacing unit operations.

Containers are unloaded in an enclosed truck bay and placed in an indoor staging area. The area is large enough to maneuver the containers and provide sufficient surge storage capacity to meet the desired operational reliability.

The assay/inspect unit operation is used to determine radioactivity, physical properties, and other parameters that are needed to categorize the containerized waste before processing, and in accordance with the criteria established for the processing unit operations. Various devices, such as passive/active neutron (PAN) counting instruments, may be used. Containers holding waste classified as other than LLW/LLMW or alpha-LLW/LLMW are returned to the generator.

Waste containers are also examined to allow classification by gamma radioactivity (in accordance with the criteria established for the processing unit operations) and to ensure that they are suitable for contact handling (less than 200 mRem/h on surface) and for treatment by the given process units. Various devices, such as Segmented Gamma Scan (SGS) instruments, may be used. Containerized wastes that do not meet the criteria are either handled as special waste or returned to the generator.

After the containers are examined, they are weighed and measured to determine waste density. Contents (such as metals, paper, glass, sludge, gas cylinders, and liquids) are determined by non-destructive examination. At a minimum, each container is examined using a nondestructive assay equipped with a real-time radiography (RTR) device. Ultrasonic devices are also used. After examination, each container is labeled, and the properties of its contents are logged and entered into a computerized database.

To allow year-round operations and to minimize the effects of a potential spill, it is assumed that the unloading and staging operations will take place indoors.

3.2.2 Facility Integration

In addition to general interfaces typical for all facilities, wastes from the generator facilities become input to the receiving/inspection facility. O&M consumables, including personnel protective equipment, must be purchased. Facility output is the LLW/LLMW or alpha-LLW/LLMW containers that are transported to the open, dump, and sort facility or to treatment facilities.

3.3 Cost Bases, Assumptions, and Assessments

The general bases and assumptions for the cost estimate are presented in Appendix A. Facility specific items are discussed below.

- Major equipment capital cost items for this facility include alpha assay, gamma assay, a 20-ton bridge crane, and RTR units.

- Estimated operating staff is shown below in Table 3-1.

Table 3-1. Estimated operating staff for front-end receiving and inspection facility (cost module B).

Unit operation	Description	Small	Medium	Large
B-1	Unloading, staging and storage	4	10	24
B-2	Inspect and assay	2	8	24
	Total	6	18	48

- The crane cost is based on vendor quotations. The inspection and assay units are based on conceptual designs and cost estimates for a radiological and hazardous material measurement system (RHMMS) provided by EG&G Idaho. Budget estimate for inspection and assay system is $2.0 million.

- Small, medium, and large facility capacities and unit costs are shown in Table 3-2.

3.4 Cost Summaries

Cost summaries for receiving and inspection are shown in Table 3-3. A histogram of cost versus capacity is given in Figure 3-1.

Table 3-2. Capacity and cost information for treatment receiving and inspection facility (cost module B).[a]

Mod.	Module Description	Facility	Life Cycle Cost ($x1000)	Capacity (lbs/hr)	Unit Cost ($/lb)	Capacity (ft3/hr)	Cap(Tot Vol) (ft3x1000)	Unit Cost ($/ft3)
B	Treatment Rec./Insp.	Small	$62,612	200	$3.88	6	461	$135.88
B	Treatment Rec./Insp.	Medium	$128,900	5,600	$0.29	160	12,902	$9.99
B	Treatment Rec./Insp.	Large	$204,179	12,500	$0.20	357	28,800	$7.09

a. Average density used is 35 lbs/ft.[3]

Table 3-3. PLCC estimate summary for treatment receiving/inspection facility (cost module B).

Cost component		Cost Items	Cost ($ x 1000) Small	Medium	Large
1.0	**Studies and bench scale test costs**				
	1.1 Manpower costs during research		$0	$0	$0
	1.2 Equipment costs		$0	$0	$0
	1.3 Installation costs		$0	$0	$0
	1.4 Project management before title I	(10 % of 1.1 through 1.3)	$0	$0	$0
	1.5 Contingency	(25 % of 1.1 through 1.4)	$0	$0	$0
	Subtotal 1.0		$0	$0	$0
2.0	**Demonstration costs**				
	2.1 Manpower costs during demonstration		$600	$600	$600
	2.2 Design cost	(30 % of 2.5)	$194	$194	$194
	2.3 Inspection cost	(7 % of 2.5)	$45	$45	$45
	2.4 Project management	(10 % of 2.5)	$65	$65	$65
	2.5 Construction cost				
	2.5.1 Building structure costs		$0	$0	$0
	2.5.2 Equipment costs		$500	$500	$500
	2.5.3 Indirect	(29 % of 2.5.1 & 2.5.2)	$145	$145	$145
	Subtotal of 2.5		$645	$645	$645
	2.6 Construction management costs	(17.1 % of 2.5)	$110	$110	$110
	2.7 Management Reserve	(10 % of 2.5)	$65	$65	$65
	2.8 Contingency	(25 % of 2.1 through 2.7)	$431	$431	$43.
	Subtotal 2.0		$2.155	$2.155	$2.155
3.0	**Production facility construction costs**				
	3.1 Design cost	(18 % of 3.4)	$1,242	$2.206	$3.804
	3.2 Inspection cost	(7 % of 3.4)	$483	$858	$1.479
	3.3 Project management	(10 % of 3.4)	$690	$1.225	$2.113
	3.4 Construction cost				
	3.4.1 Building structure costs		$1,332	$5,382	$8.424
	3.4.2 Equipment costs		$4,017	$4,117	$7.959
	3.4.3 Indirect	(29 % of 3.4.1 & 3.4.2)	$1,551	$2,755	$4,751
	Subtotal of 3.4		$6,900	$12,254	$21,134
	3.5 Construction management	(17.1 % of 3.4)	$1,180	$2,095	$3,614
	3.6 Management Reserve	(10 % of 3.4)	$690	$1,225	$2,113
	3.7 Contingency	(25 % of 3.1 through 3.5)	$2,624	$4,660	$8,036
	Subtotal 3.0		$13,809	$24,523	$42,293
4.0	**Operations Budget Funded Activities (See Sect. 7)**				
	4.1 Conceptual design	(1.5 % of 3.0)	$207	$368	$63
	4.2 Safety assurance	(1 % of 3.0)	$138	$245	$42
	4.3 NEPA permitting ($ 6 Mill for EIS, $1 Mill for EA)		$0	$0	$0
	4.4 Preparation for operations	(100 % of 5.0)	$2,035	$4,175	$6.51
	4.5 Project Management	(10 % of 4.1 through 4.4)	$238	$479	$75
	Subtotal 4.0		$2,618	$5,267	$8,331
	Total Initial Cost (1.0,2.0,3.0 & 4.0)		**$18,582**	**$31,945**	**$52,77**
5.0	**Operating and maintainence costs**				
	5.1 Annual operating costs		$840	$2,520	$3,64
	5.2 Annual utility costs		$10	$9	$1
	5.3 Annual material costs		$4	$12	$2
	5.4 Annual maintainence costs		$774	$799	$1,54
	5.5 Contingency	(25 % of 5.1 through 5.4)	$407	$835	$1,30
	Subtotal 5.0		$2,035	$4,175	$6.51
	Total 20 year O & M cost (20 times Subtotal 4.0)		$40,700	$83,500	$130,34
6.0	Decontamination & Decommissioning		$3,330	$13,455	$21,06
7.0	**ROM Life cycle costs (20 years operation)**		**$62,612**	**$128,900**	**$204,17**

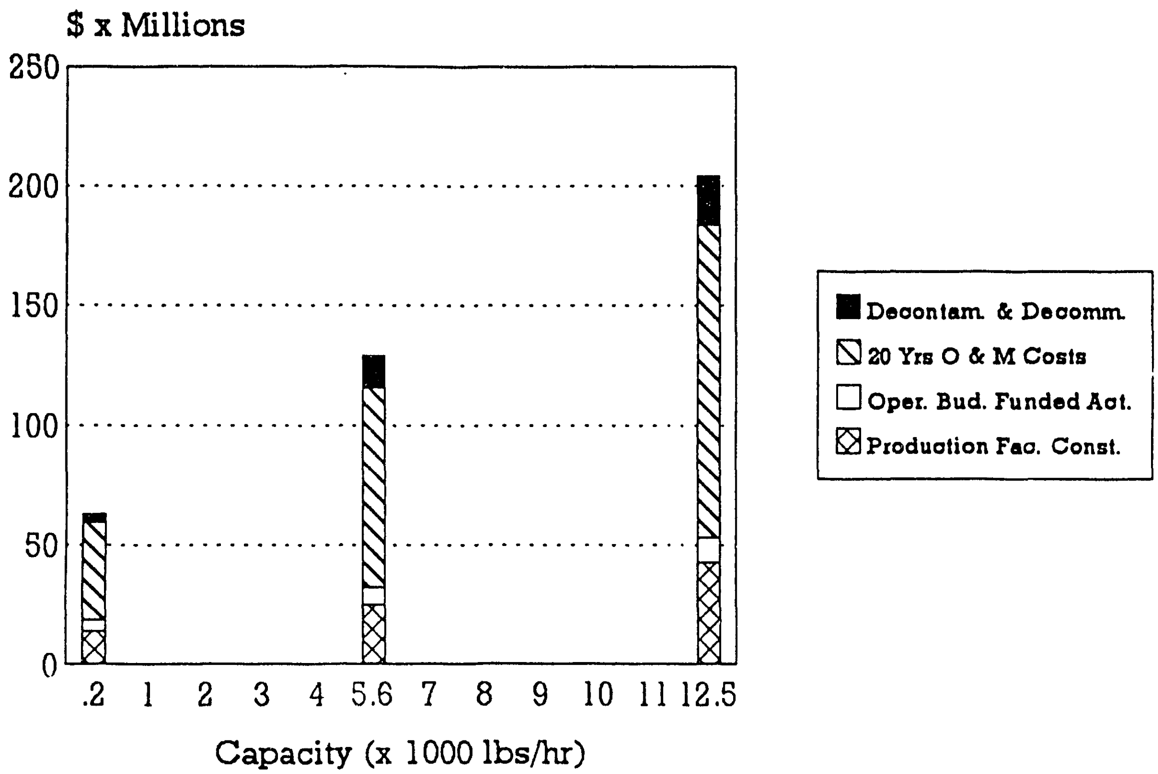


Figure 3-1. Cost versus capacity histogram for treatment receiving and inspection facility.

4. CONTAINER OPEN, DUMP, AND SORT FACILITY (COST MODULES CL AND CA)

4.1 Basic Information

The open, dump, and sort facility, shown in Figure 4-1, is designed to be contiguous with the treatment facilities and is ideal for use with an integrated waste management facility that requires multitreatment streams. The facility opens and dumps the incoming waste containers and segregates the waste so that it can be fed to a combination of incineration, vitrification, solidification (or shredding compaction), and metal melting treatment processes. The facility handles the wastes in drums, boxes, or metal bins that are assumed to be properly characterized before they are opened. The facility is not needed if the waste arrives presorted. Cost module CL is applicable to LLW/LLMW while cost module CA is intended for alpha LLW/LLMW. Unit operations are given in Figure 4-2.

The facility also has the capability to reduce the size of empty, nonmetal containers. Metal containers, however, must be transported to other facilities for handling (such as a decontamination facility for washdown and reuse and/or a metal melting facility for processing).

4.2 Technical Bases and Assumptions

4.2.1 Functional and Operational Description

At the open, dump, and sort facility the waste containers are decapped, and the waste is dumped either onto sorting devices or into transport bins that carry the waste to the treatment operations.

LLW/LLMW container opening is done manually while alpha-LLW/LLMW container opening is done by remote means. Both LLW/LLMW and alpha-LLW/LLMW container dumping and sorting operations are accomplished remotely by manipulators and robots housed in a cubicle that has a controlled environment and multiple barriers. Adequate hoods and supporting ventilation are provided to minimize the spread of dust and contamination. Alpha-LLW/LLMW operations are accomplished in an alpha cell where containers enter the cell through airlock doors. Equipment maintenance is accomplished manually in a controlled environment. In addition, the equipment can be pulled out and decontaminated before performing maintenance.

After the waste containers enter the controlled cubicle environment through airlock doors, they are grouped according to two categories: those that must only be opened and dumped, and those that require open, dump, and sort operations. After container caps are removed, the waste in the containers of the first category are dumped into bins that directly transport it to the treatment facilities.

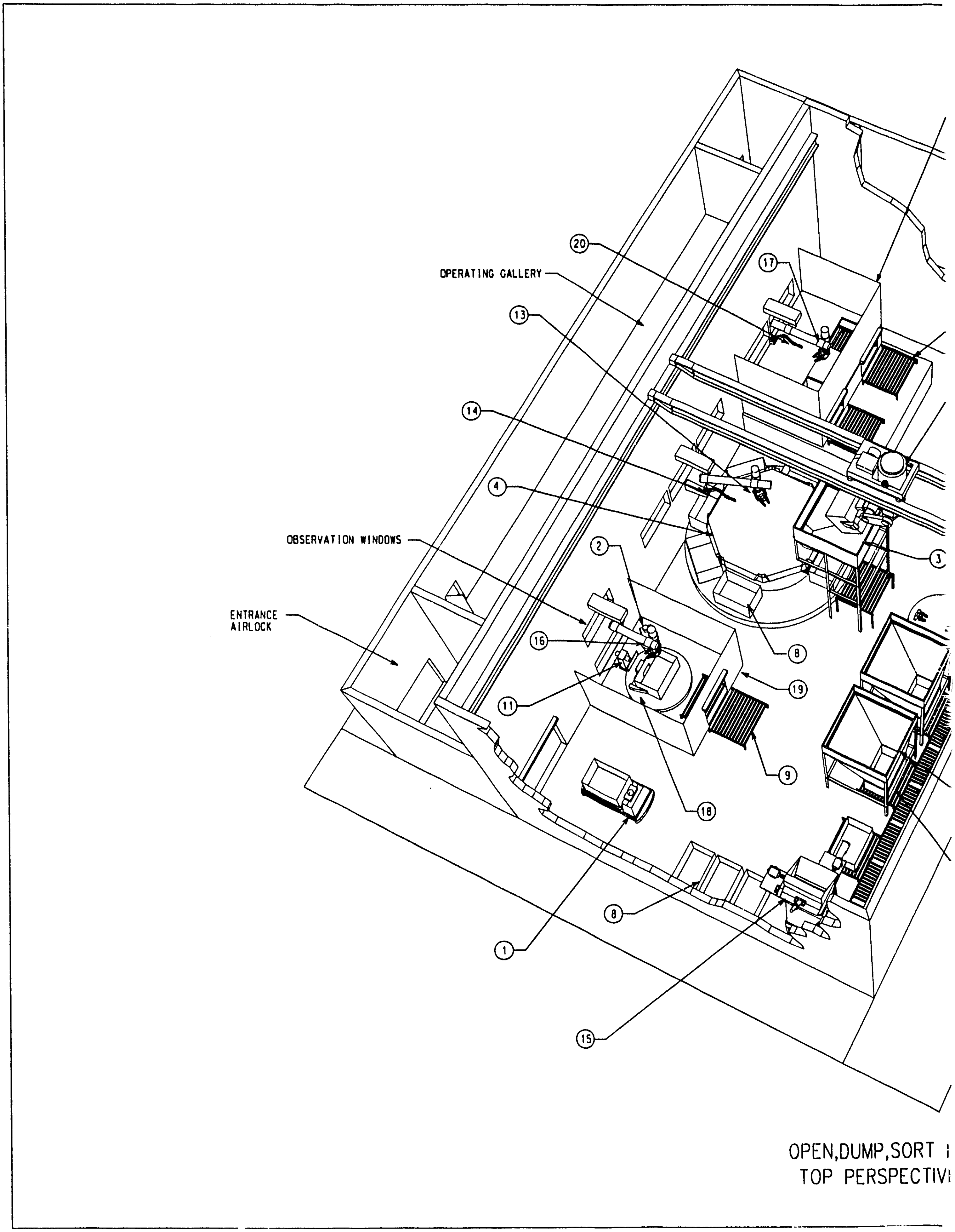
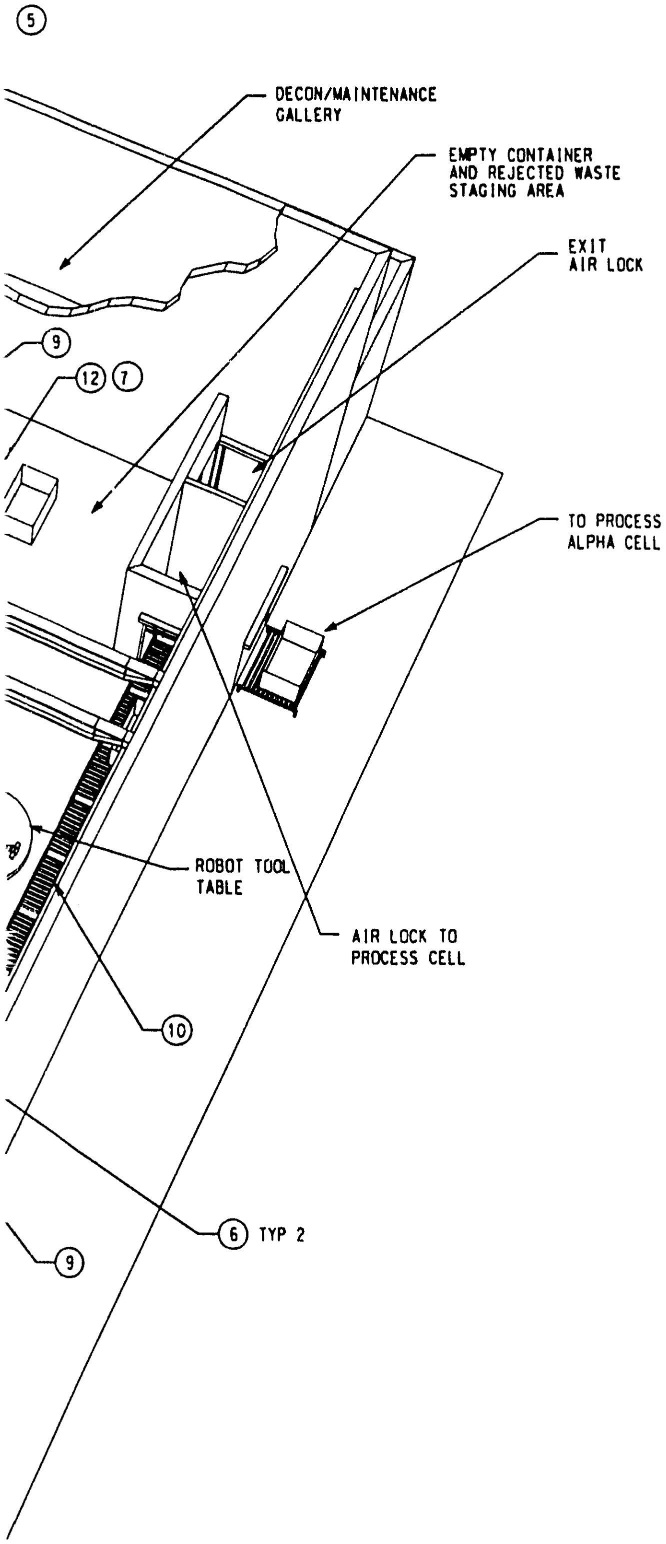


Figure 4-1. Typical arrangement for alpha-LLW/LLMW open, dump, and sort facility.



MAJOR EQUIPMENT LIST

1. SELF GUIDED VEHICLE
2. DE-CAP DEVICE
3. SORT HOPPER
4. SORT TABLE/ROTATING TABLE
5. SPECIAL WASTE GLOVEBOX
6. DUMP HOPPER
7. MAINTENANCE CRANE
8. BINS 4 (4'X4'X6')
9. BIN CONVEYORS 8' LONG
10. BIN CONVEYOR 70' LONG
11. BIN PUSHER
12. MAIN CELL GANTRY ROBOT
13. SORTING TABLE HYDRAULIC MANIPULATOR
14. SORTING MASTER SLAVE MANIPULATOR
15. BOX SIZE REDUCTION UNIT
16. DRUN OPENING GANTRY ROBOT
17. GLOVEBOX HYDRAULIC MANIPULATOR
18. CONTAINER GRAPPLER
19. DECAP ENCLOSURE
20. GLOVEBOX MASTER SLAVE MANIPULATOR

ACILITY
VIEW

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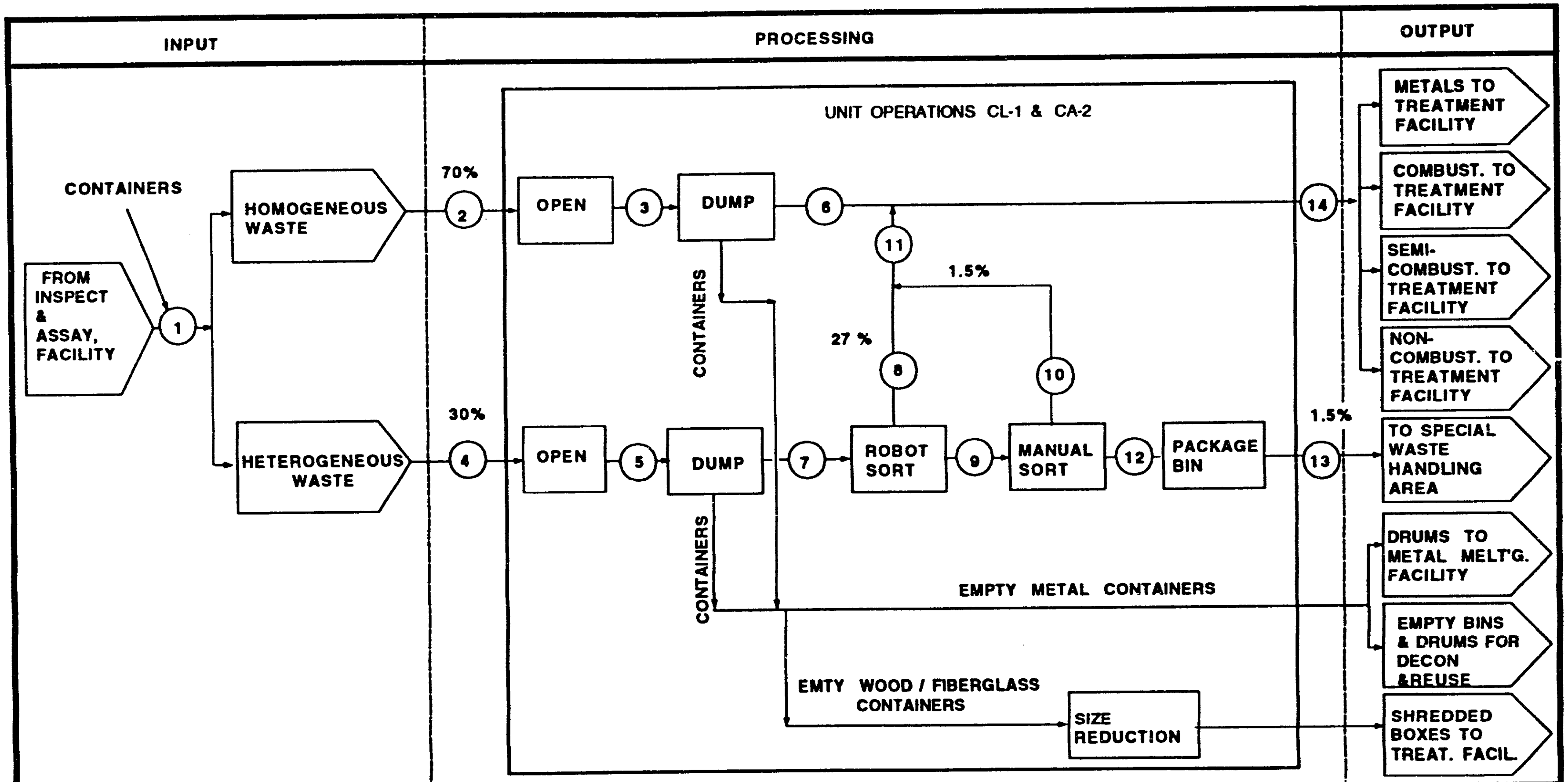

	Nod	1	2	3	4	5	6	7	8	9	10	11	12	13	14
FLOWRATES (LB/HR)	Material	Input Waste													
	LLW Small	200	140	140	60	60	140	60	54	6	3	57	3	3	197
	LLW Medium	5600	3920	3920	1680	1680	3920	1680	1512	168	84	1596	84	84	5516
	LLW Large	12500	8750	8750	3750	3750	8750	3750	3375	375	188	3563	188	188	12313
	Alpha Small	200	140	140	60	60	140	60	54	6	3	57	3	3	197
	Alpha Medium	4500	3150	3150	1350	1350	3150	1350	1215	135	68	1283	68	68	4433
	Alpha Large	7700	5390	5390	2310	2310	5390	2310	2079	231	116	2195	116	116	7585

Figure 4-2. Open, dump, and sort facility process functional diagram.

The waste in the containers that are designated for segregation is dumped onto a sorting station, which removes bulk metals, noncombustibles, semicombustibles, combustibles, special wastes,[c] and gas cylinders. Various sorting technologies, such as robotic assisted sort tables, vibratory screens, and air classifiers, may be used in the sorting station. Any spilled liquid is collected and sent to other unit operations for treatment. The sorted waste materials are placed into transfer bins and transferred to the treatment facilities. Nonmetallic containers are cut into smaller pieces as required for processing.

4.2.2 Facility Integration

In addition to general interfaces for all facilities, input interfaces to the open, dump, and sort facility are waste containers from the receiving/inspection facility. O&M consumables including personnel protective equipment are purchased. Output interfaces include sorted LLW/LLMW or alpha-LLW/LLMW solid waste to treatment. Also, reusable empty metal drums and boxes are sent to a decontamination facility for cleaning and recycle.

4.3 Cost Bases, Assumptions, and Assessments

General cost bases and assumptions are given in Appendix A. Facility specific items are discussed below.

- Estimated operating staff is shown below in Table 4-1.

Table 4-1. Estimated operating staff for open, dump, and sort facility (cost module CL and CA).

Activity	Small (LLM/LLMW) and alpha- (LLM/LLMW)	Medium (LLM/LLMW) and alpha- (LLM/LLMW)	Large (LLW/LLMW)	Large alpha- (LLW/LLMW)
1. Sorting table	8	32	128	96
2. Glovebox	4	4	16	12
3. Oven container	4	20	80	60
4. Gantry robot (transport and dump bins)	2	6	24	18
5. Self-guided vehicle	4	4	16	12
Total FTE	22	66	264	198

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c. Special wastes are those materials that are not compatible with the treatment techniques provided in the facility (e.g., mercury). After identification and removal, special wastes are treated by mobile units provided on a case-by-case basis.

- Major equipment capital cost items for this cost module are container open, dump, and sort devices and robotics arms. The costs for these items are developed based on consultation with personnel from DOE contractors involved in the Office of Technology Development, Robotic Technology Development Program.

- Small, medium, and large facility capacities and unit costs are shown in Table 4-2.

4.4 Cost Summaries

Cost summaries for the LLW/LLMW and alpha-LLW/LLMW open, dump, and sort facilities are shown in Tables 4-3 and 4-4. A histogram of cost versus capacity is given in Figures 4-3 and 4-4.

Table 4-2. Capacities and cost information for open, dump, and sort facility (cost modules CL and CA).[a]

Mod.	Module Description	Facility	Life Cycle Cost ($x1000)	Capacity (lbs/hr)	Unit Cost ($/lb)	Capacity (ft3/hr)	Cap(Tot Vol) (ft3x1000)	Unit Cost ($/ft3)
CL	Front-end Treatment	Small	$170,095	200	$10.55	6	461	$369.13
CL	Front-end Treatment	Medium	$689,326	5,600	$1.53	160	12,902	$53.43
CL	Front-end Treatment	Large	$1,522,432	12,500	$1.51	357	28,800	$52.86
CA	Front-end Treatment	Small	$216,026	200	$13.39	6	461	$468.81
CA	Front-end Treatment	Medium	$1,182,462	4,500	$3.26	129	10,368	$114.05
CA	Front-end Treatment	Large	$1,419,910	7,700	$2.29	220	17,741	$80.04

a. Average density used is 35 lbs/ft^3

Table 4-3. PLCC estimate summary for LLW/LLMW treatment open, dump, and sort facility (cost module CL).

Cost component	Cost Items		Basis	Cost ($ x 1000) Small	Medium	Large
1.0	**Studies and bench scale test costs**					
	1.1 Manpower costs during research			$300	$300	$300
	1.2 Equipment costs			$0	$0	$0
	1.3 Installation costs			$0	$0	$0
	1.4 Project management before title I		(10 % of 1.1 through 1.3)	$30	$30	$30
	1.5 Contingency		(25 % of 1.1 through 1.4)	$83	$83	$83
	Subtotal 1.0			$413	$413	$413
2.0	**Demonstration costs**					
	2.1 Manpower costs during demonstration			$900	$900	$900
	2.2 Design cost		(30 % of 2.5)	$174	$174	$174
	2.3 Inspection cost		(7 % of 2.5)	$41	$41	$41
	2.4 Project management		(10 % of 2.5)	$58	$58	$58
	2.5 Construction cost					
	2.5.1	Building structure costs		$100	$100	$100
	2.5.2	Equipment costs		$350	$350	$350
	2.5.3	Indirect	(29 % of 2.5.1 & 2.5.2)	$131	$131	$131
	Subtotal of 2.5			$581	$581	$581
	2.6 Construction management costs		(17.1 % of 2.5)	$99	$99	$99
	2.7 Management Reserve		(10 % of 2.5)	$58	$58	$58
	2.8 Contingency		(25 % of 2.1 through 2.7)	$478	$478	$478
	Subtotal 2.0			$2,389	$2,389	$2,389
3.0	**Production facility construction costs**					
	3.1 Design cost		(18 % of 3.4)	$2,789	$9,501	$17,584
	3.2 Inspection cost		(7 % of 3.4)	$1,085	$3,695	$6,838
	3.3 Project management		(10 % of 3.4)	$1,549	$5,278	$9,769
	3.4 Construction cost					
	3.4.1	Building structure costs		$2,880	$11,220	$22,440
	3.4.2	Equipment costs		$9,130	$29,698	$53,286
	3.4.3	Indirect	(29 % of 3.4.1 & 3.4.2)	$3,483	$11,866	$21,961
	Subtotal of 3.4			$15,493	$52,784	$97,687
	3.5 Construction management		(17.1 % of 3.4)	$2,649	$9,026	$16,704
	3.6 Management Reserve		(10 % of 3.4)	$1,549	$5,278	$9,769
	3.7 Contingency		(25 % of 3.1 through 3.5)	$5,891	$20,071	$37,146
	Subtotal 3.0			$31,005	$105,633	$195,497
4.0	**Operations Budget Funded Activities (See Sect. 7)**					
	4.1 Conceptual design		(1.5 % of 3.0)	$465	$1,584	$2,932
	4.2 Safety assurance		(1 % of 3.0)	$310	$1,056	$1,953
	4.3 NEPA permitting ($ 6 Mill for EIS, $1 Mill for EA)			$1,000	$1,000	$1,000
	4.4 Preparation for operations		(100 % of 5.0)	$6,196	$26,688	$61,143
	4.5 Project Management		(10 % of 4.1 through 4.4)	$797	$3,033	$6,703
	Subtotal 4.0			$8,768	$33,361	$73,733
	Total Initial Cost (1.0,2.0,3.0 & 4.0)			$42,575	$141,796	$272,032
5.0	**Operating and maintenance costs**					
	5.1 Annual operating costs			$3,080	$18,480	$36,960
	5.2 Annual utility costs			$30	$150	$300
	5.3 Annual material costs			$20	$600	$1,000
	5.4 Annual maintenance costs			$1,827	$2,120	$10,654
	5.5 Contingency		(25 % of 5.1 through 5.4)	$1,239	$5,338	$12,229
	Subtotal 5.0			$6,196	$26,688	$61,143
	Total 20 year O & M cost (20 times Subtotal 5.0)			$123,920	$533,760	$1,222,860
6.0	Decontamination & Decommissioning			$3,600	$13,770	$27,540
7.0	**ROM Life cycle costs (20 years operation)**			$170,093	$689,326	$1,522,432

Table 4-4. PLCC estimate summary for alpha-LLW/LLMW treatment open, dump, and sort facility (cost module CA).

Cost component	Cost Items			Cost ($ x 1000) Small	Medium	Large
1.0	**Studies and bench scale test costs**					
	1.1 Manpower costs during research			$300	$300	$300
	1.2 Equipment costs			$0	$0	$0
	1.3 Installation costs			$0	$0	$0
	1.4 Project management before title I		(10 % of 1.1 through 1.3)	$30	$30	$30
	1.5 Contingency		(25 % of 1.1 through 1.4)	$83	$83	$83
	Subtotal 1.0			$413	$413	$413
2.0	**Demonstration costs**					
	2.1 Manpower costs during demonstration			$900	$900	$900
	2.2 Design cost		(30 % of 2.5)	$174	$174	$174
	2.3 Inspection cost		(7 % of 2.5)	$41	$41	$41
	2.4 Project management		(10 % of 2.5)	$58	$58	$58
	2.5 Construction cost					
	2.5.1	Building structure costs		$100	$100	$100
	2.5.2	Equipment costs		$350	$350	$350
	2.5.3	Indirect	(29 % of 2.5.1 & 2.5.2)	$131	$131	$131
	Subtotal of 2.5			$581	$581	$581
	2.6 Construction management costs		(17.1 % of 2.5)	$99	$99	$99
	2.7 Management Reserve		(10 % of 2.5)	$58	$58	$58
	2.8 Contingency		(25 % of 2.1 through 2.7)	$478	$478	$478
	Subtotal 2.0			$2,389	$2,389	$2,389
3.0	**Production facility construction costs**					
	3.1 Design cost		(25 % of 3.4)	$7,460	$27,041	$40,647
	3.2 Inspection cost		(7 % of 3.4)	$2,089	$7,572	$11,381
	3.3 Project management		(10 % of 3.4)	$2,984	$10,317	$16,259
	3.4 Construction cost					
	3.4.1	Building structure costs		$11,616	$49,620	$73,980
	3.4.2	Equipment costs		$11,514	$34,229	$52,056
	3.4.3	Indirect	(29 % of 3.4.1 & 3.4.2)	$6,708	$24,316	$36,550
	Subtotal of 3.4			$29,838	$108,165	$162,586
	3.5 Construction management		(17.1 % of 3.4)	$5,102	$18,496	$27,802
	3.6 Management Reserve		(10 % of 3.4)	$2,984	$10,817	$16,259
	3.7 Contingency		(25 % of 3.1 through 3.5)	$11,868	$43,023	$64,669
	Subtotal 3.0			$62,325	$225,931	$339,603
4.0	**Operations Budget Funded Activities (See Sect. 7)**					
	4.1 Conceptual design		(1.5 % of 3.0)	$935	$3,389	$5,094
	4.2 Safety assurance		(1 % of 3.0)	$623	$2,259	$3,396
	4.3 NEPA permitting ($ 6 Mill for EIS, $1 Mill for EA)			$1,000	$1,000	$1,000
	4.4 Preparation for operations		(100 % of 5.0)	$6,805	$44,021	$49,329
	4.5 Project Management		(10 % of 4.1 through 4.4)	$936	$5,067	$5,882
	Subtotal 4.0			$10,299	$55,736	$64,701
	Total Initial Cost (1.0,2.0,3.0 & 4.0)			$75,426	$284,469	$407,106
5.0	**Operating and maintainence costs**					
	5.1 Annual operating costs			$3,080	$27,720	$27,720
	5.2 Annual utility costs			$30	$150	$225
	5.3 Annual material costs			$20	$550	$1,224
	5.4 Annual maintainence costs			$2,314	$6,797	$10,294
	5.5 Contingency		(25 % of 5.1 through 5.4)	$1,361	$8,804	$9,866
	Subtotal 5.0			$6,805	$44,021	$49,329
	Total 20 year O & M cost (20 times Subtotal 5.0)			$136,100	$880,420	$986,580
6.0	Decontamination & Decommissioning			$4,500	$17,573	$26,224
7.0	**ROM Life cycle costs (20 years operation)**			$216,026	$1,182,462	$1,419,910

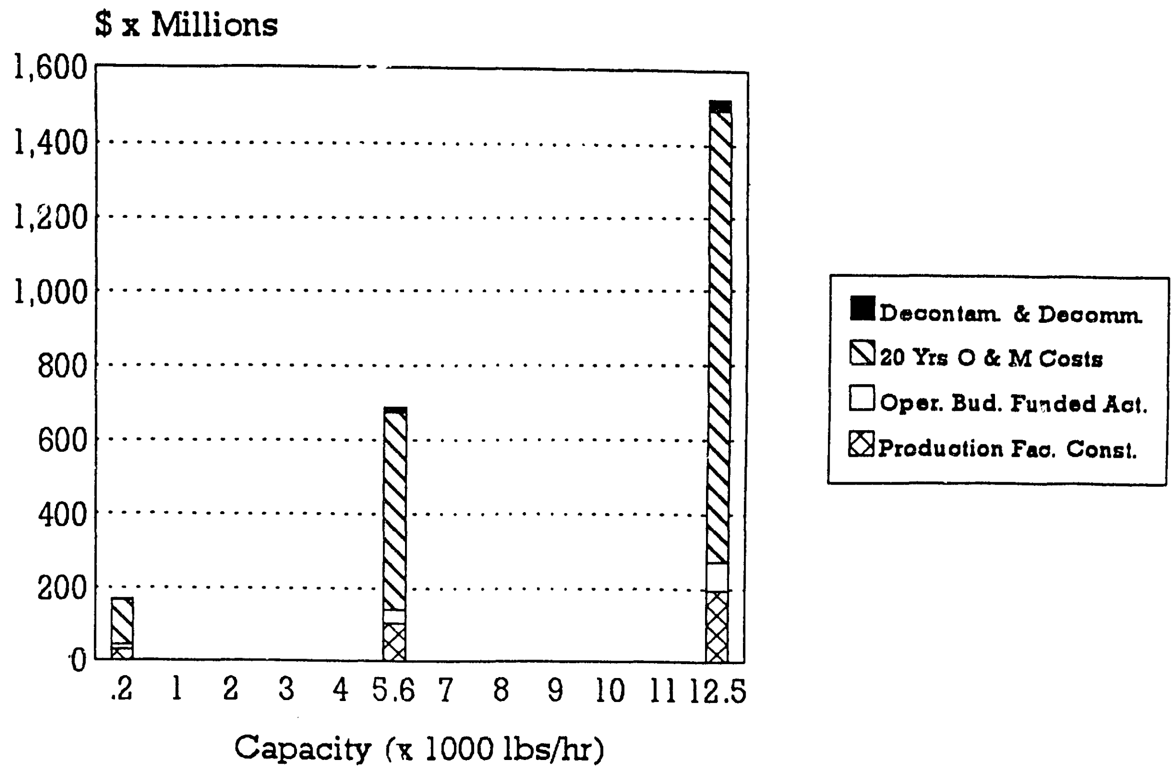

Figure 4-3. Cost versus capacity histogram for LLW/LLMW treatment open, dump, and sort facility (cost module CL).

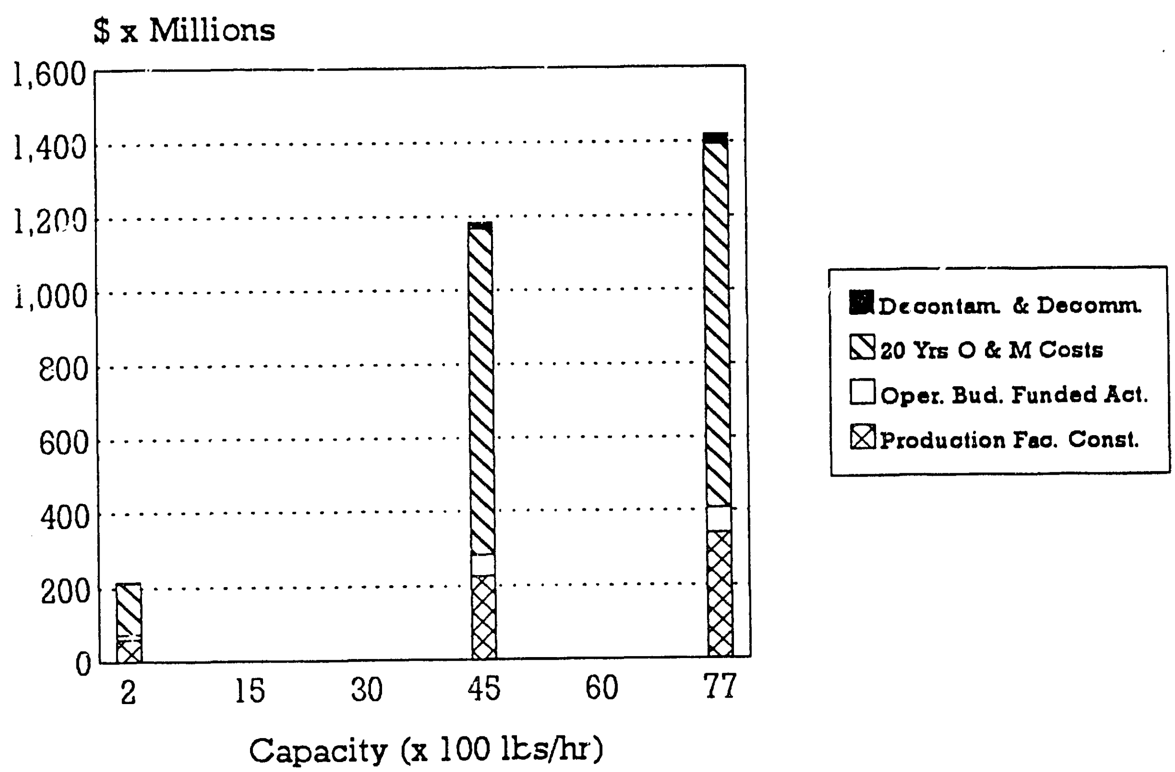

Figure 4-4. Cost versus capacity histogram for alpha-LLW/LLMW treatment open, dump, and sort facility (cost module CA).

5. INCINERATION FACILITY (COST MODULES DL AND DA)

5.1 Basic Information

The incineration facility, shown in Figure 5-1, must be either used in conjunction with the front-end and back-end support facilities (see cost modules A, B, CA/CL, I, and JA/JL) or constructed next to existing facilities where similar functions are already available. The incineration incorporates nine major unit operations that process and package either LLW/LLMW or alpha-LLW/LLMW. The process incinerates waste and solidifies the resulting ash, thus converting the waste into a form that complies with land disposal restrictions (LDR) requirements (refer to Appendix A). Cost module DA is applicable to alpha-LLW/LLMW, while cost module DL is for LLW/LLMW. Unit operations are shown in Figure 5-2.

The faciiity is designed to treat combustible solid waste, noncombustible solid waste that is mixed with combustible (semicombustible) solid waste, inorganic and organic liquid waste, and organic sludge. These categories are defined in Appendix A. When used for semicombustible solids, the resultant ash must not be more than 15% of the input waste by weight. If the ash weight exceeds 15%, cost adjustments must be made for larger ash handling and solidification units. If inorganic liquid waste feed is considered, up to 15% of the incoming waste feed rate can be incorporated without adjusting the costs for a higher thermal capacity burner.

The facility is based on costs and layout for either a stationary or rotary kiln incinerator. Rotary kiln designs are preferable if a significant portion of the feed is organic-contaminated solids (such as soil).

5.2 Technical Bases and Assumptions

5.2.1 Functional and Operational Description

The sorted waste enters the facility and is fed to the incinerator via an input preparation and feed unit, where the material is crushed and shredded. All combustible materials are thermally destroyed while inert materials pass through with the ash. In the solidification feed and preparation unit operation, the ash discharged from the incineration unit is collected, cooled, and stored. Upon demand, the ash is transported to a solidification unit, where it is mixed with plant wastewater and a binder (such as Portland cement) at a predetermined ratio to produce a stabilized waste form. After the components are properly mixed, the mixture is poured into disposal containers. The filled containers are capped and sent through a wash unit operation, where the drums are sealed and then washed by a high-pressure water spray. The containerized waste is ready for processing through radioassay and final certification, which are part of the back-end support facility.

The incineration facility generates two secondary waste streams: liquid and off-gas. The incinerator off-gas treatment unit is equipped with a secondary combustion unit that destroys the volatile organics. The secondary combustion effluent is fed to air pollution control devices designed to remove particulates, SO_2, HCl, and NOx. A surge tank retains off-gas for reprocessing in the event of a process upset. Secondary liquid waste is processed through a treatment unit, where dissolved and suspended solids (organic and inorganic) are removed. Treated wastewater is recycled for reuse. Sludge and other wet solids are fed into either the incinerator or the solidification unit for processing.

The anticipated net weight reduction for the input waste is approximately 50% based on the assumption that the treatment facility is a zero-discharge site. The anticipated density of the solidified waste is 112 lbs/ft^3. In addition, the incineration cost module will meet the following performance requirements:

- *Input Waste*: The facility can receive diverse types of waste material. The incinerators are sized based on 7,000 Btu/lb of incoming waste. At a minimum, the facility will process combustible and semicombustible solids, organic sludge, and organic and inorganic liquids.

- *Output Waste*: The solidified LLW/LLMW waste produced by incineration is suitable for disposal in an engineered as shallow land burial site. The suitability of engineered as shallow land disposal for alpha-LLW/LLMW requires further investigation.

- *Efficiency*: The system minimizes the volume of waste that requires disposal and the quantity of secondary waste and other discharges to the environment.

5.2.2 Facility Integration

Facility input interfaces include waste from the open, dump, and sort facility. Purchased materials include consumables such as personnel protective equipment, laboratory material, solidification materials, packaging materials, and disposable and reusable shipping containers.

The output interface consists of packaged LLW/LLMW or alpha-LLW/LLMW drums transported to the back-end facility. Scrubbed exhaust gases are discharged to the atmosphere.

5.3 Cost Bases, Assumptions, and Assessments

General cost bases and assumptions are given in Appendix A. Facility-specific items are discussed below.

- The incinerator, off-gas, and solidification units constitute the major equipment capital cost items. Incinerator prices are based on vendor bids for both rotary-kiln and stationary (controlled air) incinerators. Similar bids obtained for the off-gas and solidification units and the cost of the TSCA incinerator at ORNL were also considered in developing estimates.

- Major equipment capital costs are verified against the purchased costs at a commercial LLW incineration facility (SEG facility in Oak Ridge). The alpha-LLW incinerator is verified against the cost estimates contained in the EG&G Idaho SWSDS.[2]

- Estimated operating staff is shown in Table 5-1.

- Small, medium, and large facility capacities and unit costs are shown in Table 5-2.

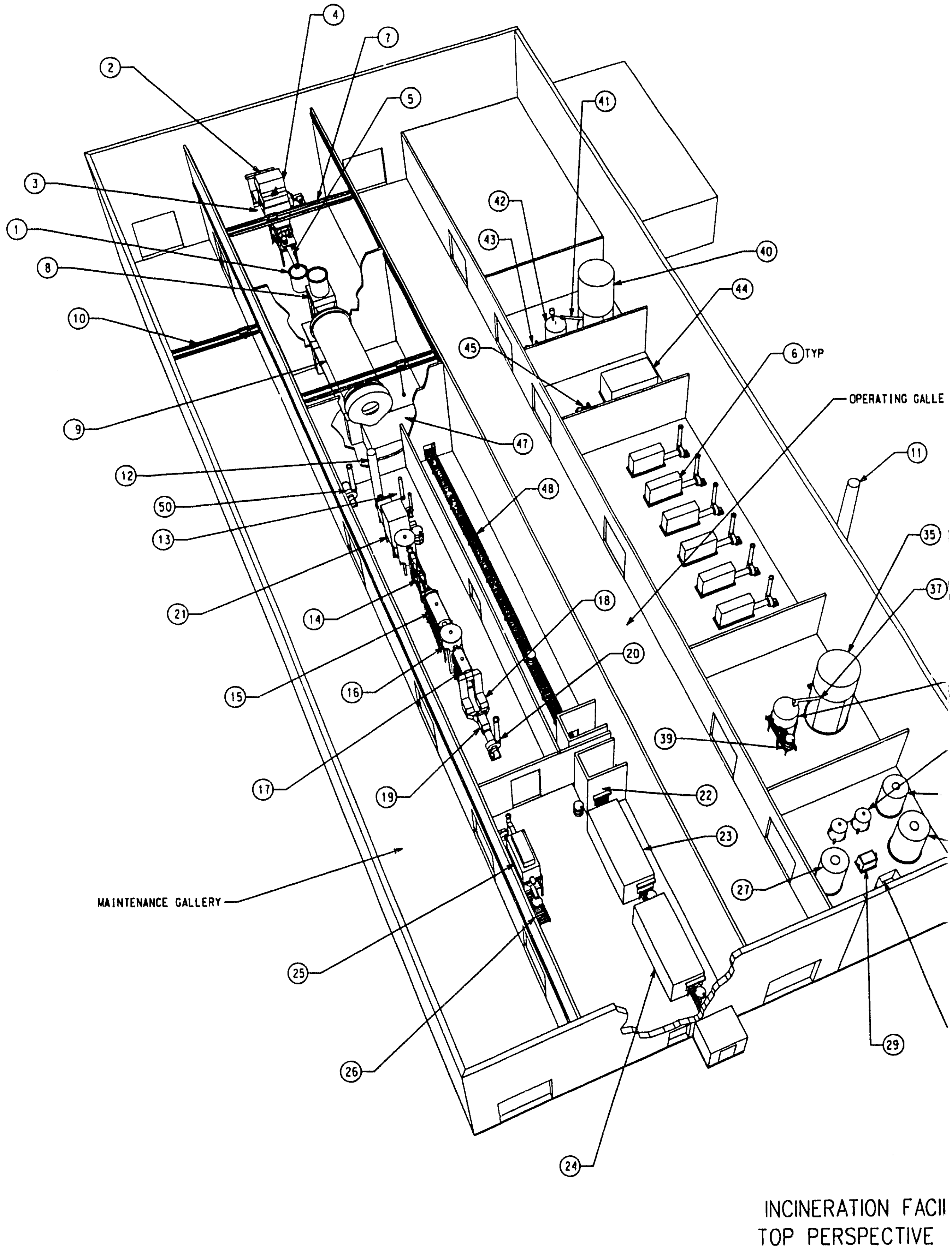

Figure 5-1. Typical arrangement for alpha-LLW/LLMW incineration facility.

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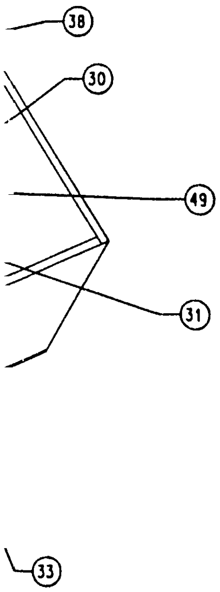

TY
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MAJOR EQUIPMENT LIST

1. WASTE TRANSFER BIN
2. INCOMING WASTE BIN
3. BIN HOIST
4. SHREDDER (2) WITH FEED HOPPER, DUST HOOD AND HYDRAULIC RAM
5. AUGER FEEDER
6. HEPA FILTER AND FAN
7. UNDERHUNG CRANE IN ENCLOSED PROCESS AREA
8. FEED BIN
9. INCINERATOR
10. UNDERHUNG CRANE IN ENCLOSED MAINTENANCE AREA
11. STACK
12. AFTERBURNER
13. GAS COOLER
14. DOUBLE VENTURI
15. CONDENSER
16. MIST ELIMINATOR
17. REHEATER
18. DOUBLE HEPA FILTERS
19. FINAL HEPA FILTER
20. I.D. FAN
21. CERAMIC BAG FILTER
22. DRUM STAGING CONVEYOR (POWERED ROLL)
23. SOLIDIFICATION SYSTEM
24. DRUM CAPPING AND WASHING SYSTEM
25. DUST COLLECTOR, FAN AND HEPA FILTER
26. DRUM STAGING CONVEYOR (POWERED ROLL)
27. RECEIVING TANK
28. PUMP
29. FILTER
30. ION EXCHANGE
31. TREATED WASTE TANK
32. PUMP
33. SLUDGE TANK
34. PUMP
35. STORAGE SILO
36. BIN HOIST
37. CONVEYOR
38. DAY BIN
39. DRUM STAGING CONVEYOR (GRAVITY)
40. LIME SILO
41. SCREW CONVEYOR
42. MIXING TANK W/MIXER
43. FEED PUMP
44. COOLING SYSTEM
45. CIRC. PUMP
46. DRUM STAGING CONVEYOR (POWERED ROLL)
47. ASH HOPPER AND CONVEYOR
48. DRUM STAGING CONVEYOR (POWERED ROLL)
49. PRECIPITATION TANK
50. INCINERATOR AIR SUPPLY FAN

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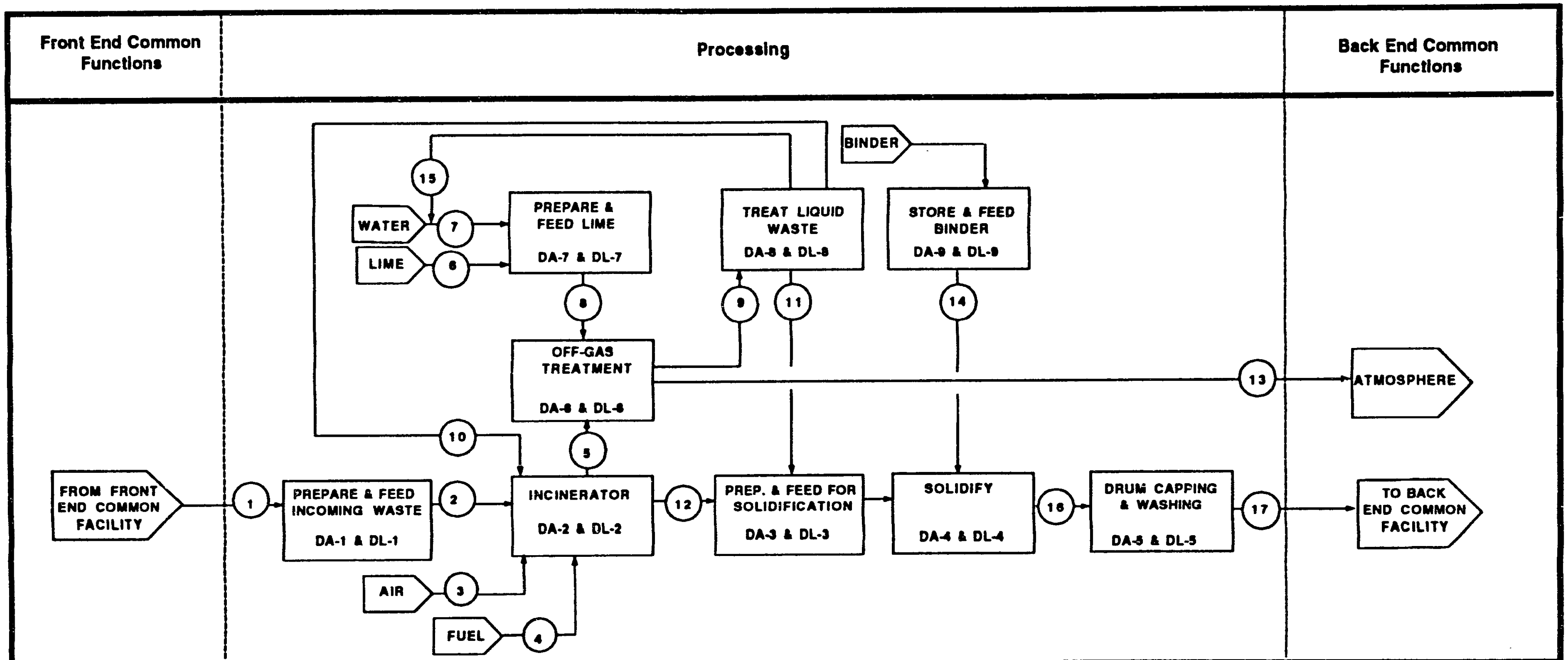


	NODE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
FLOWRATES	FACILITY SIZE	Input Waste	Waste	Air	Fuel	Off Gas	Lime	Water	Lime & Water Mixture	Off Gas	Sludge	Treated Water	Ash	Treated Off Gas	Binder	Treated Water	Solidif. Waste Output	Drummed Waste
(LB/HR)	LLW Small	200	200	1651	30	2105	50	1188	1238	1309	248	25	24	2033	50	1037	99	99
	LLW Medium	1000	1000	8253	150	10523	248	5942	6190	6547	1238	126	118	10165	249	5183	493	493
	LLW Large	2000	2000	16506	300	21046	495	11884	12379	13095	2476	252	236	20330	498	10367	986	986
	Alpha Small	150	150	1238	23	1578	37	891	928	982	186	19	18	1525	37	778	74	74
	Alpha Medium	1000	1000	8253	150	10523	248	5942	6190	6547	1238	126	118	10165	249	5183	493	493
	Alpha Large	2000	2000	16506	300	21046	495	11884	12379	13095	2476	252	236	20330	498	10367	986	986

Figure 5-2. Incineration facility process functional diagram.

Table 5-1. Estimated operating staff for incineration facility (cost module D).

Unit operation	Description	Small (FTE)	Medium (FTE)	Large (FTE)
D-1	Prepare and feed incoming waste	10	13	19
D-2	Incinerator	10	13	16
D-3	Prepare and feed for solidification	2	4	4
D-4	Solidify	2	4	7
D-5	Drum capping and washing	0	0	0
D-6	Off-gas treatment	2	4	4
D-7	Prepare and feed lime	2	2	4
D-8	Treat liquid waste	4	4	4
D-9	Store and feed binder	2	4	4
D-10	Electrical distribution and Motor Control Center	1	2	4
D-11	Heating, ventilation, and exhaust	2	4	4
D-12	Other equipment	6	10	14
	Total	43	64	84

Table 5-2. Capacities and costs information for incineration facility (cost module DL and DA).[a]

Mod.	Module Description	Facility	Life Cycle Cost ($x1000)	Capacity (lbs/hr)	Unit Cost ($/lb)	Capacity (ft3/hr)	Cap(Tot Vol) (ft3x1000)	Unit Cost ($/ft3)
DL	Incineration	Small	$296,245	200	$18.37	6	461	$642.89
DL	Incineration	Medium	$453,292	1,000	$5.62	29	2,304	$196.74
DL	Incineration	Large	$624,390	2,000	$3.87	57	4,608	$135.50
DA	Incineration	Small	$364,684	150	$30.15	4	346	$1,055.22
DA	Incineration	Medium	$536,989	1,000	$6.66	29	2,304	$233.07
DA	Incineration	Large	$732,819	2,000	$4.54	57	4,608	$159.03

a. Average density used is 35 lbs/ft.[3]

5.4 Cost Summaries

Cost summaries for the LLW/LLMW and alpha-LLW/LLMW incineration cost modules are shown in Tables 5-3 and 5-4. Histograms for cost versus capacity are given in Figures 5-3 and 5-4.

Table 5-3. PLCC estimate summary for LLW/LLMW incineration facility (cost module DL).

Cost component	Cost Items			Cost ($ x 1000) Small	Medium	Large
1.0	**Studies and bench scale test costs**					
	1.1 Manpower costs during research			$1.350	$1.350	$1.350
	1.2 Equipment costs			$50	$50	$50
	1.3 Installation costs			$150	$150	$150
	1.4 Project management before title I		(10 % of 1.1 through 1.3)	$155	$155	$155
	1.5 Contingency		(25 % of 1.1 through 1.4)	$426	$426	$426
	Subtotal 1.0			$2.131	$2.131	$2.131
2.0	**Demonstration costs**					
	2.1 Manpower costs during demonstration			$2.400	$2.400	$2.400
	2.2 Design cost		(30 % of 2.5)	$360	$360	$360
	2.3 Inspection cost		(7 % of 2.5)	$84	$84	$84
	2.4 Project management		(10 % of 2.5)	$120	$120	$120
	2.5 Construction cost					
	2.5.1	Building structure costs		$180	$180	$180
	2.5.2	Equipment costs		$750	$750	$750
	2.5.3	Indirect	(29 % of 2.5.1 & 2.5.2)	$270	$270	$270
	Subtotal of 2.5			$1.200	$1.200	$1.200
	2.6 Construction management costs		(17.1 % of 2.5)	$205	$205	$205
	2.7 Management Reserve		(10 % of 2.5)	$120	$120	$120
	2.8 Contingency		(25 % of 2.1 through 2.7)	$1.122	$1.122	$1.122
	Subtotal 2.0			$5.611	$5.611	$5.611
3.0	**Production facility construction costs**					
	3.1 Design cost		(18 % of 3.4)	$3.637	$4.826	$6.202
	3.2 Inspection cost		(7 % of 3.4)	$1.415	$1.877	$2.412
	3.3 Project management		(10 % of 3.4)	$2.021	$2.681	$3.446
	3.4 Construction cost					
	3.4.1	Building structure costs		$3.351	$5.229	$6.222
	3.4.2	Equipment costs		$12.314	$15.555	$20.490
	3.4.3	Indirect	(29 % of 3.4.1 & 3.4.2)	$4.543	$6.027	$7.746
	Subtotal of 3.4			$20.208	$26.811	$34.458
	3.5 Construction management		(17.1 % of 3.4)	$3.456	$4.585	$5.892
	3.6 Management Reserve		(10 % of 3.4)	$2.021	$2.681	$3.446
	3.7 Contingency		(25 % of 3.1 through 3.5)	$7.634	$10.195	$13.103
	Subtotal 3.0			$40.442	$53.656	$68.959
4.0	**Operations Budget Funded Activities (See Sect. 7)**					
	4.1 Conceptual design		(1.5 % of 3.0)	$607	$805	$1.034
	4.2 Safety assurance		(1 % of 3.0)	$404	$537	$690
	4.3 NEPA permitting ($ 6 Mill for EIS, $1 Mill for EA)			$6.000	$6.000	$6.000
	4.4 Preparation for operations		(100 % of 5.0)	$11.200	$17.895	$25.198
	4.5 Project Management		(10 % of 4.1 through 4.4)	$1.821	$2.524	$3.292
	Subtotal 4.0			$20.032	$27.761	$36.214
	Total Initial Cost (1.0,2.0,3.0 & 4.0)			**$68,216**	**$89,159**	**$112,915**
5.0	**Operating and maintainence costs**					
	5.1 Annual operating costs			$6.020	$8.960	$11.760
	5.2 Annual utility costs			$324	$1.889	$3.742
	5.3 Annual material costs			$136	$323	$506
	5.4 Annual maintainence costs			$2.480	$3.144	$4.150
	5.5 Contingency		(25 % of 5.1 through 5.4)	$2.240	$3.579	$5.040
	Subtotal 5.0			$11.200	$17.895	$25.198
	Total 20 year O & M cost (20 times Subtotal 5.0)			$224.000	$357.900	$503.960
6.0	Decontamination & Decommissioning			$4.029	$6.233	$7.515
7.0	**ROM Life cycle costs (20 years operation)**			**$296,245**	**$453,292**	**$624,390**

Table 5-4. PLCC estimate summary for alpha-LLW/LLMW incineration facility (cost module DA).

Cost component	Cost Items			Cost ($ x 1000) Small	Medium	Large
1.0	**Studies and bench scale test costs**					
	1.1 Manpower costs during research			$1,650	$1,650	$1,650
	1.2 Equipment costs			$50	$50	$50
	1.3 Installation costs			$150	$150	$150
	1.4 Project management before title I		(10 % of 1.1 through 1.3)	$185	$185	$185
	1.5 Contingency		(25 % of 1.1 through 1.4)	$509	$509	$509
	Subtotal 1.0			$2,544	$2,544	$2,544
2.0	**Demonstration costs**					
	2.1 Manpower costs during demonstration			$2,400	$2,400	$2,400
	2.2 Design cost		(30 % of 2.5)	$360	$360	$360
	2.3 Inspection cost		(7 % of 2.5)	$84	$84	$84
	2.4 Project management		(10 % of 2.5)	$120	$120	$120
	2.5 Construction cost					
	2.5.1	Building structure costs		$180	$180	$180
	2.5.2	Equipment costs		$750	$750	$750
	2.5.3	Indirect	(29 % of 2.5.1 & 2.5.2)	$270	$270	$270
	Subtotal of 2.5			$1,200	$1,200	$1,200
	2.6 Construction management costs		(17.1 % of 2.5)	$205	$205	$205
	2.7 Management Reserve		(10 % of 2.5)	$120	$120	$120
	2.8 Contingency		(25 % of 2.1 through 2.7)	$1,122	$1,122	$1,122
	Subtotal 2.0			$5,611	$5,611	$5,611
3.0	**Production facility construction costs**					
	3.1 Design cost		(25 % of 3.4)	$9,923	$12,769	$16,643
	3.2 Inspection cost		(7 % of 3.4)	$2,779	$3,575	$4,660
	3.3 Project management		(10 % of 3.4)	$3,969	$5,107	$6,657
	3.4 Construction cost					
	3.4.1	Building structure costs		$14,901	$19,818	$26,047
	3.4.2	Equipment costs		$15,869	$19,774	$25,558
	3.4.3	Indirect	(29 % of 3.4.1 & 3.4.2)	$8,923	$11,482	$14,965
	Subtotal of 3.4			$39,693	$51,074	$66,570
	3.5 Construction management		(17.1 % of 3.4)	$6,788	$8,734	$11,383
	3.6 Management Reserve		(10 % of 3.4)	$3,969	$5,107	$6,657
	3.7 Contingency		(25 % of 3.1 through 3.5)	$15,788	$20,315	$26,478
	Subtotal 3.0			$82,909	$106,681	$139,048
4.0	**Operations Budget Funded Activities (See Sect. 7)**					
	4.1 Conceptual design		(1.5 % of 3.0)	$1,244	$1,600	$2,086
	4.2 Safety assurance		(1 % of 3.0)	$829	$1,067	$1,390
	4.3 NEPA permitting ($ 6 Mill for EIS, $1 Mill for EA)			$6,000	$6,000	$6,000
	4.4 Preparation for operations		(100 % of 5.0)	$12,196	$19,084	$26,661
	4.5 Project Management		(10 % of 4.1 through 4.4)	$2,027	$2,775	$3,614
	Subtotal 4.0			$22,296	$30,526	$39,751
	Total Initial Cost (1.0,2.0,3.0 & 4.0)			**$113,360**	**$145,362**	**$186,954**
5.0	**Operating and maintainence costs**					
	5.1 Annual operating costs			$6,020	$8,960	$11,760
	5.2 Annual utility costs			$324	$1,889	$3,742
	5.3 Annual material costs			$176	$363	$566
	5.4 Annual maintainence costs			$3,237	$4,055	$5,261
	5.5 Contingency		(25 % of 5.1 through 5.4)	$2,439	$3,817	$5,332
	Subtotal 5.0			$12,196	$19,084	$26,661
	Total 20 year O & M cost (20 times Subtotal 5.0)			$243,920	$381,680	$533,220
6.0	Decontamination & Decommissioning			$7,404	$9,947	$12,645
7.0	**ROM Life cycle costs (20 years operation)**			**$364,684**	**$536,989**	**$732,819**

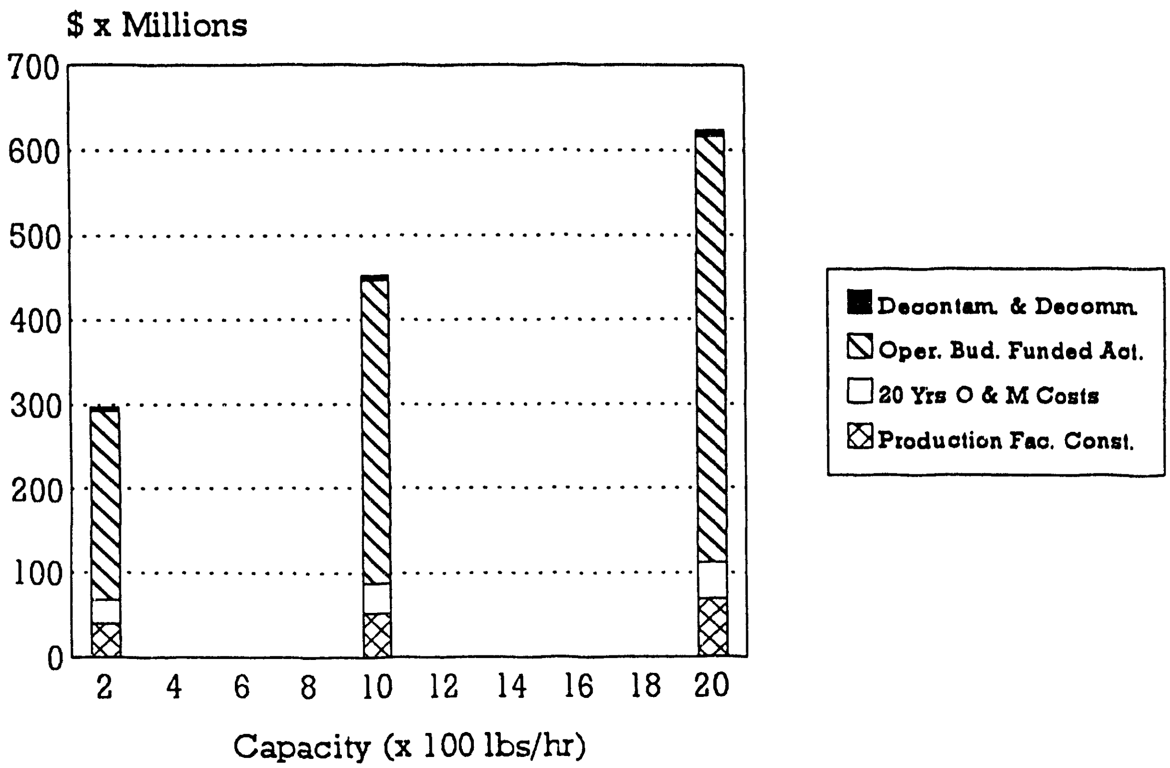


Figure 5-3. Cost versus capacity histogram for LLW/LLMW incineration facility (cost module DL).

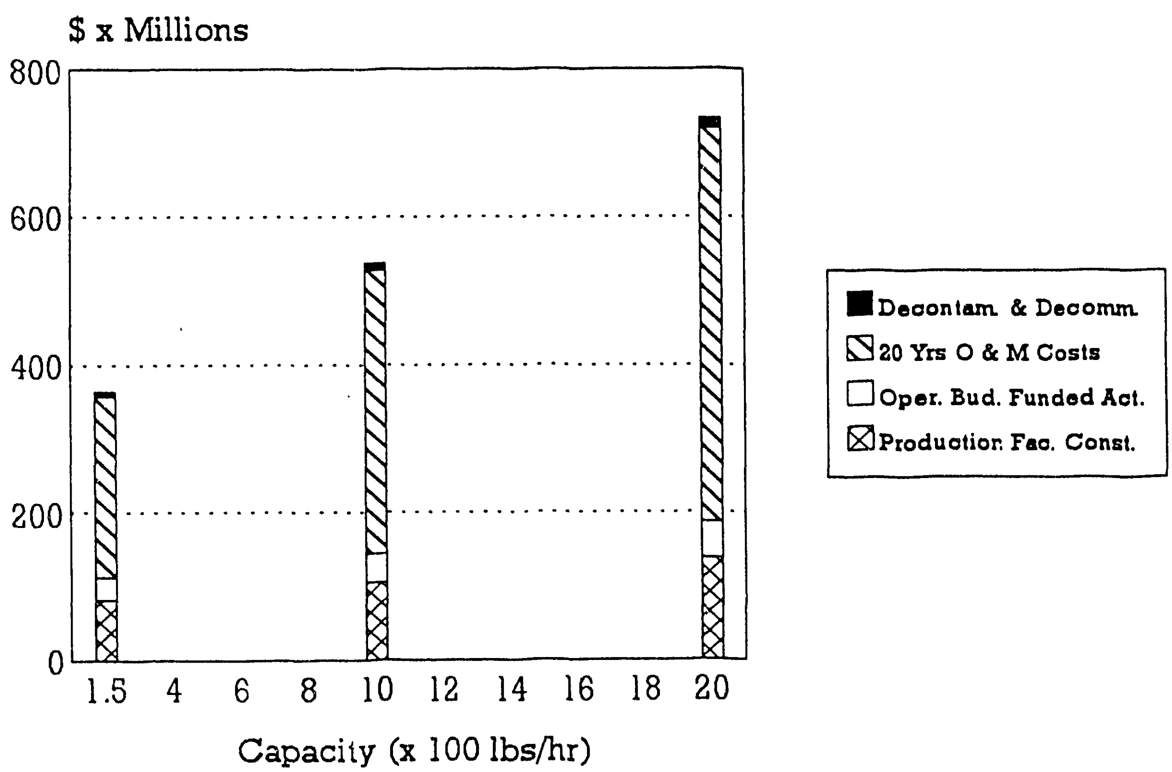


Figure 5-4. Cost versus capacity histogram for alpha-LLW/LLMW incineration facility (cost module DA).

6. METAL MELTING FACILITY (COST MODULES EL AND EA)

6.1 Basic Information

The metal melting facility, shown in Figure 6-1, is used either as an addition to the existing facility where similar functions are already available, or in conjunction with the treatment front-end and back-end support facilities (see cost modules A, B, CA/CL, I, and JA/JL). Cost module EA is applicable to alpha-LLW/LLMW while cost module EL is for LLW/LLMW. Unit operations are given in Figure 6-2.

The facility involves ten process unit operations that convert metals into cast ingots and treat secondary liquid and gaseous wastes. Secondary waste treatment by-products, such as off-gas scrubber sludge and slag, are solidified and placed in drums. (Other general support functions are described in Appendix A.)

The facility is equipped for processing ferrous and nonferrous bulk metals of various shapes and forms such as waste containers, failed equipment, and contaminated scrap structural steel. The cost module is designed to handle incoming waste in 55-gal drums containing up to 10% combustibles. However, this facility cannot sort different metal types. The metals must, therefore, arrive at the facility presorted.

6.2 Technical Bases and Assumptions

6.2.1 Functional and Operational Description

Incoming sorted bulk metal is shredded and prepared via an input preparation and feed unit. The feed conveyor transports the shredded metal to an electric furnace, where the metal is melted and any accompanying combustible materials are thermally destroyed. A metal cooling and casting unit operation allows for withdrawal of the molten metal and slag from the furnace so it can be poured into ingots for casting and cooling.

The unit operations produce three secondary waste streams: slag, liquid, and off-gas. The slag is separated at the casting and cooling unit and placed into containers for disposal. Secondary liquid waste is processed in the liquid waste treatment unit that removes dissolved and suspended solids (organic and inorganic) from the liquid waste. The facility recycles and reuses the treated wastewater so that there is zero discharge to the environment. The melter off-gas system is equipped with a secondary combustion unit that completes the volatile gas destruction process. An induced air blower moves the secondary combustor effluent through air pollution control devices that are designed to remove particulates, SO_2, HCl, and NO_x. A surge tank is provided for off-gas retention for reprocessing of melter exhaust in the event of a process upset.

In the solidification unit operation, liquid waste treatment sludge is mixed with a binder (such as Portland cement) in a drum. A predetermined mixing ratio is used to produce a stabilized waste form. The filled drums are washed with high-pressure water spray jets at the drum capping and washing unit operation.

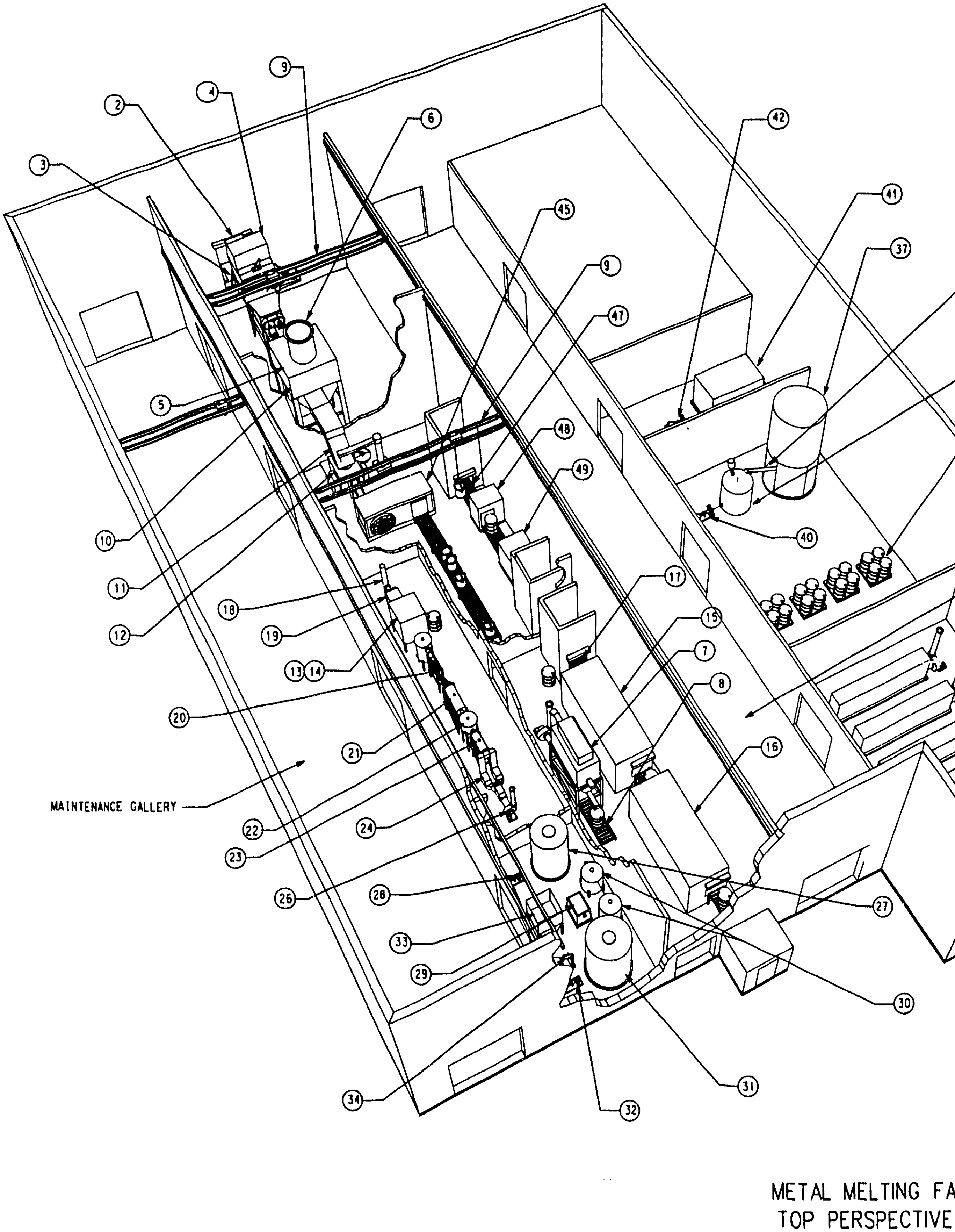
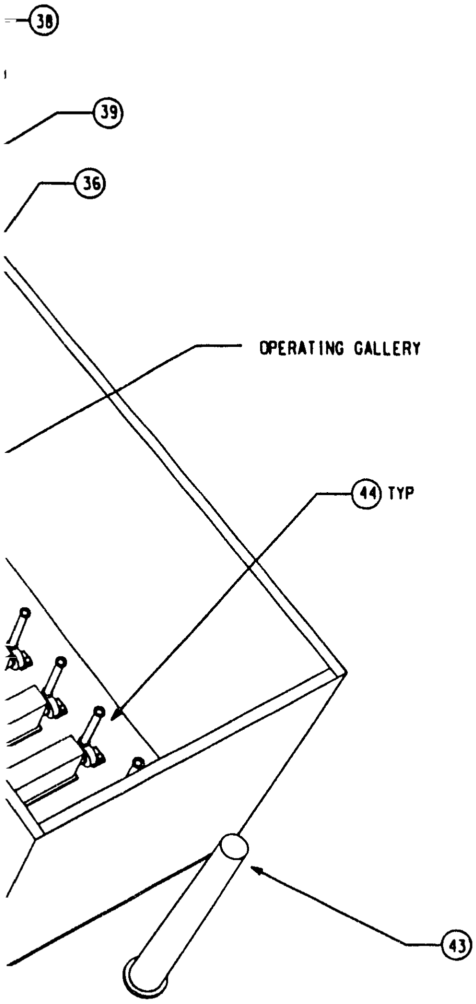


Figure 6-1. Typical arrangement for alpha-LLW/LLMW metal melting facility.



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MAJOR EQUIPMENT LIST

1. BIN PUSHER
2. INCOMING WASTE BIN
3. BIN HOIST
4. SHREDDER (2) WITH FEED HOPPER, DUST HOOD AND HYDRAULIC RAM
5. SCREW CONVEYOR
6. SHREDDED WASTE BIN
7. DUST COLLECTOR, I.D. FAN AND HEPA FILTER
8. DRUM STAGING CONVEYOR (POWERED ROLL)
9. UNDERHUNG CRANE WITHIN ENCLOSED PROCESS AREA
10. LIVE BOTTOM BULK STORAGE HOPPER
11. REMOVABLE FEED CHUTE
12. INDUCTION FURNACE (TILTING)
13. CERAMIC BAG FILTER
14. DRUM STAGING CONVEYOR (POWERED ROLL)
15. SOLIDIFICATION SYSTEM
16. DRUM CAPPING AND WASHING SYSTEM
17. DRUM TRANSPORT CONVEYOR (POWERED ROLL)
18. AFTERBURNER
19. GAS COOLER
20. DOUBLE VENTURI
21. CONDENSER
22. MIST ELIMINATOR
23. REHEATER
24. DOUBLE HEPA FILTERS
25. FINAL HEPA FILTER
26. I.D. FAN
27. RECEIVING TANK
28. PUMP
29. FILTER
30. ION EXCHANGE
31. TREATED WASTE TANK
32. PUMP
33. SLUDGE TANK
34. PUMP
35. UNDERHUNG CRANE WITHIN ENCLOSED MAINTENANCE AREA
36. BINDER DRUMS
37. LIME SILO
38. SCREW CONVEYOR
39. MIXING TANK
40. FEED PUMP
41. CHILLER
42. CIRC. PUMP
43. STACK
44. HEPA FILTER AND FAN
45. REMOTE CONTROLLED INGOT FORMING
46. INGOT FORM STAGING CONVEYOR (POWERED ROLL)
47. OVERPACK STAGING CONVEYOR (POWERED ROLL)
48. CAPPING DEVICE
49. WASHING DEVICE
50. TRANSFER MONORAIL WITH HOIST

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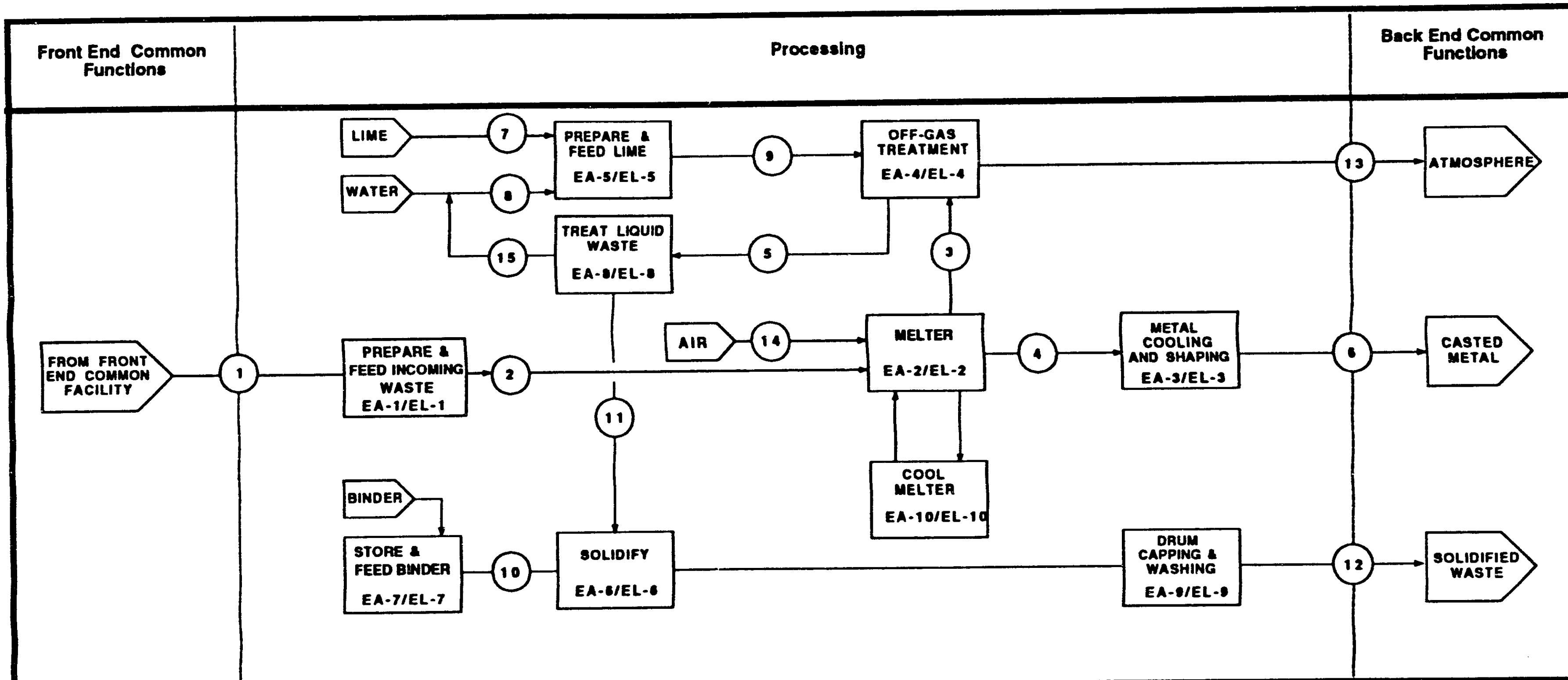


	NODE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
FLOWRATES	FACILITY SIZE	Input Waste	Non Combust	Melter Gas	Melted Metal	Misc Liquid Waste	Metal	Lime	Water	Lime Sol'n	Binder	Sludge	Solidified Waste	Treated Off Gas	Air	Treated Water
(LB/HR)	LLW Small	50	50	39	50	31	50	1	28	29	9	6	15	38	39	25
	LLW Medium	1600	1600	1255	1600	984	1600	38	904	942	301	188	490	1213	1255	796
	LLW Large	2500	2500	1962	2500	1538	2500	59	1412	1471	471	294	765	1895	1962	1244
	Alpha Small	60	60	47	60	37	60	1	34	35	11	7	18	45	47	30
	Alpha Medium	600	600	471	600	369	600	14	339	353	113	71	184	455	471	298
	Alpha Large	1000	1000	785	1000	615	1000	24	565	588	188	118	306	758	785	497

Figure 6-2. Metal melting process functional diagram.

Drums containing solidified waste, slag containers, and cast metal ingots are the main output from this facility. This output is ready for examinations by radioassay and final certification included in the back-end support facility.

The metal ingots can have a limited potential for reuse or may be disposed of safely in shallow land disposal units. The anticipated density of the solidified waste is 112 lbs/ft^3, and the densities for cast metal are the same as their absolute densities.

6.2.2 Facility Integration

Major input is contaminated scrap metal either from the open, dump, and sort facility (cost module CL or CA) or directly from generator sites through the unloading inspection facility (cost module B). Major O&M purchased materials such as personnel protective equipment, laboratory material, binder, and disposable containers are assumed to be consumable supplies, and their respective costs are estimated accordingly.

Major discharges from the system are metal ingots, slag containers, and drums of solidified LLW/LLMW or alpha-LLW/LLMW waste that are transported to a back-end facility (see cost module I). Treated off-gas is discharged into the atmosphere.

6.3 Cost Bases, Assumptions, and Assessments

General cost bases and assumptions are given in Appendix A. Facility specific items are discussed below.

- The metal sizing and preparation units (shredders), melter and off-gas treatment/scrubber system, and solidification units are major equipment capital cost items.

- Major equipment capital costs were verified against the purchased costs incurred by a commercial LLW waste processing facility (SEG facility in Oak Ridge) that recently began to operate a metal melting process.

- Estimated operating staff is shown in Table 6-1.

- Budgetary cost for the preparation and feed unit is based on vendor quotes for shredders, conveyors, and dust collection equipment.

- Melter prices are based on budgetary quotes from Ajax Corporation. Overall facility costs are checked against a metal melting reference facility in Germany (Siempelkamp, Siempelkamp Street 45, 4150 Krefeld, Germany).[5]

- Callidus Technologies provided budgetary quotes for the various off-gas scrubbers.

- The selected solidification unit is manufactured by Stock Equipment Company of Chagrin Falls, Ohio. This supplier provided a quote for a unit similar to that sold to DOE for a facility at the Savannah River Site.

- Small, medium, and large facility capacities and unit costs are shown in Table 6-2.

Table 6-1. Estimated operating staff for metal melting facility (cost module EL and EA).

Unit operation	Description	Small LLW	Medium LLW	Large LLW	Small alpha (FTE)	Medium alpha (FTE)	Large alpha (FTE)
E-1	Prepare and feed incoming waste	0	9	9	0	9	12
E-2	Melter	9	12	12	9	12	15
E-3	Metal cooling and storing	3	6	6	3	6	6
E-4	Off-gas treatment	1	3	3	1	3	6
E-5	Prepare and feed lime	1	3	3	1	3	6
E-6	Solidify	1	3	3	1	3	6
E-7	Store and feed binder	1	3	3	1	3	3
E-8	Treat liquid waste	1	3	3	1	3	3
E-9	Drum capping and washing	0	0	0	1	1	1
E-10	Cool melter	0	0	0	0	0	0
E-11	Electric dist and MCC	0	0	1	1	0	0
E-12	Heating, ventilation and exhaust	0	0	0	1	1	1
E-13	Other equipment	4	4	7	4	7	13
	Total	21	46	49	23	51	72

Table 6-2. Capacities and cost information for metal melting facility (cost module EL and EA).[a]

Mod.	Module Description	Facility	Life Cycle Cost ($x1000)	Capacity (lbs/hr)	Unit Cost ($/lb)	Capacity (ft3/hr)	Cap(Tot Vol) (ft3x1000)	Unit Cost ($/ft3)
EL	Metal Melting	Small	$140,950	50	$34.96	1	115	$1,223.52
EL	Metal Melting	Medium	$293,306	1,600	$2.27	46	3,686	$79.56
EL	Metal Melting	Large	$335,527	2,500	$1.66	71	5,760	$58.25
EA	Metal Melting	Small	$194,798	60	$40.26	2	138	$1,409.13
EA	Metal Melting	Medium	$372,028	600	$7.69	17	1,382	$269.12
EA	Metal Melting	Large	$469.314	1,000	$5.82	29	2,304	$203.70

a. Average density used is 35 lbs/ft.[3]

6.4 Cost Summaries

Cost summaries for the LLW/LLMW and alpha-LLW/LLMW metal melting cost modules are shown in Tables 6-3 and 6-4. Histograms for cost versus capacity are given in Figures 6-3 and 6-4.

Table 6-3. PLCC estimate summary for alpha LLW/LLMW metal-melting facility (cost module EL).

Cost component	Cost Items		Cost ($ x 1000) Small	Medium	Large
1.0	**Studies and bench scale test costs**				
	1.1 Manpower costs during research		$1,050	$1,050	$1,050
	1.2 Equipment costs		$50	$50	$50
	1.3 Installation costs		$150	$150	$150
	1.4 Project management before title I	(10 % of 1.1 through 1.3)	$125	$125	$125
	1.5 Contingency	(25 % of 1.1 through 1.4)	$344	$344	$344
	Subtotal 1.0		$1,719	$1,719	$1,719
2.0	**Demonstration costs**				
	2.1 Manpower costs during demonstration		$0	$0	$0
	2.2 Design cost	(30 % of 2.5)	$0	$0	$0
	2.3 Inspection cost	(7 % of 2.5)	$0	$0	$0
	2.4 Project management	(10 % of 2.5)	$0	$0	$0
	2.5 Construction cost				
	2.5.1 Building structure costs		$0	$0	$0
	2.5.2 Equipment costs		$0	$0	$0
	2.5.3 Indirect	(29 % of 2.5.1 & 2.5.2)	$0	$0	$0
	Subtotal of 2.5		$0	$0	$0
	2.6 Construction management costs	(17.1 % of 2.5)	$0	$0	$0
	2.7 Management Reserve	(10 % of 2.5)	$0	$0	$0
	2.8 Contingency	(25 % of 2.1 through 2.7)	$0	$0	$0
	Subtotal 2.0		$0	$0	$0
3.0	**Production facility construction costs**				
	3.1 Design cost	(18 % of 3.4)	$1,814	$3,473	$4,377
	3.2 Inspection cost	(7 % of 3.4)	$705	$1,350	$1,702
	3.3 Project management	(10 % of 3.4)	$1,008	$1,929	$2,432
	3.4 Construction cost				
	3.4.1 Building structure costs		$1,890	$2,871	$3,763
	3.4.2 Equipment costs		$5,922	$12,084	$15,086
	3.4.3 Indirect	(29 % of 3.4.1 & 3.4.2)	$2,265	$4,337	$5,466
	Subtotal of 3.4		$10,077	$19,292	$24,315
	3.5 Construction management	(17.1 % of 3.4)	$1,723	$3,299	$4,158
	3.6 Management Reserve	(10 % of 3.4)	$1,008	$1,929	$2,432
	3.7 Contingency	(25 % of 3.1 through 3.5)	$3,832	$7,336	$9,246
	Subtotal 3.0		$20,167	$38,608	$48,662
4.0	**Operations Budget Funded Activities (See Sect. 7)**				
	4.1 Conceptual design	(1.5 % of 3.0)	$303	$579	$730
	4.2 Safety assurance	(1 % of 3.0)	$202	$386	$487
	4.3 NEPA permitting ($ 6 Mill for EIS, $1 Mill for EA)		$6,000	$6,000	$6,000
	4.4 Preparation for operations	(100 % of 5.0)	$5,182	$11,444	$12,901
	4.5 Project Management	(10 % of 4.1 through 4.4)	$1,169	$1,841	$2,012
	Subtotal 4.0		$12,856	$20,250	$22,130
	Total Initial Cost (1.0,2.0,3.0 & 4.0)		$34,742	$60,577	$72,511
5.0	**Operating and maintainence costs**				
	5.1 Annual operating costs		$2,940	$6,440	$6,860
	5.2 Annual utility costs		$15	$47	$83
	5.3 Annual material costs		$5	$126	$197
	5.4 Annual maintainence costs		$1,186	$2,542	$3,181
	5.5 Contingency	(25 % of 5.1 through 5.4)	$1,036	$2,289	$2,580
	Subtotal 5.0		$5,182	$11,444	$12,901
	Total 20 year O & M cost (20 times Subtotal 4.0)		$103,640	$228,880	$258,020
6.0	Decontamination & Decommissioning		$2,568	$3,849	$4,996
7.0	**ROM Life cycle costs (20 years operation)**		$140,950	$293,306	$335,527

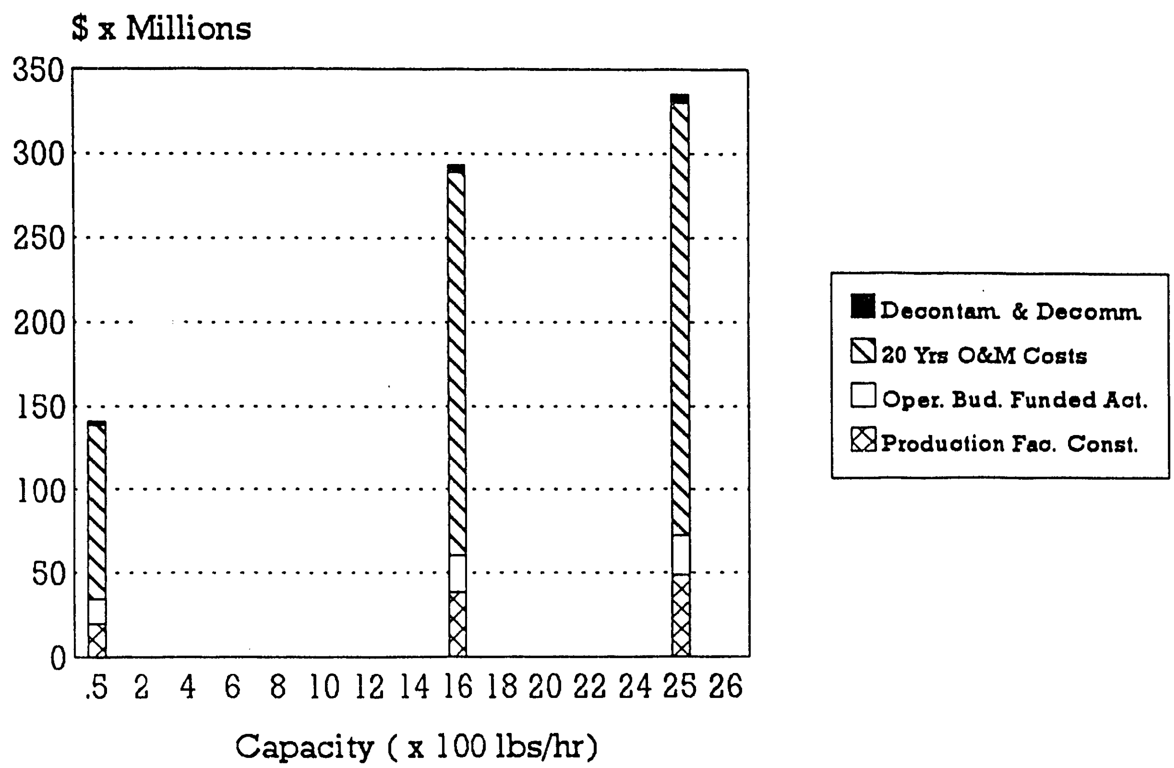


Figure 6-3. Cost versus capacity histogram for LLW/LLMW metal melting facility (cost module EL).

Table 6-4. PLCC estimate summary for LLW/LLMW metal-melting facility (cost module EA).

Cost component		Cost Items	Cost ($ x 1000) Small	Medium	Large
1.0	**Studies and bench scale test costs**				
	1.1 Manpower costs during research		$1,050	$1,050	$1,050
	1.2 Equipment costs		$50	$50	$50
	1.3 Installation costs		$150	$150	$150
	1.4 Project management before title I	(10 % of 1.1 through 1.3)	$125	$125	$125
	1.5 Contingency	(25 % of 1.1 through 1.4)	$344	$344	$344
	Subtotal 1.0		$1,719	$1,719	$1,719
2.0	**Demonstration costs**				
	2.1 Manpower costs during demonstration		$0	$0	$0
	2.2 Design cost	(30 % of 2.5)	$0	$0	$0
	2.3 Inspection cost	(7 % of 2.5)	$0	$0	$0
	2.4 Project management	(10 % of 2.5)	$0	$0	$0
	2.5 Construction cost				
	2.5.1 Building structure costs		$0	$0	$0
	2.5.2 Equipment costs		$0	$0	$0
	2.5.3 Indirect	(29 % of 2.5.1 & 2.5.2)	$0	$0	$0
	Subtotal of 2.5		$0	$0	$0
	2.6 Construction management costs	(17.1 % of 2.5)	$0	$0	$0
	2.7 Management Reserv	(10 % of 2.5)	$0	$0	$0
	2.8 Contingency	(25 % of 2.1 through 2.7)	$0	$0	$0
	Subtotal 2.0		$0	$0	$0
3.0	**Production facility construction costs**				
	3.1 Design cost	(25 % of 3.4)	$5,266	$8,676	$9,781
	3.2 Inspection cost	(7 % of 3.4)	$1,474	$2,429	$2,739
	3.3 Project management	(10 % of 3.4)	$2,106	$3,470	$3,912
	3.4 Construction cost				
	3.4.1 Building structure costs		$7,506	$11,259	$13,789
	3.4.2 Equipment costs		$8,821	$15,643	$16,538
	3.4.3 Indirect	(29 % of 3.4.1 & 3.4.2)	$4,735	$7,802	$8,795
	Subtotal of 3.4		$21,062	$34,704	$39,122
	3.5 Construction management	(17.1 % of 3.4)	$3,602	$5,934	$6,690
	3.6 Management Reserve	(10 % of 3.4)	$2,106	$3,470	$3,912
	3.7 Contingency	(25 % of 3.1 through 3.5)	$8,378	$13,803	$15,561
	Subtotal 3.0		$43,994	$7[illegible],486	$81,717
4.0	**Operations Budget Funded Activities (See Sect. 7)**				
	4.1 Conceptual design	(1.5 % of 3.0)	$660	$1,087	$1,226
	4.2 Safety assurance	(1 % of 3.0)	$440	$725	$817
	4.3 NEPA permitting ($ 6 Mill for EIS, $1 Mill for EA)		$6,000	$6,000	$6,000
	4.4 Preparation for operations	(100 % of 5.0)	$6,497	$13,410	$17,504
	4.5 Project Management	(10 % of 4.1 through 4.4)	$1,360	$2,122	$2,555
	Subtotal 4.0		$14,957	$23,344	$28,102
	Total Initial Cost (1.0,2.0,3.0 & 4.0)		**$60,670**	**$97,549**	**$111,538**
5.0	**Operating and maintainence costs**				
	5.1 Annual operating costs		$3,360	$7,140	$10,080
	5.2 Annual utility costs		$15	$120	$203
	5.3 Annual material costs		$4	$126	$197
	5.4 Annual maintainence costs		$1,819	$3,342	$3,523
	5.5 Contingency	(25 % of 5.1 through 5.4)	$1,299	$2,682	$3,501
	Subtotal 5.0		$6,497	$13,410	$17,504
	Total 20 year O & M cost (20 times Subtotal 5.0)		$129,940	$268,200	$350,080
6.0	Decontamination & Decommissioning		$4,188	$6,279	$7,696
7.0	**ROM Life cycle costs (20 years operation)**		**$194,798**	**$372,028**	**$469,314**

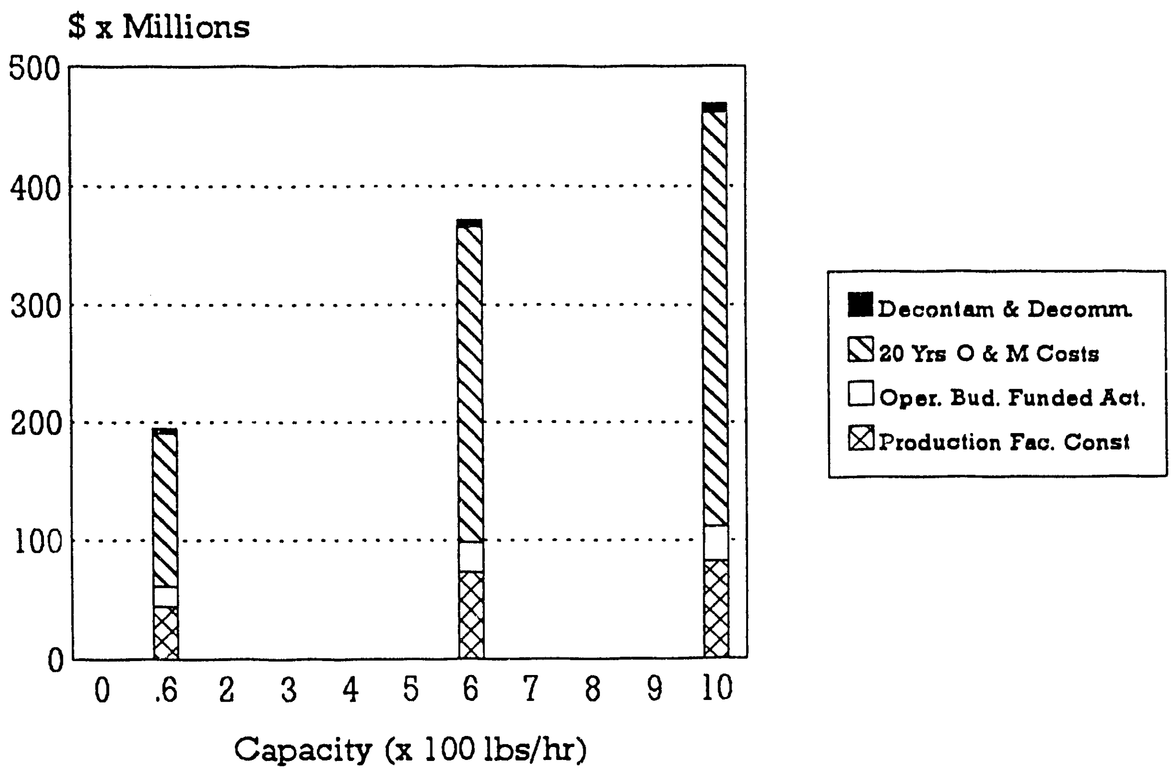


Figure 6-4. Cost versus capacity histogram for alpha-LLW/LLMW metal melting facility (cost module EA).

7. SHREDDING/COMPACTION FACILITY (COST MODULES FL AND FA)

7.1 Basic Information

The shredding/compaction facility, shown in Figure 7-1, is used either as an addition to existing facilities where similar functions are already available or in conjunction with the treatment front-end and back-end support facilities (see cost modules A, B, CA/CL, I, and JA/JL). Cost module FA is applicable to alpha-LLW, while cost module FL treats LLW. Unit operations are given in Figure 7-2.

This high force (1500-2000 metric ton) compaction facility is comprised of seven main process unit operations. The three main treatment steps are (a) size reduction of the incoming waste, (b) supercompaction of the reduced waste, and (c) solidification of secondary by-products (such as liquid waste and fugitive dust).

7.2 Technical Basis and Assumptions

7.2.1 Functional and Operational Description

The large facility is designed to shred the incoming waste and package it in 55-gal drums. This facility is equipped with a dust collection/filtration unit to treat air containing fugitive dust from the shredding operations. The small and medium sized facilities have such low capacities that the expense of a shredder cannot be economically justified and is not included. For these smaller facilities, the waste must be placed into drums before it arrives at the compaction unit operation.

At the compaction unit operation, a lift device places the filled drums onto press conveyors. The operator selects a drum from one of the conveyors and feeds it to the press through an airlock, located in the press negative pressure environmental chamber. A device pierces the drum to release any gases potentially trapped in the drum into the confined chamber. A high-pressure compactor (supercompactor) compresses the drum and transfers the pressed drum from the press to a staging conveyor (or turntable). A lift device picks up the compressed drum and places it into one of several overpacks located on an adjacent conveyor. After each overpack is filled, the operator feeds it to a sealing machine where a cap is placed on the overpack and sealed. The operator moves the sealed overpack to a drum washing unit where high-pressure water spray jets remove any loose contamination on the outside surface of the overpack.

Any liquid discharged during press operation is directed to a sump. A liquid waste treatment and a solidification unit operation is provided for treatment and solidification of any liquid effluent or other potentially radioactive waste generated at the facility.

The compacted waste is ready for processing through a radioassay and final certification, which are included in the back-end support facility.

The anticipated density of the compacted waste is about 60 to 70 lbs/ft^3. The solidified waste density is 112 lbs/ft^3.

7.2.2 Facility Integration

Primary facility input are contaminated drummed waste from generator sites. The large facility is designed to accept bulk waste from both the open, dump, and sort facility (cost module CA or CL) and directly from the generator sites. Major O&M purchased materials such as personnel protective equipment, laboratory material, binders, and overpacks are assumed to be consumable supplies and their costs are estimated accordingly.

Major facility outputs are compacted drums containing solidified LLW or alpha-LLW, which are transferred to a back-end support facility (see cost module I). The overpacks (85-gal drums) containing compacted waste and 55 gal drums containing solidified waste are the main output from this facility. Treated off-gas is discharged into the atmosphere.

7.3 Cost Bases, Assumptions, and Assessments

General cost bases and assumptions are given in Appendix A. Facility specific items are discussed below.

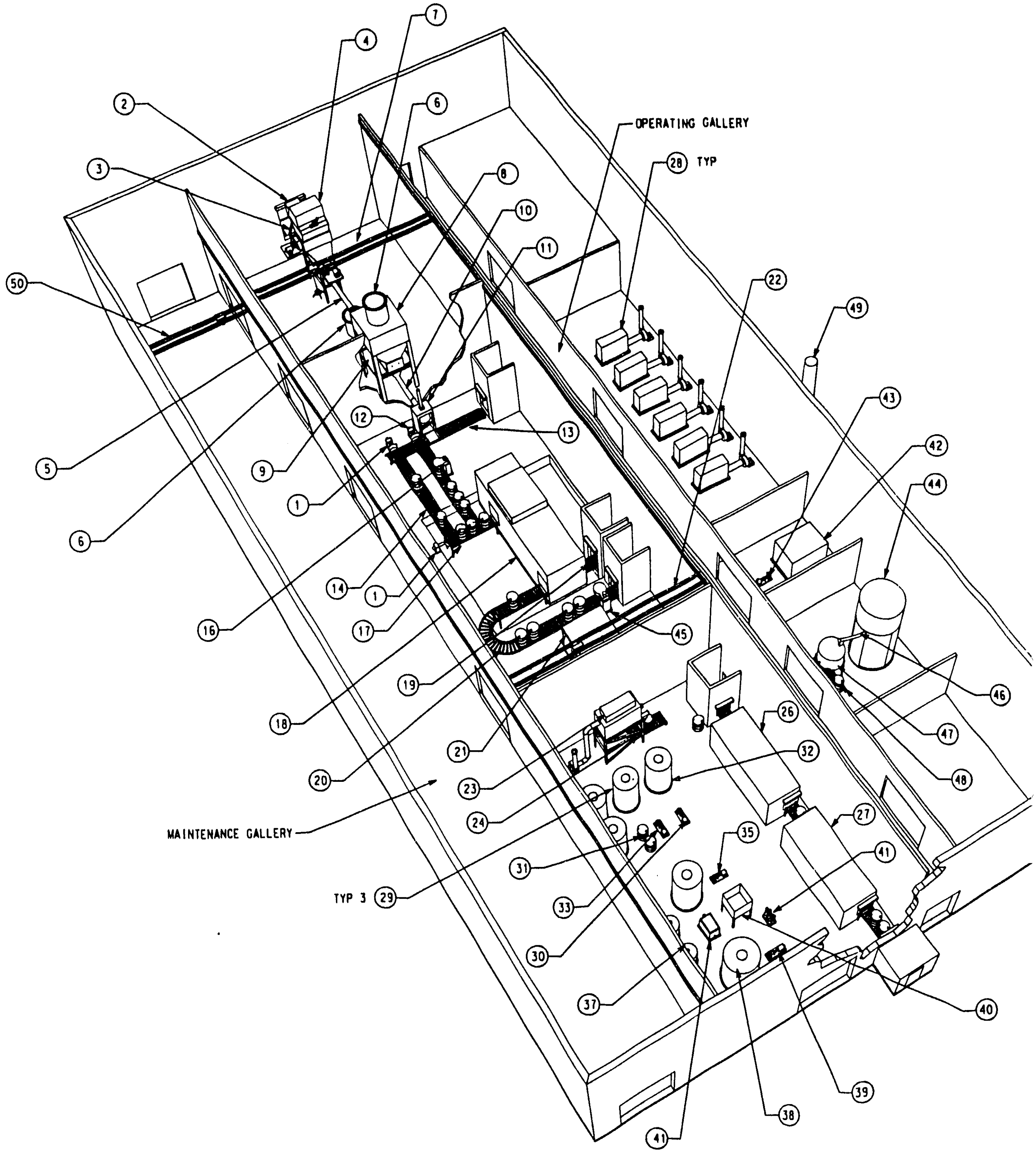
- Waste size reduction and preparation (shredders), supercompactor, and solidification units are the major equipment capital cost items.
- Major equipment capital costs are verified against the purchased costs incurred by a U.S. Navy low-level waste processing facility (B&W facility at Lynchburgh, West Virginia) that recently started operation.
- Estimated operating staff are shown below in Table 7-1.
- Budgetary cost for the preparation and feed unit is based on vendor quotes for shredders, conveyors, and dust collection equipment.
- Supercompactor prices are based on budgetary quotes by Stock Equipment Company, Chagrin Falls, Ohio.
- A fully automated solidification unit operation is selected for the large facility. This unit cost is quoted by Stock Equipment Company, the supplier of a similar unit for a DOE facility at the Savannah River Site.
- Small, medium, and large facility capacities and unit costs are as shown in Table 7-2.

7.4 Cost Summaries

Cost summaries for the LLW/LLMW and alpha-LLW/LLMW shredding/compacting cost modules are shown in Tables 7-3 and 7-4. Cost versus capacity is given in Figures 7-3 and 7-4.

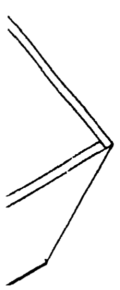
As shown, the initial capital costs are about the same for the small and medium facility. This is due to size limitations of super-compaction equipment. The smallest such equipment can handle the small and medium capacities specified for the shredding/compaction facility.

The Alpha-LLW/LLMW large facility unit cost is higher than the medium size facility because the large facility includes shredding and has a proportionately smaller additional capacity (50%) over the medium facility in comparison to the LLW/LLMW facility.



SHREDDING AND COMPACTI
TOP PERSPECTIVE

1. Typical arrangement for alpha-LLW/LLMW shredding/compaction facility.



N FACILITY
IEW

MAJOR EQUIPMENT LIST

1. DRUM PUSHER
2. INCOMING WASTE BIN
3. SKIP
4. SHREDDER (2) WITH FEED HOPPER, DUST HOOD AND HYDRAULIC RAM
5. AUGER FEEDER
6. WASTE TRANSFER BIN
7. UNDERHUNG CRANE IN ENCLOSED PROCESS AREA
8. LIVE BOTTOM BULK STORAGE HOPPER
9. TERTIARY SHREDDER
10. AUGER FEEDER
11. SHREDDED WASTE COMPACTOR (30 TON)
12. DRUM PUSHER
13. DRUM STAGING CONVEYOR (POWERED ROLL)
14. DRUM STAGING CONVEYOR (POWERED ROLL)
15. COMPACTED DRUM STAGING CONVEYOR (POWERED ROLL)
16. DRUM TOP SEAMING STATION
17. SUPERCOMPACTOR FEED CONVEYOR (POWERED ROLL)
18. MODULAR SUPERCOMPACTOR UNIT (2000 TON)
19. EMPTY OVERPACK STAGING CONVEYOR (POWERED ROLL)
20. SUPERCOMPACTED CONTAINER STAGING CONVEYOR (POWERED ROLL)
21. MODULAR HYDRAULIC POWER UNIT
22. UNDERHUNG CRANE IN ENCLOSED PROCESS AREA
23. DUST COLLECTOR, FAN AND HEPA FILTER
24. DRUM STAGING CONVEYOR (POWERED ROLL)
25. DRUM STAGING CONVEYOR (POWERED ROLL)
26. SOLIDIFICATION SYSTEM
27. DRUM CAPPING AND WASHING SYSTEM
28. HEPA FILTER AND FAN
29. NEUTRALIZATION TANK
30. NEUTRALIZED LEACHATE PUMP
31. REAGENT STORAGE METERING PUMPS
32. DRUM LEACHATE COLLECTION TANK
33. LEACHATE PUMP
34. RECEIVING TANK
35. PUMP
36. FILTER
37. ION EXCHANGE
38. TREATED WASTE TANK
39. PUMP
40. SLUDGE TANK
41. PUMP
42. CHILLER
43. CIRC. PUMP
44. STORAGE BIN
45. OVERPACK TOP SEAMING STATION
46. PNEUMATIC CONVEYOR
47. DAY BIN
48. DRUM STORAGE CONVEYOR (GRAVITY)
49. STACK
50. UNDERHUNG CRANE IN ENCLOSED MAINTENANCE AREA

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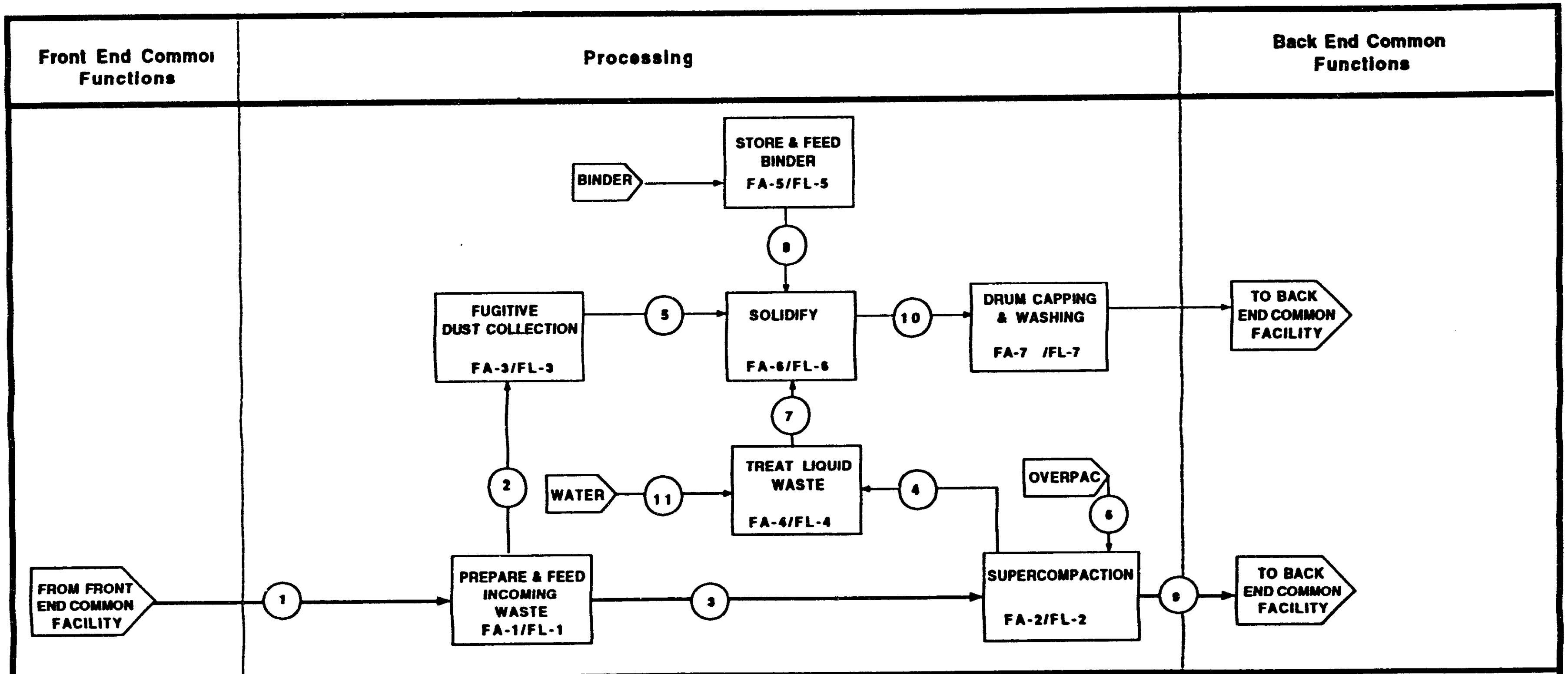


	NODE	1	2	3	4	5	6	7	8	9	10	11
	Facility Size	Input Waste	Dust	Shredded Waste	Liquid Waste	Dust	Overpac Feed	Waste Water	Binder	Compacted Drummed Waste	Solidified Waste	Water
FLOWRATE	LLW Small	300	15	285	6	15	63	16	32	342	63	10
(LB/HR)	LLW Medium	1000	50	950	19	50	210	54	106	1141	209	35
	LLW Large	4000	200	3800	76	200	842	214	422	4566	836	138
	Alpha Small	100	5	95	2	5	21	5	11	114	21	3
	Alpha Medium	1000	50	950	19	50	210	54	106	1141	209	35
	Alpha Large	1500	75	1425	29	75	316	80	158	1712	314	52

Figure 7-2. Shredding/compaction process functional diagram.

Table 7-1. Estimated operating staff for shredding and compaction facility (cost module F).

Unit operation	Description	Small (FTE)	Medium (FTE)	Large (FTE)
F-1	Prepare and feed incoming waste	0	0	7
F-2	Supercompaction	9	9	10
F-3	Fugitive dust collection	0	0	1
F-4	Treat liquid waste	1	1	2
F-5	Store and feed binder	1	1	2
F-6	Solidify	1	2	3
F-7	Drum capping and washing	0	0	0
F-8	Electrical distribution and MCC	0	1	1
F-9	Cool compactor	0	0	0
F-10	Heating, ventilation, and exhaust	0	3	3
F-11	Overpack storage	0	0	0
F-12	Other equipment	0	0	0
	Total	12	17	29

Table 7-2. Capacities and cost information for shredding and compaction facility (module FL and FA).[a]

Mod.	Module Description	Facility	Life Cycle Cost ($x1000)	Capacity (lbs/hr)	Unit Cost ($/lb)	Capacity (ft3/hr)	Cap(Tot Vol) (ft3x1000)	Unit Cost ($/ft3)
FL	Shred/Compact	Small	$100,758	300	$4.16	9	691	$145.77
FL	Shred/Compact	Medium	$120,979	1,000	$1.50	29	2,304	$52.51
FL	Shred/Compact	Large	$235,121	4,000	$0.73	114	9,216	$25.51
FA	Shred/Compact	Small	$111,222	100	$13.79	3	230	$482.73
FA	Shred/Compact	Medium	$126,232	1,000	$1.57	29	2,304	$54.79
FA	Shred/Compact	Large	$255,361	1,500	$2.11	43	3,456	$73.89

a. Average density used is 35 lbs/ft.^{3}

Table 7-3. Rough order of magnitude (ROM) life-cycle cost estimate summary for shredding and compaction.

Cost component	Cost Items		Cost ($ x 1000) Small	Medium	Large
1.0	**Studies and bench scale test costs**				
	1.1 Manpower costs during research		$750	$750	$750
	1.2 Equipment costs		$50	$50	$50
	1.3 Installation costs		$150	$150	$150
	1.4 Project management before title I	(10 % of 1.1 through 1.3)	$95	$95	$95
	1.5 Contingency	(25 % of 1.1 through 1.4)	$261	$261	$261
	Subtotal 1.0		$1,306	$1,306	$1,306
2.0	**Demonstration costs**				
	2.1 Manpower costs during demonstration		$0	$0	$0
	2.2 Design cost	(30 % of 2.5)	$0	$0	$0
	2.3 Inspection cost	(7 % of 2.5)	$0	$0	$0
	2.4 Project management	(10 % of 2.5)	$0	$0	$0
	2.5 Construction cost				
	2.5.1 Building structure costs		$0	$0	$0
	2.5.2 Equipment costs		$0	$0	$0
	2.5.3 Indirect	(29 % of 2.5.1 & 2.5.2)	$0	$0	$0
	Subtotal of 2.5		$0	$0	$0
	2.6 Construction management costs	(17.1 % of 2.5)	$0	$0	$0
	2.7 Management reserve	(10 % of 2.5)	$0	$0	$0
	2.8 Contingency	(25 % of 2.1 through 2.7)	$0	$0	$0
	Subtotal 2.0		$0	$0	$0
3.0	**Production facility construction costs**				
	3.1 Design cost	(18 % of 3.4)	$1,518	$1,535	$3,143
	3.2 Inspection cost	(7 % of 3.4)	$590	$597	$1,222
	3.3 Project management	(10 % of 3.4)	$843	$853	$1,746
	3.4 Construction cost				
	3.4.1 Building structure costs		$2,112	$2,112	$3,568
	3.4.2 Equipment costs		$4,425	$4,500	$9,966
	3.4.3 Indirect	(29 % of 3.4.1 & 3.4.2)	$1,896	$1,917	$3,925
	Subtotal of 3.4		$8,433	$8,529	$17,459
	3.5 Construction management	(17.1 % of 3.4)	$1,442	$1,458	$2,985
	3.6 Management Reserve	(10 % of 3.4)	$843	$853	$1,746
	3.7 Contingency	(25 % of 3.1 through 3.5)	$3,207	$3,243	$6,639
	Subtotal 3.0		$16,876	$17,068	$34,940
4.0	**Operations Budget Funded Activities (See Sect. 7)**				
	4.1 Conceptual design	(1.5 % of 3.0)	$253	$256	$524
	4.2 Safety assurance	(1 % of 3.0)	$169	$171	$349
	4.3 NEPA permitting ($ 6 Mill for EIS, $1 Mill for EA)		$6,000	$6,000	$6,000
	4.4 Preparation for operations	(100 % of 5.0)	$3,446	$4,395	$8,842
	4.5 Project Management	(10 % of 4.1 through 4.4)	$987	$1,082	$1,572
	Subtotal 4.0		$10,855	$11,904	$17,287
	Total Initial Cost (1.0,2.0,3.0 & 4.0)		$29,037	$30,278	$53,533
5.0	**Operating and maintainence costs**				
	5.1 Annual operating costs		$1,820	$2,380	$4,060
	5.2 Annual utility costs		$11	$19	$49
	5.3 Annual material costs		$73	$244	$979
	5.4 Annual maintainence costs		$852	$873	$1,986
	5.5 Contingency	(25 % of 5.1 through 5.4)	$689	$879	$1,768
	Subtotal 5.0		$3,446	$4,395	$8,842
	Total 20 year O & M cost (20 times Subtotal 5.0)		$68,920	$87,900	$176,840
6.0	Decontamination & Decommissioning		$2,801	$2,801	$4,748
7.0	**ROM Life cycle costs (20 years operation)**		$100,758	$120,979	$235,121

Table 7-4. ROM life-cycle cost estimate summary for alpha shredding and compaction.

Cost component		Cost Items	Cost ($ x 1000) Small	Medium	Large
1.0	**Studies and bench scale test costs**				
	1.1 Manpower costs during research		$0	$0	$0
	1.2 Equipment costs		$0	$0	$0
	1.3 Installation costs		$0	$0	$0
	1.4 Project management before title I	(10 % of 1.1 through 1.3)	$0	$0	$0
	1.5 Contingency	(25 % of 1.1 through 1.4)	$0	$0	$0
	Subtotal 1.0		$0	$0	$0
2.0	**Demonstration costs**				
	2.1 Manpower costs during demonstration		$0	$0	$0
	2.2 Design cost	(30 % of 2.5)	$0	$0	$0
	2.3 Inspection cost	(7 % of 2.5)	$0	$0	$0
	2.4 Project management	(10 % of 2.5)	$0	$0	$0
	2.5 Construction cost				
	2.5.1 Building structure costs		$0	$0	$0
	2.5.2 Equipment costs		$0	$0	$0
	2.5.3 Indirect	(29 % of 2.5.1 & 2.5.2)	$0	$0	$0
	Subtotal of 2.5		$0	$0	$0
	2.6 Construction management costs	(17.1 % of 2.5)	$0	$0	$0
	2.7 Management Reserve	(10 % of 2.5)	$0	$0	$0
	2.8 Contingency	(25 % of 2.1 through 2.7)	$0	$0	$0
	Subtotal 2.0		$0	$0	$0
3.0	**Production facility construction costs**				
	3.1 Design cost	(25 % of 3.4)	$2,876	$2,938	$5,480
	3.2 Inspection cost	(7 % of 3.4)	$805	$823	$1,534
	3.3 Project management	(10 % of 3.4)	$1,150	$1,175	$2,192
	3.4 Construction cost				
	3.4.1 Building structure costs		$3,167	$3,167	$5,665
	3.4.2 Equipment costs		$5,751	$5,944	$11,326
	3.4.3 Indirect	(29 % of 3.4.1 & 3.4.2)	$2,586	$2,642	$4,927
	Subtotal of 3.4		$11,504	$11,753	$21,918
	3.5 Construction management	(17.1 % of 3.4)	$1,967	$2,010	$3,748
	3.6 Management Reserve	(10 % of 3.4)	$1,150	$1,175	$2,192
	3.7 Contingency	(25 % of 3.1 through 3.5)	$4,576	$4,675	$8,718
	Subtotal 3.0		$24,028	$24,549	$45,782
4.0	**Operations Budget Funded Activities (See Sect. 7)**				
	4.1 Conceptual design	(1.5 % of 3.0)	$360	$368	$687
	4.2 Safety assurance	(1 % of 3.0)	$240	$245	$458
	4.3 NEPA permitting ($ 6 Mill for EIS, $1 Mill for EA)		$6,000	$6,000	$6,000
	4.4 Preparation for operations	(100 % of 5.0)	$3,616	$4,302	$9,250
	4.5 Project Management	(10 % of 4.1 through 4.4)	$1,022	$1,092	$1,640
	Subtotal 4.0		$11,238	$12,007	$18,035
	Total Initial Cost (1.0,2.0,3.0 & 4.0)		$35,266	$36,556	$63,817
5.0	**Operating and maintainence costs**				
	5.1 Annual operating costs		$1,820	$2,100	$4,760
	5.2 Annual utility costs		$11	$19	$59
	5.3 Annual material costs		$24	$244	$367
	5.4 Annual maintainence costs		$1,038	$1,079	$2,214
	5.5 Contingency	(25 % of 5.1 through 5.4)	$723	$860	$1,850
	Subtotal 5.0		$3,616	$4,302	$9,250
	Total 20 year O & M cost (20 times Subtotal 5.0)		$72,320	$86,040	$185,000
6.0	Decontamination & Decommissioning		$3,636	$3,636	$6,544
7.0	**ROM Life cycle costs (20 years operation)**		$111,222	$126,232	$255,361

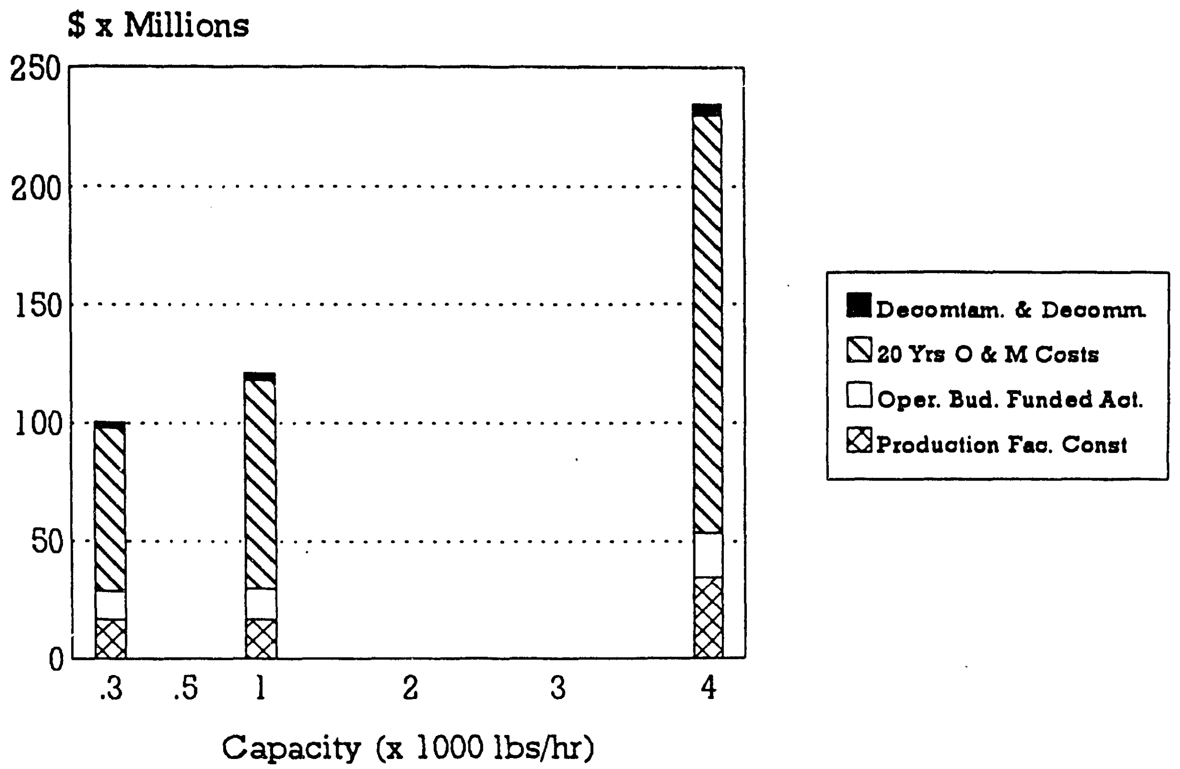


Figure 7-3. Cost versus capacity histogram for LLW/LLMW shredding and compaction facility (cost module FL).

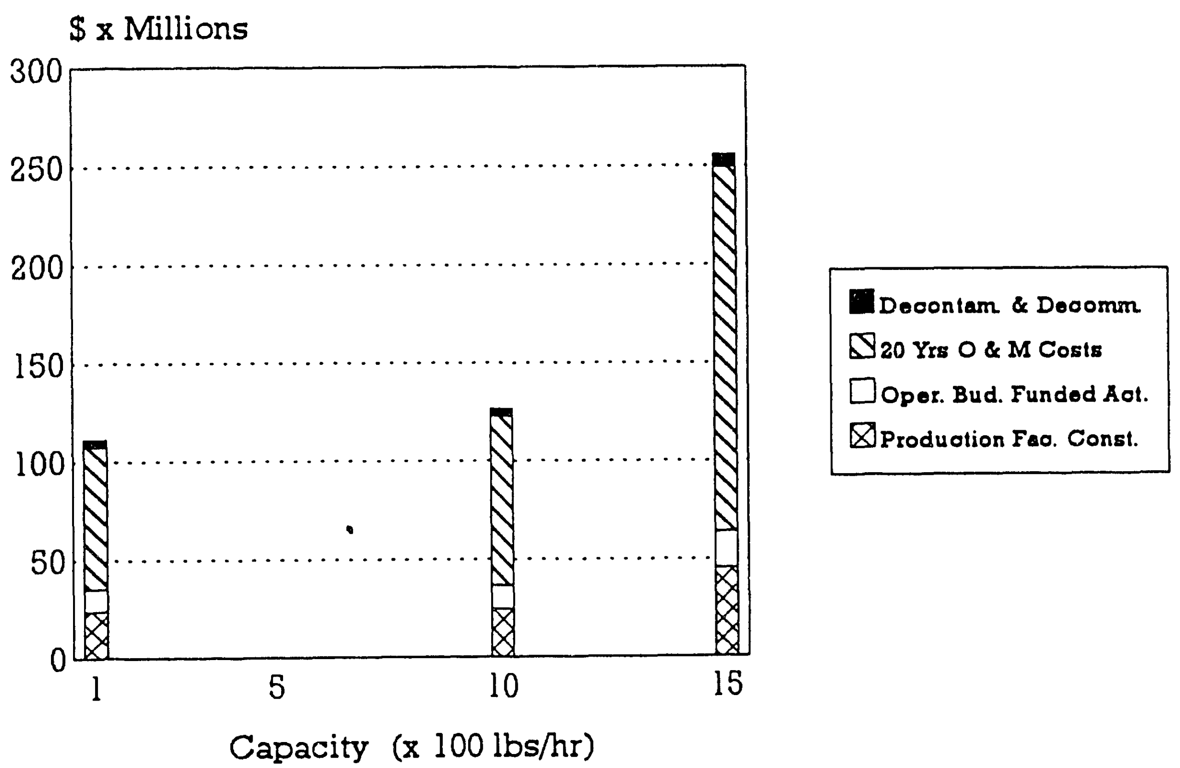


Figure 7-4. Cost versus capacity histogram for alpha-LLW/LLMW shredding and compaction facility (cost module FA).

8. SOLIDIFICATION FACILITY (COST MODULES GL AND GA)

8.1 Basic Information

The solidification facility, shown in Figure 8-1, is used either as an addition to an existing facility where similar functions are already available or in conjunction with the treatment front-end and back-end support facilities (see cost modules A, B, CA/CL, I, and JA/JL). The primary purpose of this facility is the solidification of solid and liquid waste and sludge that arrives directly from storage facilities or the generators. Solidification process used in other facilities is only for treatment of secondary waste. Cost module GA is applicable to alpha-LLW/LLMW, and module GL is for LLW/LLMW. Unit operations are shown in Figure 8-2.

The facility is composed of five main process unit operations that incorporate all buildings, systems, processes, equipment, devices, controls, and accessories required to solidify the incoming solid and liquid waste. Main treatment steps are size reduction of the incoming solid waste, treatment of the incoming liquid waste and sludge, and solidification of these waste streams.

This facility processes both noncombustible solids and inorganic liquid waste. A certain amount of oily liquid waste can be tolerated, since a budget for an oil removal unit is included to provide for removal of suspended oil in the incoming liquid waste. The crusher/shredder in the solid waste preparation unit can accept solids up to approximately 1 ft^3.

8.2 Technical Bases and Assumptions

8.2.1 Functional and Operational Description

The facility receives liquid waste via a pipeline. A liquid waste treatment unit is used to concentrate the waste and feed it to a solidification unit operation. An incoming waste preparation and feed unit crushes and shreds incoming solid waste; the shredded waste is then collected in a storage hopper.

The solidification unit operation solidifies liquid waste, solid waste, or a combination of the two. The unit has a remotely operated in-drum solidification assembly equipped with intake tanks and hoppers for solid and liquid waste and binder. To accomplish the solidification process, a drum is placed onto a transfer cart. The cart moves the drum to various fill stations where feeders place solid and liquid waste and binder in the drum. Next, the cart moves the filled drum to a mixing station where the drum is capped and tumbled to achieve the required mixture. The cart moves the drum for a repeat of the filling/mixing step to maximize the fill efficiency.

After proper mixing, the operator remotely moves the filled container to a capping and washing unit. This unit operation provides for sample collection, capping of the container, and removal of loose contamination from the container surface by high-pressure spray water jets. The containerized waste is ready for processing through radioassay and final certification, which are included in the back-end facility (cost module I).

The anticipated density of the solidified waste is 112 lbs/ft^3.

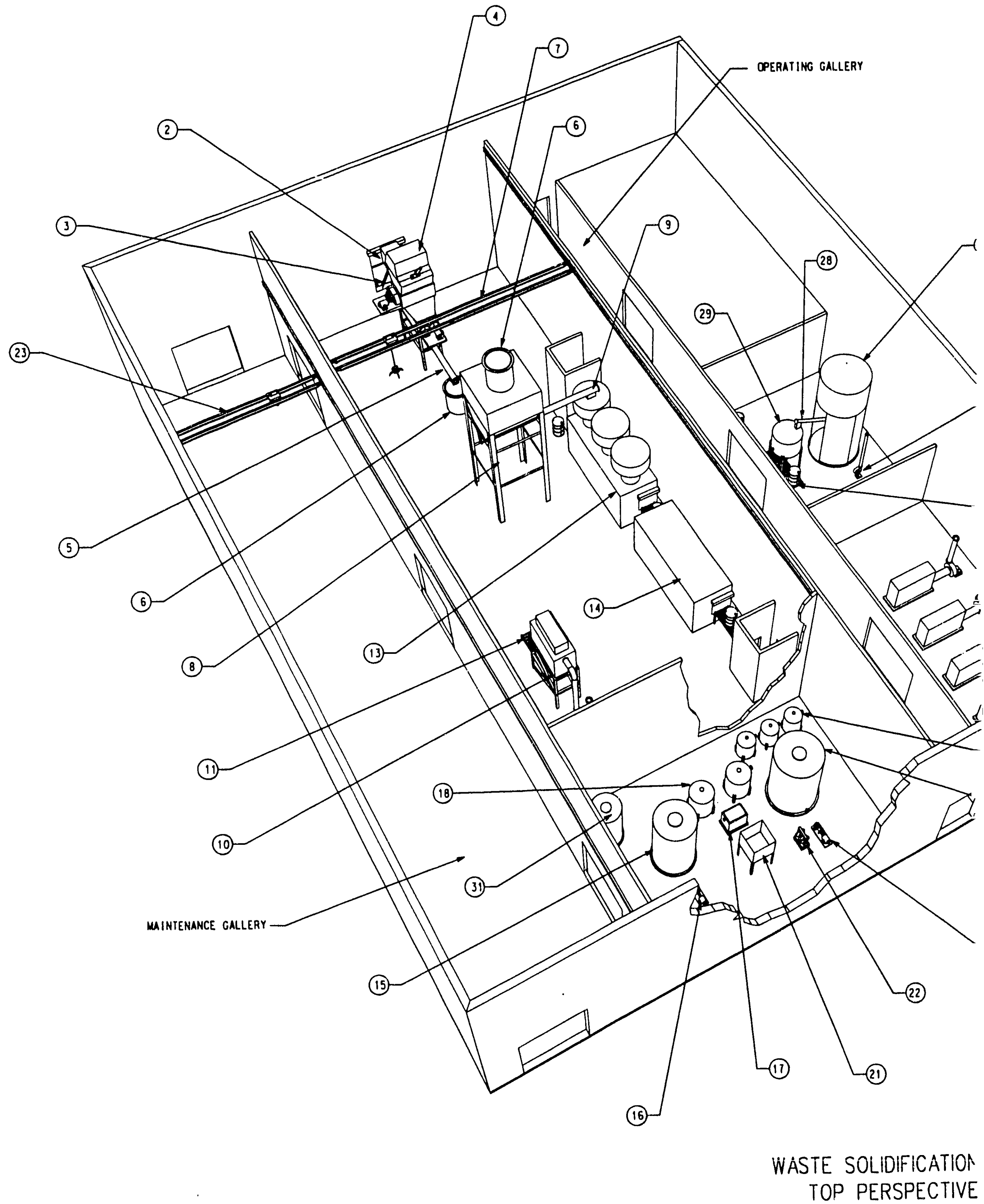
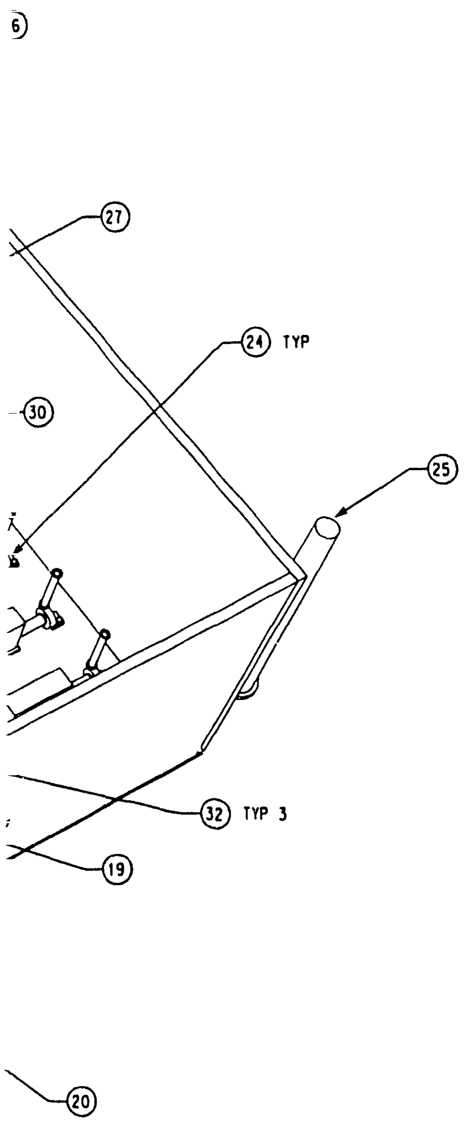


Figure 8-1. Typical arrangement for alpha-LLW/LLMW solidification facility.



FACILITY
VIEW

MAJOR EQUIPMENT LIST

1. DRUM PUSHER
2. INCOMING WASTE BIN
3. BIN HOIST
4. SHREDDER (2) WITH FEED HOPPER, DUST HOOD AND HYDRAULIC RAM
5. AUGER FEEDER
6. WASTE TRANSFER BIN
7. UNDERHUNG CRANE IN ENCLOSED PROCESS AREA
8. LIVE BOTTOM BULK STORAGE HOPPER
9. AUGER FEEDER
10. DUST COLLECTOR, FAN AND HEPA FILTER
11. DRUM STAGING CONVEYOR (POWERED ROLL)
12. DRUM STAGING CONVEYOR (POWERED ROLL)
13. SOLIDIFICATION SYSTEM
14. DRUM CAPPING AND WASHING SYSTEM
15. RECEIVING TANK
16. PUMP
17. FILTER
18. ION EXCHANGE VESSELS
19. TREATED WASTE TANK
20. PUMP
21. SLUDGE TANK
22. PUMP
23. UNDERHUNG CRANE IN ENCLOSED MAINTENANCE AREA
24. HEPA FILTER AND FAN
25. STACK
26. BINDER STORAGE SILO
27. BLOWER
28. PNEUMATIC CONVEYOR
29. DAY BIN
30. DRUM STAGING CONVEYOR (GRAVITY)
31. PRECIPITATION TANK
32. ORGANIC REMOVAL FILTER VESSELS

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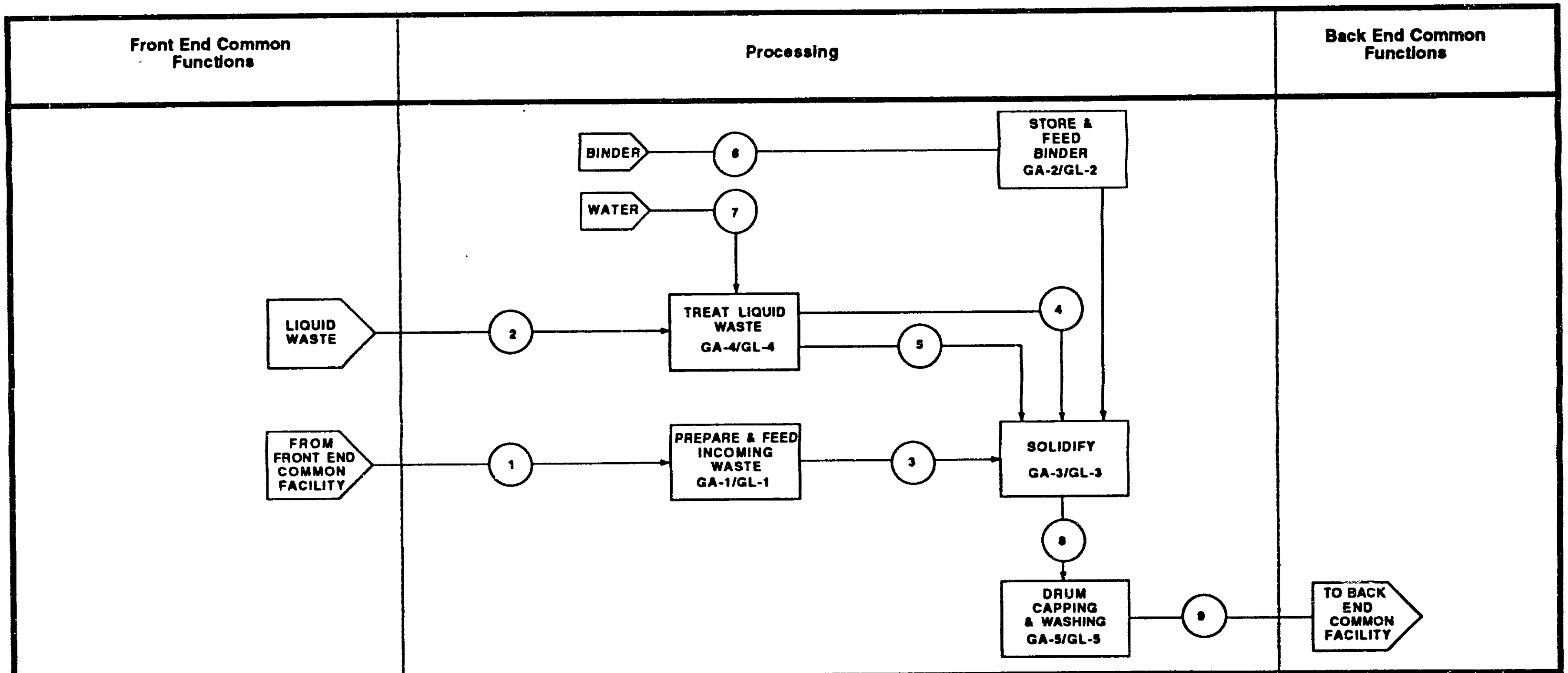


FLOWRATES (LB/HR)	NODE	Total	1	2	3	4	5	6	7	8	9
	Facility Size	Input Waste	Solid Input Waste	Liquid Input Waste	Reduced Size Waste	Treated Liquid	Sludge	Binder	Water	Solidified Waste	Solidified Drummed Waste
	LLW Small	400	280	120	280	102	18	598	187	1185	1185
	LLW Medium	1000	700	300	700	255	45	1496	468	2964	2964
	LLW Large	2000	1400	600	1400	510	90	2992	935	5927	5927
	Alpha Small	70	49	21	49	18	3	105	33	207	207
	Alpha Medium	700	490	210	490	179	32	1047	327	2075	2075
	Alpha Large	1200	840	360	840	306	54	1795	561	3556	3556

Figure 8-2. Solidification process functional diagram.

8.2.2 Facility Integration

Major facility input is comprised of inorganic liquid waste from the generator sites and bulk solid waste from the open, dump, and sort facility (cost module CA or CL) and from the generator sites. Major O&M purchased materials such as personnel protective equipment, laboratory material, binder, and containers are assumed to be consumable supplies and their costs are estimated accordingly.

Major facility output is drummed solidified LLW/LLMW or alpha-LLW/LLMW, which is transferred to a back-end facility (see cost module I). Treated off-gas is discharged into the atmosphere.

8.3 Cost Bases, Assumptions, and Assessments

General cost bases and assumptions are given in Appendix A. Facility specific items are discussed below.

- Incoming waste size reduction and preparation (shredders) and solidification mixers are the major equipment capital cost items.
- Budgetary costs for the preparation and feed unit are based on vendor quotes for shredders, conveyors, and dust collection equipment.
- Estimated operating staff is shown in Table 8-1.
- Solidification facility assembly prices are based on quotes by Stock Equipment Company.
- The input waste is assumed to be 30% liquids and 70% solids.
- Small, medium, and large facility capacities and unit costs are shown in Table 8-2.

8.4 Cost Summaries

Cost summaries for the alpha-LLW/LLMW and LLW/LLMW solidification cost modules are shown in Tables 8-3 and 8-4. Histograms for cost versus capacity are shown in Figures 8-3 and 8-4.

Table 8-1. Estimated operating staff for solidification facility (cost modules GL and GA).

Unit operation	Description	Small alpha (FTE)	Small LLW	Medium alpha (FTE)	Medium LLW	Large alpha (FTE)	Large LLW
G-1	Prepare and feed incoming waste	4	4	10	10	13	13
G-2	Store and feed binder	2	2	4	4	7	7
G-3	Solidify	7	7	13	13	20	48
G-4	Treat liquid waste	2	2	4	4	7	4
G-5	Drum capping and washing	4	4	7	7	10	7
G-6	Electrical distribution and MCC	2	2	4	4	4	4
G-7	Heating, ventilation, and exhaust	4	4	4	4	1	4
G-8	Other equipment	4	4	7	4	13	7
	Total	29	29	53	50	75	94

Table 8-2. Capacities and cost information for solidification facility (cost module GL and GA).[a]

Mod.	Module Description	Facility	Life Cycle Cost ($x1000)	Capacity (lbs/hr)	Unit Cost ($/lb)	Capacity (ft3/hr)	Cap(Tot Vol) (ft3x1000)	Unit Cost ($/ft3)
GL	Solidification	Small	$162,181	400	$5.03	11	922	$175.98
GL	Solidification	Medium	$260,896	1,000	$3.24	29	2,304	$113.24
GL	Solidification	Large	$451,794	2,000	$2.80	57	4,608	$98.05
GA	Solidification	Small	$200,672	70	$35.55	2	161	$1,244.25
GA	Solidification	Medium	$311,764	700	$5.52	20	1,613	$193.31
GA	Solidification	Large	$431,332	1,200	$4.46	34	2,765	$156.01

a. Average density used is 35 lbs/ft.^{3}

Table 8-3. PLCC estimate summary for LLW/LLMW solidification facility (cost module GL).

Cost component	Cost Items		Cost ($ x 1000) Small	Medium	Large
1.0	**Studies and bench scale test costs**				
	1.1 Manpower costs during research		$1,050	$1,050	$1,050
	1.2 Equipment costs		$50	$50	$50
	1.3 Installation costs		$150	$150	$150
	1.4 Project management before title I	(10 % of 1.1 through 1.3)	$125	$125	$125
	1.5 Contingency	(25 % of 1.1 through 1.4)	$344	$344	$344
	Subtotal 1.0		$1,719	$1,719	$1,719
2.0	**Demonstration costs**				
	2.1 Manpower costs during demonstration		$450	$450	$450
	2.2 Design cost	(30 % of 2.5)	$58	$58	$58
	2.3 Inspection cost	(7 % of 2.5)	$14	$14	$14
	2.4 Project management	(10 % of 2.5)	$19	$19	$19
	2.5 Construction cost				
	2.5.1 Building structure costs		$50	$50	$50
	2.5.2 Equipment costs		$100	$100	$100
	2.5.3 Indirect	(29 % of 2.5.1 & 2.5.2)	$44	$44	$44
	Subtotal of 2.5		$194	$194	$194
	2.6 Construction management costs	(17.1 % of 2.5)	$33	$33	$33
	2.7 Management Reserve	(10 % of 2.5)	$19	$19	$19
	2.8 Contingency	(25 % of 2.1 through 2.7)	$197	$197	$197
	Subtotal 2.0		$984	$984	$984
3.0	**Production facility construction costs**				
	3.1 Design cost	(18 % of 3.4)	$1,532	$1,830	$2,469
	3.2 Inspection cost	(7 % of 3.4)	$596	$712	$960
	3.3 Project management	(10 % of 3.4)	$851	$1,017	$1,372
	3.4 Construction cost				
	3.4.1 Building structure costs		$1,018	$1,187	$1,896
	3.4.2 Equipment costs		$5,578	$6,693	$8,737
	3.4.3 Indirect	(29 % of 3.4.1 & 3.4.2)	$1,913	$2,285	$3,084
	Subtotal of 3.4		$8,509	$10,165	$13,717
	3.5 Construction management	(17.1 % of 3.4)	$1,455	$1,738	$2,346
	3.6 Management Reserve	(10 % of 3.4)	$851	$1,017	$1,372
	3.7 Contingency	(25 % of 3.1 through 3.5)	$3,236	$3,866	$5,216
	Subtotal 3.0		$17,030	$20,345	$27,452
4.0	**Operations Budget Funded Activities (See Sect. 7)**				
	4.1 Conceptual design	(1.5 % of 3.0)	$255	$305	$412
	4.2 Safety assurance	(1 % of 3.0)	$170	$203	$275
	4.3 NEPA permitting ($ 6 Mill for EIS, $1 Mill for EA)		$1,000	$1,000	$1,000
	4.4 Preparation for operations	(100 % of 5.0)	$6,616	$11,125	$19,784
	4.5 Project Management	(10 % of 4.1 through 4.4)	$804	$1,263	$2,147
	Subtotal 4.0		$8,845	$13,896	$23,618
	Total Initial Cost (1.0,2.0,3.0 & 4.0)		**$28,578**	**$36,944**	**$53,773**
5.0	**Operating and maintainence costs**				
	5.1 Annual operating costs		$4,060	$7,000	$13,160
	5.2 Annual utility costs		$34	$44	$58
	5.3 Annual material costs		$46	$465	$798
	5.4 Annual maintainence costs		$1,153	$1,391	$1,811
	5.5 Contingency	(25 % of 5.1 through 5.4)	$1,323	$2,225	$3,957
	Subtotal 5.0		$6,616	$11,125	$19,784
	Total 20 year O & M cost (20 times Subtotal 5.0)		$132,320	$222,500	$395,680
6.0	Decontamination & Decommissioning		$1,283	$1,452	$2,341
7.0	**ROM Life cycle costs (20 years operation)**		**$162,181**	**$260,896**	**$451,794**

Table 8-4. PLCC estimate summary alpha-KLLW/LLMW solidification facility (cost module GA).

Cost component	Cost Items			Cost ($ x 1000) Small	Medium	Large
1.0	**Studies and bench scale test costs**					
	1.1 Manpower costs during research			$1,050	$1,050	$1,050
	1.2 Equipment costs			$50	$50	$50
	1.3 Installation costs			$150	$150	$150
	1.4 Project management before title I		(10 % of 1.1 through 1.3)	$125	$125	$125
	1.5 Contingency		(25 % of 1.1 through 1.4)	$344	$344	$344
	Subtotal 1.0			$1,719	$1,719	$1,719
2.0	**Demonstration costs**					
	2.1 Manpower costs during demonstration			$450	$450	$450
	2.2 Design cost		(30 % of 2.5)	$58	$58	$58
	2.3 Inspection cost		(7 % of 2.5)	$14	$14	$14
	2.4 Project management		(10 % of 2.5)	$19	$19	$19
	2.5 Construction cost					
	2.5.1	Building structure costs		$50	$50	$50
	2.5.2	Equipment costs		$100	$100	$100
	2.5.3	Indirect	(29 % of 2.5.1 & 2.5.2)	$44	$44	$44
	Subtotal of 2.5			$194	$194	$194
	2.6 Construction management costs		(17.1 % of 2.5)	$33	$33	$33
	2.7 Management Reserve		(10 % of 2.5)	$19	$19	$19
	2.8 Contingency		(25 % of 2.1 through 2.7)	$197	$197	$197
	Subtotal 2.0			$984	$984	$984
3.0	**Production facility construction costs**					
	3.1 Design cost		(25 % of 3.4)	$3,947	$4,484	$5,646
	3.2 Inspection cost		(7 % of 3.4)	$1,105	$1,255	$1,581
	3.3 Project management		(10 % of 3.4)	$1,579	$1,793	$2,259
	3.4 Construction cost					
	3.4.1	Building structure costs		$3,959	$4,468	$6,453
	3.4.2	Equipment costs		$8,280	$9,434	$11,055
	3.4.3	Indirect	(29 % of 3.4.1 & 3.4.2)	$3,549	$4,032	$5,077
	Subtotal of 3.4			$15,788	$17,934	$22,585
	3.5 Construction management		(17,1 % of 3.4)	$2,700	$3,067	$3,862
	3.6 Management Reserve		(10 % of 3.4)	$1,579	$1,793	$2,259
	3.7 Contingency		(25 % of 3.1 through 3.5)	$6,280	$7,133	$8,983
	Subtotal 3.0			$32,978	$37,459	$47,175
4.0	**Operations Budget Funded Activities (See Sect. 7)**					
	4.1 Conceptual design		(1.5 % of 3.0)	$495	$562	$708
	4.2 Safety assurance		(1 % of 3.0)	$330	$375	$472
	4.3 NEPA permitting ($ 6 Mill for EIS, $1 Mill for EA)			$1,000	$1,000	$1,000
	4.4 Preparation for operations		(100 % of 5.0)	$7,640	$12,674	$17,793
	4.5 Project Management		(10 % of 4.1 through 4.4)	$947	$1,461	$1,997
	Subtotal 4.0			$10,412	$16,072	$21,970
	Total Initial Cost (1.0,2.0,3.0 & 4.0)			**$46,093**	**$56,234**	**$71,848**
5.0	**Operating and maintainence costs**					
	5.1 Annual operating costs			$4,060	$7,420	$10,500
	5.2 Annual utility costs			$34	$48	$62
	5.3 Annual material costs			$266	$664	$1,329
	5.4 Annual maintainence costs			$1,752	$2,007	$2,343
	5.5 Contingency		(25 % of 5.1 through 5.4)	$1,528	$2,535	$3,559
	Subtotal 5.0			$7,640	$12,674	$17,793
	Total 20 year O & M cost (20 times Subtotal 5.0)			$152,800	$253,480	$355,860
6.0	Decontamination & Decommissioning			$1,779	$2,050	$3,624
7.0	**ROM Life cycle costs (20 years operation)**			**$200,672**	**$311,764**	**$431,332**

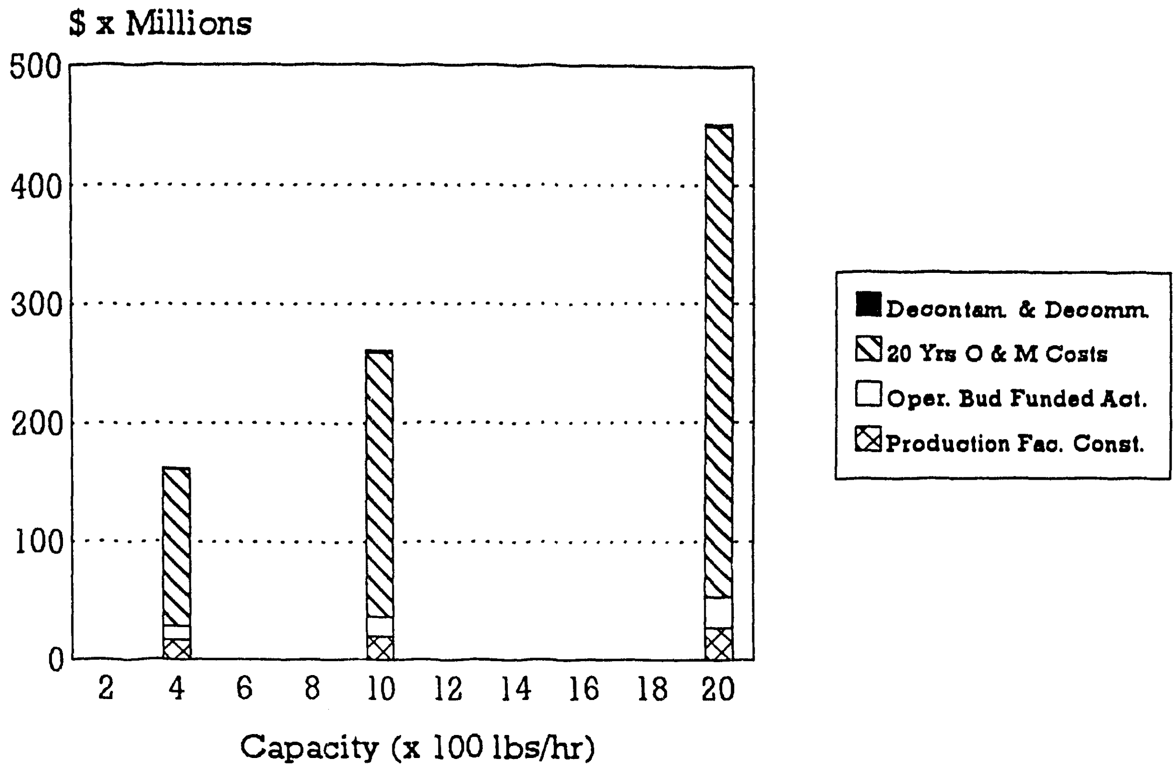


Figure 8-3. Cost versus capacity histogram for LLW/LLMW shredding and compaction facility (cost module GL).

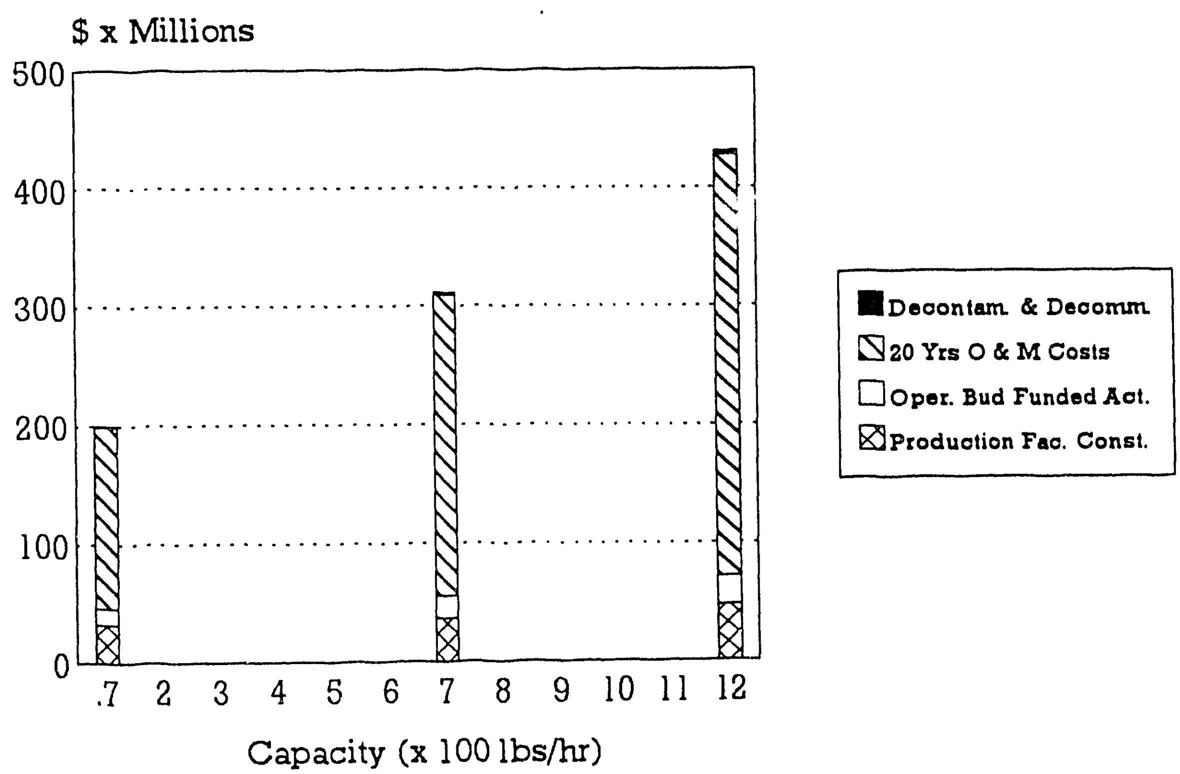


Figure 8-4. Cost versus capacity histogram for alpha-LLW/LLMW shredding and compaction facility (cost module GA).

9. VITRIFICATION FACILITY (COST MODULES HL AND HA)

9.1 Basic Information

The vitrification facility, shown in Figure 9-1, is used either in conjunction with the treatment front-end and back-end facilities (see cost modules A, B, CA/CL, I, and JA/JL), or as an addition to existing facilities where similar functions are already available. Cost module HA is applicable to alpha-LLW/LLMW, and cost module HL is for LLW/LLMW. Unit operations are shown in Figure 9-2.

The facility is comprised of 10 main process unit operations designed to convert the incoming waste into a leach-resistant rock/glass-like material. Vitrified LLW/LLMW and alpha-LLW/LLMW waste that is based on iron-enriched basalt should meet both the LDR and DOE disposal requirements.[2,6] Secondary liquid and gaseous wastes are also treated. Secondary waste treatment by-products, such as off-gas scrubber sludge, are either fed to the melter or solidified in drums.

The vitrification facility processes noncombustible wastes such as inorganic sludge, ash, soil, brick, concrete, and other similar material. The facility can process solid waste of various shapes and forms. The size limitation imposed by the crusher/shredder is approximately 1 ft^3 and the incoming waste can contain as much as 10% combustibles. The facility is equipped with a predryer for processing wet sludge from its own secondary waste stream (i.e., wet sludges from the off-gas scrubber waste water). As a result, the facility can also treat a limited amount (up to 15%) of additional inorganic wet sludge from outside sources.

9.2 Technical Basis and Assumptions

9.2.1 Functional and Operational Description

Specific operations include an input waste preparation and feed unit that crushes and shreds the incoming waste and transfers it to a melter unit operation. At the melter unit operation, a predryer, operating at approximately 300-400°F, receives, dries, and feeds shredded waste and any sludge that must be vitrified to a vitrification furnace (or melter). Soil is added to the melter through a soil storage and feed unit operation. The furnace melts the soil/waste combination to form a molten slag. A slag cooling and packaging unit is used to receive the molten slag from the melter and cast it into containers. A transport device carries the slag containers to a drum capping and washing unit operation, where loose contamination is removed from the container surface with a high-pressure water spray.

The melter off-gas scrubber is equipped with a secondary combustion unit that completes the volatile gas destruction. An induced air blower moves the secondary combustor effluent through the air pollution control device that is designed to remove particulates, SO_2, HCl, and NOx. A surge tank retains off-gas for reprocessing in the event of a process upset. Secondary liquid waste is processed by a liquid waste-treatment unit operation This unit operation removes dissolved and suspended solids, both organic and inorganic, from the liquid waste. The facility recycles and reuses the treated wastewater resulting in zero discharge to the environment.

The sludge from the waste treatment unit is pumped to the melter predryer before vitrification. A solidification unit operation treats any sludge that cannot be vitrified. At the solidification unit, the sludge is mixed with a binder, such as Portland cement, and transferred to a drum. A predetermined ratio is used to produce a stabilized waste. The filled container is moved to a capping and washing unit operation, where the drum is capped and loose contamination is removed from the container surface by high-pressure water spray.

The containerized vitrified waste and drummed solidified waste drums are the main output from this cost module. These are ready for processing through radioassay and final certification, which is included in the back-end support facility.

9.2.2 Facility Integration

Major facility inputs include waste from the open, dump, and sort facility (cost module CA or CL) and from the generator sites, as well as soil that is mined. Major O&M purchased materials are consumables such as personal protective equipment, laboratory material, binder, soil, and disposable containers.

Major facility outputs are containerized, vitrified, and solidified LLW/LLMW and alpha-LLW/LLMW, which are transported to a back-end support facility (see cost module I). Treated off-gas is discharged into the atmosphere.

9.3 Cost Bases, Assumptions, and Assessments

General cost bases and assumptions are given in Appendix A. Facility specific items are discussed below.

- Estimated operating staff are shown in Table 9-1.
- Metal sizing and preparation (shredders), melter and its off-gas, scrubber, and solidification unit are the major equipment capital cost items.
- Cost for the preparation and feed unit are based on vendor quotes for shredders, conveyors, and dust collection equipment.
- Melter prices are based on budgetary quotes received from two vendors (Callidus Technologies and Retec).
- Callidus Technologies provided budgetary quotes for the various off-gas scrubbers.
- The selected solidification unit operation is manufactured by Stock Equipment Company, Chagrin Falls, Ohio. This suppliers provided a quote based on a unit similar to that sold to the DOE for installation at Savanna River Site.
- Small, medium, and large facility capacities and unit costs are shown in Table 9-2.

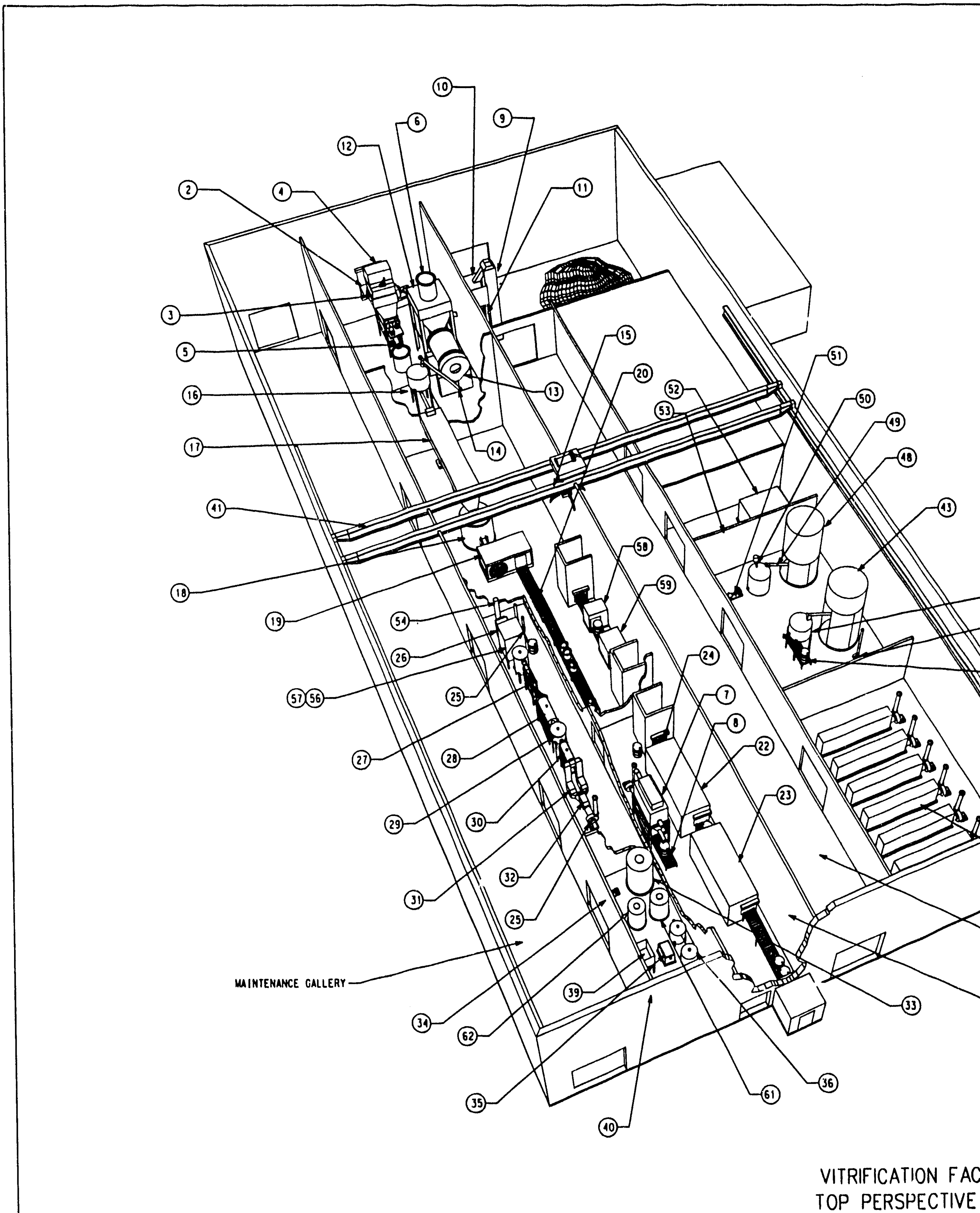
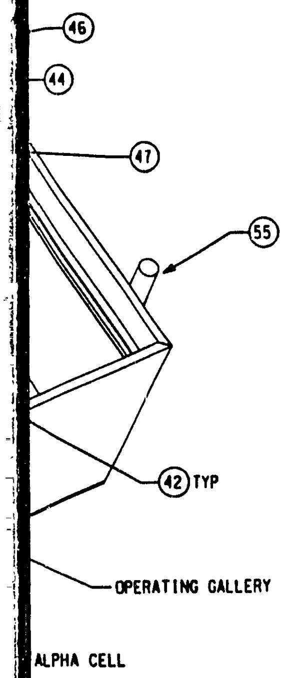


Figure 9-1. Typical arrangement for alpha-LLW/LLMW vitrification facility.



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MAJOR EQUIPMENT LIST

1. BIN PUSHER
2. INCOMING WASTE BIN
3. BIN HOIST
4. CRUSHER WITH FEED HOPPER AND DUST HOOD
5. AUGER FEEDER
6. WASTE TRANSFER BIN
7. DUST COLLECTOR, FAN AND HEPA FILTER
8. DRUM STAGING CONVEYOR (POWERED ROLL)
9. BUCKET ELEVATOR
10. BIN HOPPER
11. AUGER FEEDER
12. FEED BIN
13. HOMOGENIZER (WASTE AND SILICA OR SOIL)
14. AUGER FEEDER
15. UNDERHUNG CRANE IN ENCLOSED PROCESS AREA
16. FEED BIN
17. DRYER
18. VITRIFICATION UNIT
19. REMOTE CONTROLLED SLAG FORMING AND COOLING
20. SLAG FORM STAGING CONVEYOR (POWERED ROLL)
21. OVERPACK STAGING CONVEYOR (POWERED ROLL)
22. SOLIDIFICATION SYSTEM
23. DRUM CAPPING AND WASHING SYSTEM
24. DRUM STAGING CONVEYOR (POWERED ROLL)
25. FAN
26. GAS COOLER
27. DOUBLE VENTURI SCRUBBER
28. CONDENSER
29. MIST ELIMINATOR
30. REHEATER
31. DOUBLE HEPA FILTERS
32. FINAL HEPA FILTER
33. RECEIVING TANK
34. PUMP
35. FILTER
36. ION EXCHANGE
37. TREATED WASTE TANK
38. PUMP
39. SLUDGE TANK
40. PUMP
41. UNDERHUNG CRANE WITHIN ENCLOSED MAINTENANCE AREA
42. HEPA FILTER AND FAN
43. BINDER STORAGE SILO
44. BLOWER
45. PNEUMATIC CONVEYOR
46. DAY BIN
47. DRUM STAGING CONVEYOR (GRAVITY)
48. LIME STORAGE SILO
49. SCREW CONVEYOR
50. MIXING TANK W/ MIXER
51. FEED PUMP
52. COOLING SYSTEM
53. CIRC. PUMP
54. AFTERBURNER
55. STACK
56. CERAMIC BAG FILTER
57. DRUM STAGING CONVEYOR (POWERED ROLL)
58. CAPPING DEVICE
59. WASHING DEVICE
60. TRANSFER MONORAIL WITH HOIST
61. AQUEOUS WASTE FEED TANK
62. ORGANIC LIQUID WASTE FEED TANK

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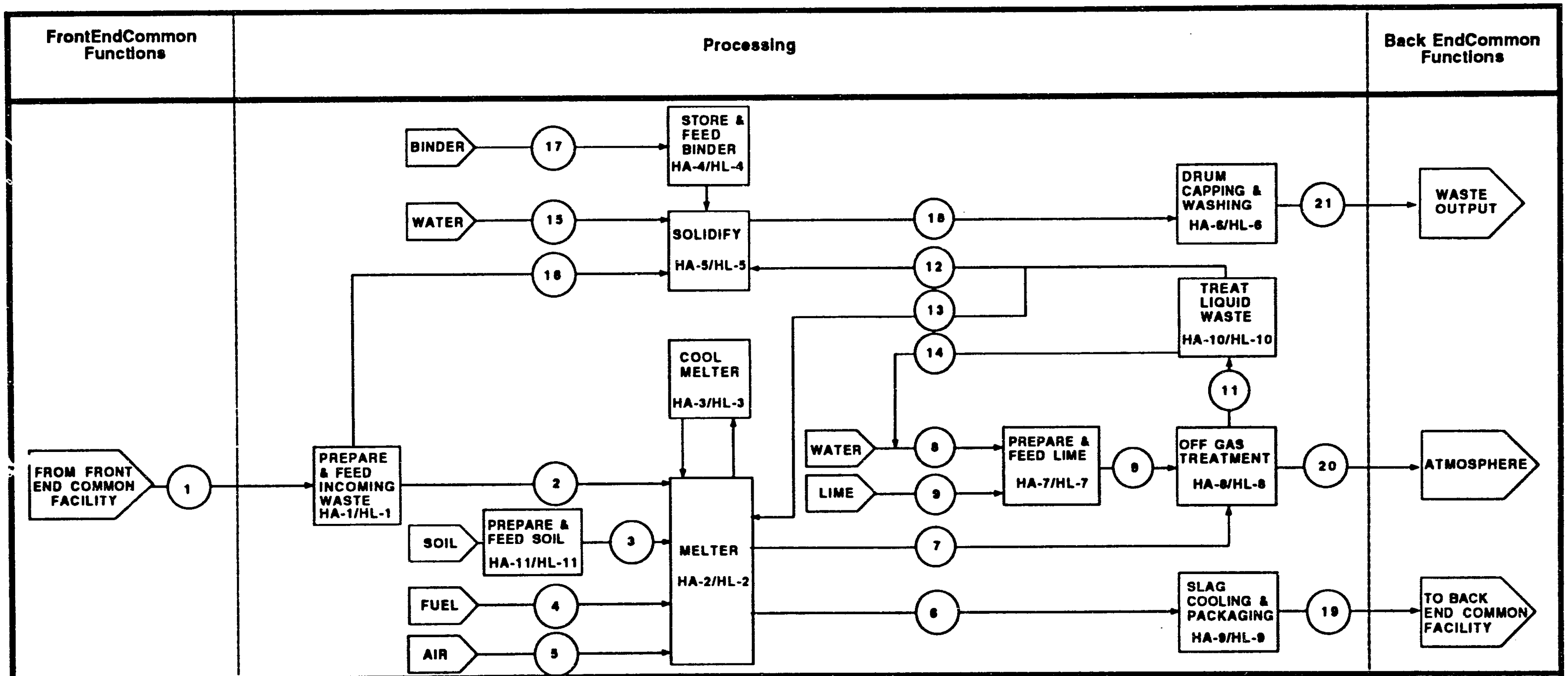


	NODE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
FLOWRATES	Material Description	Input Waste	Melter Feed	Soil	Melter Fuel	Melter Air	Vitrified Waste	Off Gas	Water Feed	Lime Feed	Off Gas Neut. Soln	Off Gas Treat-ment Sludge	Liq.Waste Treatment Sludge	Liq.Waste Treatment Sludge	Treated Water	Water	Over-sized Waste	Binder	Solidified Waste	Cooled Glass	Treated Off Gas	Drummed WasteO/P
(LB/HR)	LLW Small	300	285	82	3	188	287	297	135	6	141	151	3	25.3935	123	16.65	15	33	67	287	287	67
	LLW Medium	1000	950	274	11	627	958	989	451	19	470	504	9	84.645	410	55.51	50	109	224	958	955	224
	LLW Large	2000	1900	547	22	1254	1915	1977	903	38	941	1008	19	169.29	820	111	100	219	449	1915	1910	449
	Alpha Small	300	285	82	3	188	287	297	135	6	141	151	3	25.3935	123	16.65	15	33	67	287	287	67
	Alpha Medium	1200	1140	328	13	752	1149	1186	542	23	564	805	11	101.574	492	66.62	60	131	269	1149	1146	269
	Alpha Large	2000	1900	547	22	1254	1915	1977	903	38	941	1008	19	169.29	820	111	100	219	449	1915	1910	449

Figure 9-2. Vitrification process functional diagram.

Table 9-1. Estimated operating staff for vitrification facility (cost module H).

Unit operation	Description	Small (FTE)	Medium (FTE)	Large (FTE)
H-1	Prepare and feed incoming waste	4	6	10
H-2	Melter	7	7	10
H-3	Cool melter	0	0	0
H-4	Store and feed binder	2	4	6
H-5	Solidify	2	4	6
H-6	Drum capping and washing	2	2	4
H-7	Prepare and feed lime	2	4	4
H-8	Off-gas treatment	2	4	7
H-9	Slag cooling and packaging	4	4	7
H-10	Treat liquid waste	2	4	7
H-11	Prepare and feed soil	2	4	7
H-12	Electrical distribution and MCC	2	4	4
H-13	Heating, ventilation, and exhaust	4	4	4
H-14	Other equipment	6	10	14
	Total	41	61	90

Table 9-2. Capacities and cost information for vitrification facility (cost module HL and HA).[a]

Mod.	Module Description	Facility	Life Cycle Cost ($x1000)	Capacity (lbs/hr)	Unit Cost ($/lb)	Capacity (ft3/hr)	Cap(Tot Vol) (ft3x1000)	Unit Cost ($/ft3)
HL	Vitrification	Small	$316,401	300	$13.08	9	691	$457.76
HL	Vitrification	Medium	$430,303	1,000	$5.34	29	2,304	$186.76
HL	Vitrification	Large	$587,311	2,000	$3.64	57	4,608	$127.45
HA	Vitrification	Small	$359,866	300	$14.88	9	691	$520.64
HA	Vitrification	Medium	$490,069	1,200	$5.06	34	2,765	$177.25
HA	Vitrification	Large	$655,339	2,000	$4.06	57	4,608	$142.22

a. Average density used is 35 lbs/ft.[3]

9.4 Cost Summaries

Cost summaries for the LLW/LLMW and alpha-LLW/LLMW vitrification facilities are shown in Tables 9-3 and 9-4. Figures 9-3 and 9-4 contain a histogram of the PLCC estimates.

Table 9-3. PLCC estimate summary for LLW/LLMW vitrification facility (cost module HL).

Cost component	Cost Items			Cost ($ x 1000) Small	Medium	Large
1.0	**Studies and bench scale test costs**					
	1.1 Manpower costs during research			$3,600	$3,600	$3,600
	1.2 Equipment costs			$250	$250	$250
	1.3 Installation costs			$650	$650	$650
	1.4 Project management before title I		(10 % of 1.1 through 1.3)	$450	$450	$450
	1.5 Contingency		(25 % of 1.1 through 1.4)	$1,238	$1,238	$1,238
	Subtotal 1.0			$6,188	$6,188	$6,188
2.0	**Demonstration costs**					
	2.1 Manpower costs during demonstration			$2,400	$2,400	$2,400
	2.2 Design cost		(30 % of 2.5)	$167	$554	$554
	2.3 Inspection cost		(7 % of 2.5)	$39	$129	$129
	2.4 Project management		(10 % of 2.5)	$56	$185	$185
	2.5 Construction cost					
	2.5.1	Building structure costs		$80	$180	$180
	2.5.2	Equipment costs		$350	$1,250	$1,250
	2.5.3	Indirect	(29 % of 2.5.1 & 2.5.2)	$125	$415	$415
	Subtotal of 2.5			$555	$1,845	$1,845
	2.6 Construction management costs		(17.1 % of 2.5)	$95	$315	$315
	2.7 Management Reserve		(10 % of 2.5)	$56	$185	$185
	2.8 Contingency		(25 % of 2.1 through 2.7)	$842	$1,403	$1,403
	Subtotal 2.0			$4,210	$7,016	$7,016
3.0	**Production facility construction costs**					
	3.1 Design cost		(18 % of 3.4)	$4,378	$5,296	$6,627
	3.2 Inspection cost		(7 % of 3.4)	$1,703	$2,059	$2,577
	3.3 Project management		(10 % of 3.4)	$2,432	$2,942	$3,682
	3.4 Construction cost					
	3.4.1	Building structure costs		$3,203	$3,947	$5,778
	3.4.2	Equipment costs		$1[illegible],650	$18,859	$22,764
	3.4.3	Indirect	(29 % of 3.4.1 & 3.4.2)	$5,468	$6,614	$8,277
	Subtotal of 3.4			$24,323	$29,420	$36,819
	3.5 Construction management		(17.1 % of 3.4)	$4,159	$5,031	$6,296
	3.6 Management Reserve		(10 % of 3.4)	$2,432	$2,942	$3,682
	3.7 Contingency		(25 % of 3.1 through 3.5)	$9,249	$11,187	$14,000
	Subtotal 3.0			$48,676	$58,877	$73,683
4.0	**Operations Budget Funded Activities (See Sect. 7)**					
	4.1 Conceptual design		(1.5 % of 3.0)	$730	$883	$1,105
	4.2 Safety assurance		(1 % of 3.0)	$487	$589	$737
	4.3 NEPA permitting ($ 6 Mill for EIS, $1 Mill for EA)			$6,000	$6,000	$6,000
	4.4 Preparation for operations		(100 % of 5.0)	$11,623	$16,338	$22,956
	4.5 Project Management		(10 % of 4.1 through 4.4)	$1,884	$2,381	$3,080
	Subtotal 4.0			$20,724	$26,191	$33,878
	Total Initial Cost (1.0,2.0,3.0 & 4.0)			**$79,798**	**$98,272**	**$120,765**
5.0	**Operating and maintainence costs**					
	5.1 Annual operating costs			$5,740	$8,54[illegible]	$12,600
	5.2 Annual utility costs			$226	$57[illegible]	$836
	5.3 Annual material costs			$130	$84	$271
	5.4 Annual maintainence costs			$3,202	$3,871	$4,658
	5.5 Contingency		(25 % of 5.1 through 5.4)	$2,325	$3,268	$4,591
	Subtotal 5.0			$11,623	$16,338	$22,956
	Total 20 year O & M cost (20 times Subtotal 4.0)			$232,460	$326,760	$459,120
6.0	Decontamination & Decommissioning			$4,[illegible]43	$5,271	$7,426
7.0	**ROM Life cycle costs (20 years operation)**			**$[illegible]401**	**$430,303**	**$587,311**

Table 9-4. PLCC estimate summary for alpha-LLW/LLMW vitrification facility (cost module HA).

Cost component	Cost Items		Cost ($ x 1000) Small	Medium	Large
1.0	**Studies and bench scale test costs**				
	1.1 Manpower costs during research		$3,600	$3,600	$3,600
	1.2 Equipment costs		$250	$250	$250
	1.3 Installation costs		$650	$650	$650
	1.4 Project management before title I	(10 % of 1.1 through 1.3)	$450	$450	$450
	1.5 Contingency	(25 % of 1.1 through 1.4)	$1,238	$1,238	$1,238
	Subtotal 1.0		$6,188	$6,188	$6,188
2.0	**Demonstration costs**				
	2.1 Manpower costs during demonstration		$2,400	$2,400	$2,400
	2.2 Design cost	(30 % of 2.5)	$167	$554	$554
	2.3 Inspection cost	(7 % of 2.5)	$39	$129	$129
	2.4 Project management	(10 % of 2.5)	$56	$185	$185
	2.5 Construction cost				
	2.5.1 Building structure costs		$80	$180	$180
	2.5.2 Equipment costs		$350	$1,250	$1,250
	2.5.3 Indirect	(29 % of 2.5.1 & 2.5.2)	$125	$415	$415
	Subtotal of 2.5		$555	$1,845	$1,845
	2.6 Construction management costs	(17.1 % of 2.5)	$95	$315	$315
	2.7 Management Reserve	(10 % of 2.5)	$56	$185	$185
	2.8 Contingency	(25 % of 2.1 through 2.7)	$842	$1,403	$1,403
	Subtotal 2.0		$4,210	$7,016	$7,016
3.0	**Production facility construction costs**				
	3.1 Design cost	(25 % of 3.4)	$8,020	$10,270	$12,494
	3.2 Inspection cost	(7 % of 3.4)	$2,246	$2,876	$3,498
	3.3 Project management	(10 % of 3.4)	$3,208	$4,108	$4,998
	3.4 Construction cost				
	3.4.1 Building structure costs		$5,031	$7,803	$10,268
	3.4.2 Equipment costs		$19,837	$24,041	$28,474
	3.4.3 Indirect	(29 % of 3.4.1 & 3.4.2)	$7,212	$9,235	$11,235
	Subtotal of 3.4		$32,080	$41,079	$49,977
	3.5 Construction management	(17.1 % of 3.4)	$5,486	$7,025	$8,546
	3.6 Management Reserve	(10 % of 3.4)	$3,208	$4,108	$4,998
	3.7 Contingency	(25 % of 3.1 through 3.5)	$12,760	$16,340	$19,878
	Subtotal 3.0		$67,008	$85,806	$104,389
4.0	**Operations Budget Funded Activities (See Sect. 7)**				
	4.1 Conceptual design	(1.5 % of 3.0)	$1,005	$1,287	$1,566
	4.2 Safety assurance	(1 % of 3.0)	$670	$858	$1,044
	4.3 NEPA permitting ($ 6 Mill for EIS, $1 Mill for EA)		$6,000	$6,000	$6,000
	4.4 Preparation for operations	(100 % of 5.0)	$12,690	$17,693	$24,487
	4.5 Project Management	(10 % of 4.1 through 4.4)	$2,037	$2,584	$3,310
	Subtotal 4.0		$22,402	$28,422	$36,407
	Total Initial Cost (1.0,2.0,3.0 & 4.0)		$99,808	$127,432	$154,000
5.0	**Operating and maintainence costs**				
	5.1 Annual operating costs		$5,740	$8,540	$12,600
	5.2 Annual utility costs		$226	$575	$836
	5.3 Annual material costs		$130	$84	$271
	5.4 Annual maintainence costs		$4,056	$4,955	$5,883
	5.5 Contingency	(25 % of 5.1 through 5.4)	$2,538	$3,539	$4,897
	Subtotal 5.0		$12,690	$17,693	$24,487
	Total 20 year O & M cost (20 times Subtotal 5.0)		$253,800	$353,860	$489,740
6.0	Decontamination & Decommissioning		$6,258	$8,777	$11,599
7.0	**ROM Life cycle costs (20 years operation)**		$359,866	$490,069	$655,339

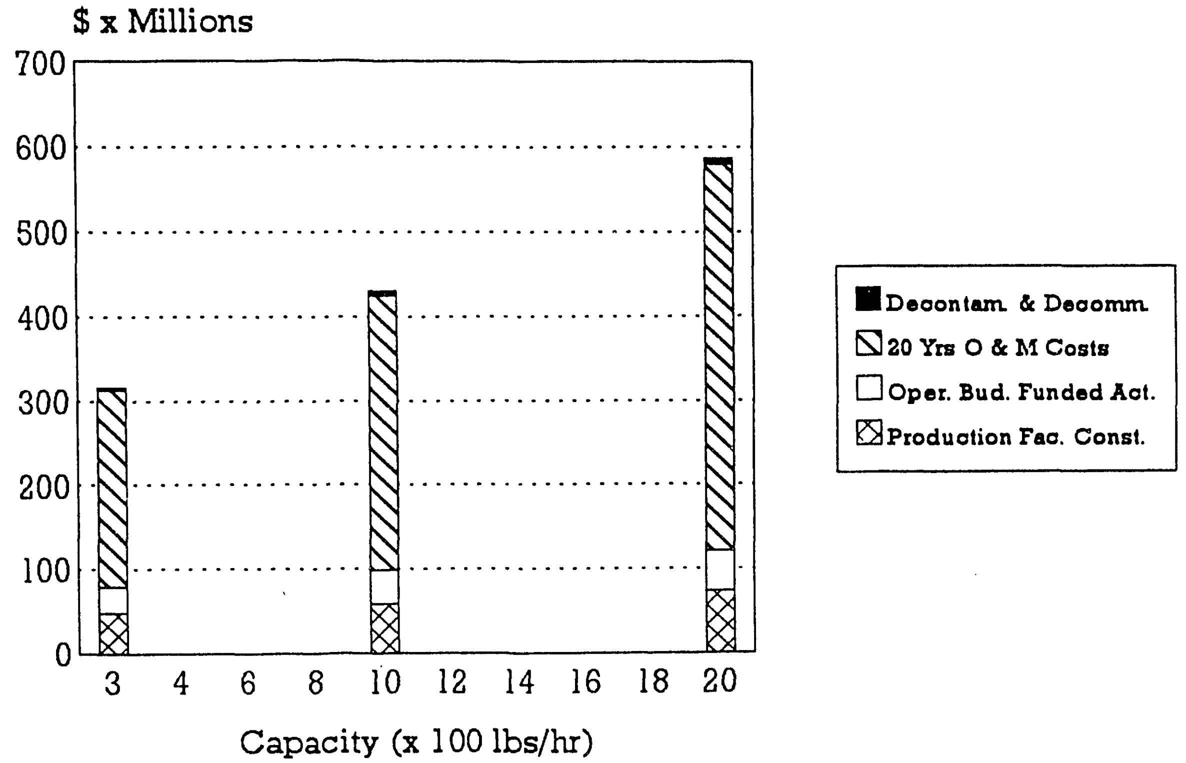


Figure 9-3. Cost versus capacity histogram for LLW/LLMW shredding and compaction facility (cost module HL).

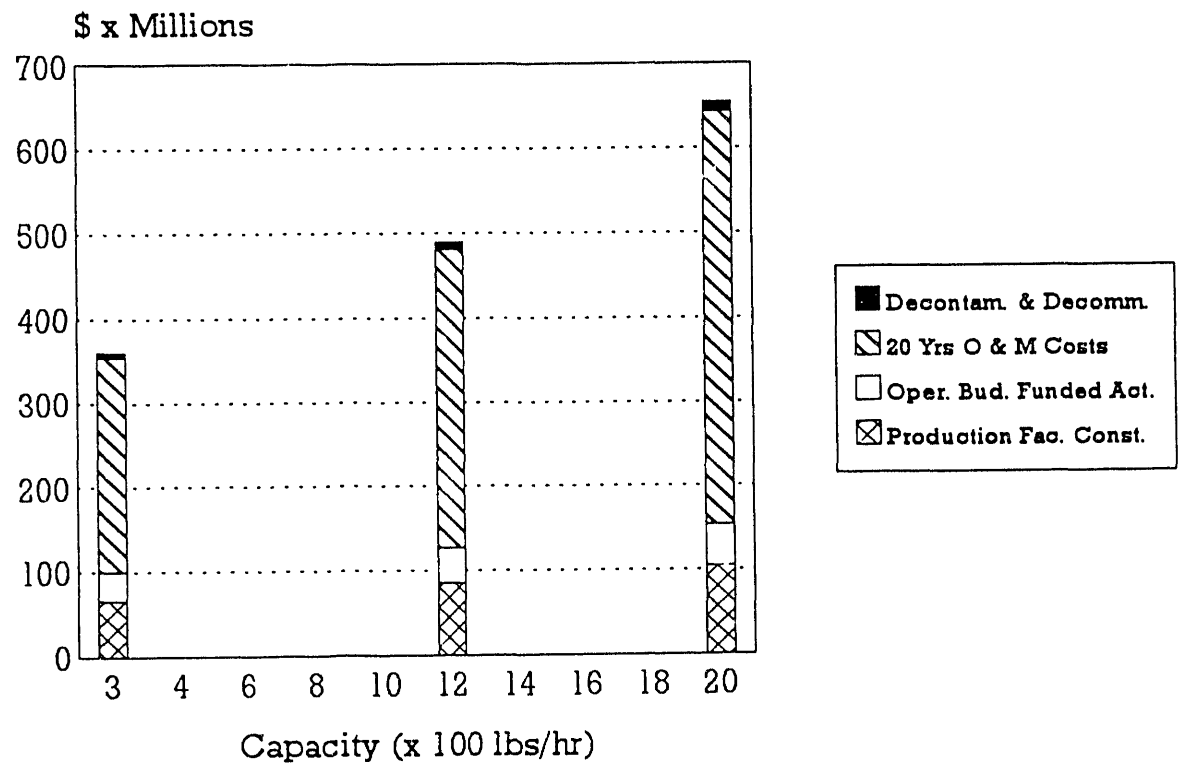


Figure 9-4. Cost versus capacity histogram for alpha-LLW/LLMW shredding and compaction facility (cost module HA).

10. CERTIFICATION/SHIPPING FACILITY (COST MODULE I)

Certification/shipping facility is the same for LLW/LLMW and alpha-LLW/LLMW and LLW/LLMW waste treatment facilities. There are only minor differences in the assay/certification equipment that do not affect the overall PLCC estimates. Unit operations are given in Figure 10-1.

10.1 Basic Information

The certification/shipping facility consists of three unit operations: incoming material storage, assay/certification, and truck loading. This facility receives packaged waste containers from treatment facilities (cost modules DA, DL, EA, EL, FA, FL, GA, GL, HA and HL), and provides temporary storage, radiological and physical characterization of the waste, and shipment of the containers.

The certification/shipping facility is used in conjunction with treatment facilities when the required functions are not available at existing facilities. The facility includes all equipment needed for certification of the waste in compliance with the transportation, storage, and disposal regulations and requirements.

10.2 Technical Bases and Assumptions

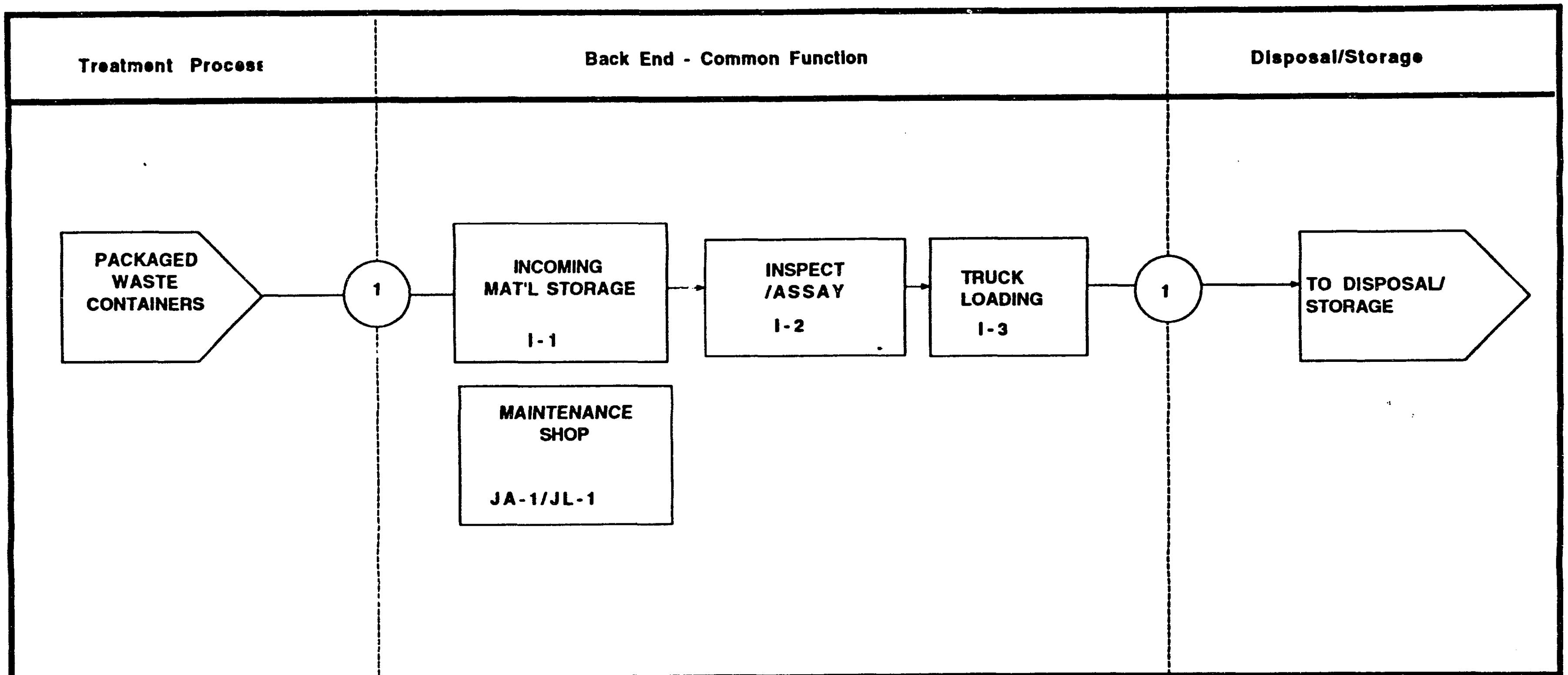
10.2.1 Functional and Operational Description

Packaged waste containers arrive from treatment facilities on conveyors, carts, or other transport devices. Containers are removed from the transport devices and placed in a staging area. The containers are then visually examined, tagged, logged, recorded, and sent to an assay/certification unit operation. In this unit operation, the containers are examined by radioassay devices to allow both alpha and gamma radioactivity classification in accordance with the transportation, storage and disposal criteria. Various devices, such as PAN counting and SGS instruments, may be used.

Next, the containers are weighed and measured to determine waste density. The existence of materials restricted by transportation, storage, and disposal is determined by nondestructive examinations such as ultrasonic instruments or a RTR device. After examination, each container is labeled and its properties are logged and recorded into a computerized database. After inspection, the container is moved to a temporary storage area until they are ready for shipment to an interim storage or disposal facility. Containers that do not meet the transportation dose criteria are shipped in a truck equipped with a shield overpacks.

The shipping/certification facility is equipped with a bridge crane and a forklift. Containers can be loaded onto flat-bed trailer or van trucks. Containers can also be loaded into large transportation overpacks (e.g., TRAMPAC). This facility is designed to be installed contiguous to a treatment facility.

To allow year-round operations and minimize the effects of a potential spill, it is assumed that the certification/shipping operations will take place indoors.



	lb/hr	ft^3/hr
Facillility Size	Node 1	Node 1
Small	450	5
Medium	6235	62
Large	18200	182

Figure 10-1. Certification/shipping facility process functional diagram.

10.2.2 Facility Integration

Facility input includes packaged waste from treatment facilities. Input from the site includes utilities, service water, normal and emergency power, and communications. O&M consumables including personal protective equipment must be purchased. Facility output includes truck shipments of containerized LLW/LLMW or alpha-LLW/LLMW to storage and disposal facilities.

10.3 Cost Bases, Assumptions, and Assessments

General cost bases and assumptions are given in Appendix A. Facility specific items are discussed below:

- Major equipment capital cost items for this facility are a 20 ton bridge crane, alpha assay, gamma assay, and RTR units. The equipment estimates were obtained as discussed in Section 4 of this report.
- Estimated operating staff are shown in Table 10-1.
- Small, medium, and large facility capacities and unit costs are shown in Table 10-2.

10.4 Cost Summaries

Cost summaries for the LLW/LLMW and alpha-LLW/LLMW receiving and unloading cost facilities are shown in Table 10-3. Histograms for cost versus capacity are given in Figure 10-2.

Table 10-1. Estimated operating staff for certification/shipping facility (module I).

Unit operation	Description	Small (FTE)	Medium (FTE)	Large (FTE)
I-1	Incoming material storage	0	0	0
I-2	Inspect and assay	4	10	20
I-3	Truck loading	4	10	20
	Total	8	20	40

Table 10-2. Capacities and cost information for certification/shipping facility (cost module I).[a]

Mod.	Module Description	Facility	Life Cycle Cost ($x1000)	Capacity (lbs/hr)	Unit Cost ($/lb)	Capacity (ft3/hr)	Cap(Tot Vol) (ft3x1000)	Unit Cost ($/ft3)
I	Cert./Shipment	Small	$69,315	450	$1.91	4	324	$213.94
I	Cert./Shipment	Medium	$127,960	6,235	$0.25	56	4,489	$28.50
I	Cert./Shipment	Large	$239,201	18,200	$0.16	163	13,104	$18.25

a. Average density used is 112 lbs/ft^3.

Table 10-3. PLCC estimate summary for treatment certification/shipping facility (cost module I).

Cost component	Cost Items		Cost ($ x 1000) Small	Medium	Large
1.0	**Studies and bench scale test costs**				
	1.1 Manpower costs during research		$0	$0	$0
	1.2 Equipment costs		$0	$0	$0
	1.3 Installation costs		$0	$0	$0
	1.4 Project management before title I	(10 % of 1.1 through 1.3)	$0	$0	$0
	1.5 Contingency	(25 % of 1.1 through 1.4)	$0	$0	$0
	Subtotal 1.0		$0	$0	$0
2.0	**Demonstration costs**				
	2.1 Manpower costs during demonstration		$0	$0	$0
	2.2 Design cost	(30 % of 2.5)	$0	$0	$0
	2.3 Inspection cost	(7 % of 2.5)	$0	$0	$0
	2.4 Project management	(10 % of 2.5)	$0	$0	$0
	2.5 Construction cost				
	2.5.1 Building structure costs		$0	$0	$0
	2.5.2 Equipment costs		$0	$0	$0
	2.5.3 Indirect	(29 % of 2.5.1 & 2.5.2)	$0	$0	$0
	Subtotal of 2.5		$0	$0	$0
	2.6 Construction management costs	(17.1 % of 2.5)	$0	$0	$0
	2.7 Management Reserve	(10 % of 2.5)	$0	$0	$0
	2.8 Contingency	(25 % of 2.1 through 2.7)	$0	$0	$0
	Subtotal 2.0		$0	$0	$0
3.0	**Production facility construction costs**				
	3.1 Design cost	(18 % of 3.4)	$1,270	$1,868	$3,380
	3.2 Inspection cost	(7 % of 3.4)	$494	$726	$1,314
	3.3 Project management	(10 % of 3.4)	$706	$1,038	$1,878
	3.4 Construction cost				
	3.4.1 Building structure costs		$1,152	$3,528	$8,496
	3.4.2 Equipment costs		$4,317	$4,517	$6,059
	3.4.3 Indirect	(29 % of 3.4.1 & 3.4.2)	$1,586	$2,333	$4,221
	Subtotal of 3.4		$7,055	$10,378	$18,776
	3.5 Construction management	(17.1 % of 3.4)	$1,206	$1,775	$3,211
	3.6 Management Reserve	(10 % of 3.4)	$706	$1,038	$1,878
	3.7 Contingency	(25 % of 3.1 through 3.5)	$2,683	$3,946	$7,140
	Subtotal 3.0		$14,120	$20,769	$37,577
4.0	**Operations Budget Funded Activities (See Sect. 7)**				
	4.1 Conceptual design	(1.5 % of 3.0)	$212	$312	$564
	4.2 Safety assurance	(1 % of 3.0)	$141	$208	$376
	4.3 NEPA permitting ($ 6 Mill for EIS, $1 Mill for EA)		$0	$0	$0
	4.4 Preparation for operations	(100 % of 5.0)	$2,461	$4,635	$8,500
	4.5 Project Management	(10 % of 4.1 through 4.4)	$281	$516	$944
	Subtotal 4.0		$3,095	$5,671	$10,384
	Total Initial Cost (1.0,2.0,3.0 & 4.0)		**$17,215**	**$26,440**	**$47,961**
5.0	**Operating and maintainence costs**				
	5.1 Annual operating costs		$1,120	$2,800	$5,600
	5.2 Annual utility costs		$5	$15	$30
	5.3 Annual material costs		$0	$0	$0
	5.4 Annual maintainence costs		$844	$893	$1,170
	5.5 Contingency	(25 % of 5.1 through 5.4)	$492	$927	$1,700
	Subtotal 5.0		$2,461	$4,635	$8,500
	Total 20 year O & M cost (20 times Subtotal 4.0)		$49,220	$92,700	$170,000
6.0	Decontamination & Decommissioning		$2,880	$8,820	$21,240
7.0	**ROM Life cycle costs (20 years operation)**		**$69,315**	**$127,960**	**$239,201**

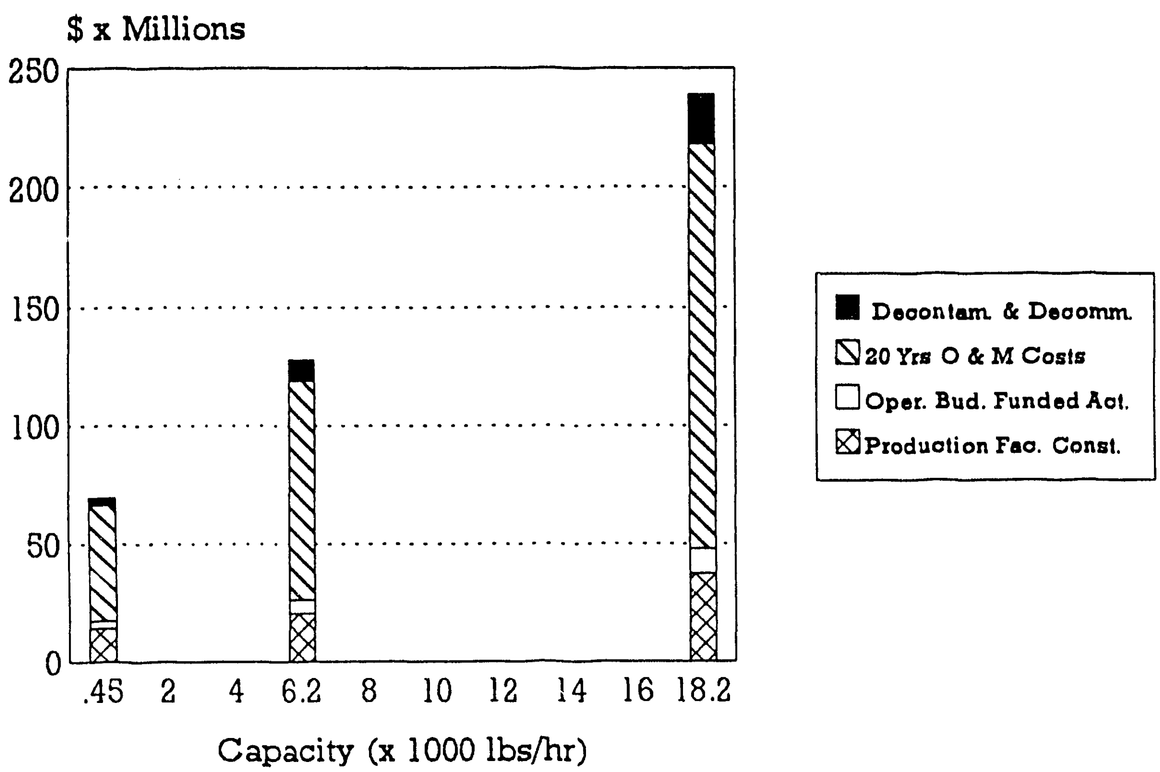


Figure 10-2. Cost versus capacity histogram for treatment certification/shipping facility (cost module I).

11. TREATMENT MAINTENANCE FACILITY (COST MODULES JL AND JA)

The maintenance shop is the same for alpha-LLW/LLMW and LLW/LLMW TSD facilities with the exception that the alpha-LLW/LLMW facility includes a mock-up shop.

11.1 Basic Information

The maintenance facility is equipped with a failed equipment receiving and repair building housing machinery and tools. This facility is used in conjunction with the treatment facilities when such function is not available at the existing facilities. The maintenance shop costs assumes repair of components contaminated with low-level radioactivity but not alpha-emitters. Components contaminated with alpha particles must be decontaminated in the alpha maintenance galleries before they are brought into the maintenance shop. Cost module JA has remote component mock-up area.

11.2 Technical Bases and Assumptions

Contaminated failed equipment and parts arrive at the shop in transfer carts. Parts are removed from the transport carts and placed in a decontamination area where high pressure spray or other techniques are used to remove any loose contamination. After cleaning and decontamination, components are moved to maintenance tables. Maintenance machinery and tools are used as needed. The shop includes an overhead and a jib crane for material handling. A paint booth is also included.

11.3 Cost Bases, Assumptions, and Assessments

Major equipment capital cost items are milling, sanding, and lathe machinery and tools. Costs for all machinery and equipment including the cranes are based on industrial (nonradioactive) applications.

- Estimated operating staff are shown in Table 11-1.
- Back-end facility capacities and unit costs are shown in Table 11-2.

11.4 Cost Summaries

Cost summaries for the cost modules are shown in Tables 11-3 and 11-4. Histograms for cost versus capacity are given in Figures 11-1 and 11-2.

Table 11-1. Estimated operating staff for back-end treatment facilities (cost module J).

Unit operation	Description	Small (FTE)	Medium (FTE)	Large (FTE)
J-1	Warehouse/maintenance	7	15	30
	Total	7	15	30

Table 11-2. Capacities and cost information for treatment maintenance facility (cost module JL and JA).[a]

Mod.	Module Description	Facility	Life Cycle Cost ($x1000)	Capacity (lbs/hr)	Unit Cost ($/lb)	Capacity (ft3/hr)	Cap(Tot Vol) (ft3x1000)	Unit Cost ($/ft3)
JL	Treatment Maint.	Small	$36,887	450	$1.02	4	324	$113.85
JL	Treatment Maint.	Medium	$72,588	6,235	$0.14	56	4,489	$16.17
JL	Treatment Maint.	Large	$136,592	18,200	$0.09	163	13,104	$10.42
JA	Treatment Maint.	Small	$38,091	450	$1.05	4	324	$117.56
JA	Treatment Maint.	Medium	$73,048	6,235	$0.15	56	4,489	$16.27
JA	Treatment Maint.	Large	$156,741	18,200	$0.11	163	13,104	$11.96

a. Average desity used is 112 lbs/ft^3.

Table 11-3. PLCC estimate summary LLW/LLMW treatment maintenance facility (cost module JL).

Cost component			Cost Items	Cost ($ x 1000) Small	Medium	Large
1.0	**Studies and bench scale test costs**					
	1.1 Manpower costs during research			$0	$0	$0
	1.2 Equipment costs			$0	$0	$0
	1.3 Installation costs			$0	$0	$0
	1.4 Project management before title I		(10 % of 1.1 through 1.3)	$0	$0	$0
	1.5 Contingency		(25 % of 1.1 through 1.4)	$0	$0	$0
	Subtotal 1.0			$0	$0	$0
2.0	**Demonstration costs**					
	2.1 Manpower costs during demonstration			$0	$0	$0
	2.2 Design cost		(30 % of 2.5)	$0	$0	$0
	2.3 Inspection cost		(7 % of 2.5)	$0	$0	$0
	2.4 Project management		(10 % of 2.5)	$0	$0	$0
	2.5 Construction cost					
	2.5.1	Building structure costs		$0	$0	$0
	2.5.2	Equipment costs		$0	$0	$0
	2.5.3	Indirect	(29 % of 2.5.1 & 2.5.2)	$0	$0	$0
	Subtotal of 2.5			$0	$0	$0
	2.6 Construction management costs		(17.1 % of 2.5)	$0	$0	$0
	2.7 Management Reserve		(10 % of 2.5)	$0	$0	$0
	2.8 Contingency		(25 % of 2.1 through 2.7)	$0	$0	$0
	Subtotal 2.0			$0	$0	$0
3.0	**Production facility construction costs**					
	3.1 Design cost		(18 % of 3.4)	$368	$596	$961
	3.2 Inspection cost		(7 % of 3.4)	$143	$232	$374
	3.3 Project management		(10 % of 3.4)	$204	$331	$534
	3.4 Construction cost					
	3.4.1	Building structure costs		$720	$1,500	$3,000
	3.4.2	Equipment costs		$863	$1,065	$1,138
	3.4.3	Indirect	(29 % of 3.4.1 & 3.4.2)	$459	$744	$1,200
	Subtotal of 3.4			$2,042	$3,309	$5,338
	3.5 Construction management		(17.1 % of 3.4)	$349	$566	$913
	3.6 Management Reserve		(10 % of 3.4)	$204	$331	$534
	3.7 Contingency		(25 % of 3.1 through 3.5)	$777	$1,259	$2,030
	Subtotal 3.0			$4,087	$6,624	$10,684
4.0	**Operations Budget Funded Activities (See Sect. 7)**					
	4.1 Conceptual design		(1.5 % of 3.0)	$61	$99	$160
	4.2 Safety assurance		(1 % of 3.0)	$41	$66	$107
	4.3 NEPA permitting ($ 6 Mill for EIS, $1 Mill for EA)			$0	$0	$0
	4.4 Preparation for operations		(100 % of 5.0)	$1,498	$3,011	$5,740
	4.5 Project Management		(10 % of 4.1 through 4.4)	$160	$318	$601
	Subtotal 4.0			$1,760	$3,494	$6,608
	Total Initial Cost (1.0,2.0,3.0 & 4.0)			$5,847	$10,118	$17,292
5.0	**Operating and maintainence costs**					
	5.1 Annual operating costs			$980	$2,100	$4,200
	5.2 Annual utility costs			$7	$22	$41
	5.3 Annual material costs			$15	$45	$95
	5.4 Annual maintainence costs			$196	$242	$256
	5.5 Contingency		(25 % of 5.1 through 5.4)	$300	$602	$1,148
	Subtotal 5.0			$1,498	$3,011	$5,740
	Total 20 year O & M cost (20 times Subtotal 4.0)			$29,960	$60,220	$114,800
6.0	Decontamination & Decommissioning			$1,080	$2,250	$4,500
7.0	**ROM Life cycle costs (20 years operation)**			$36,887	$72,588	$136,592

Table 11-4. PLCC estimate summary alpha-LLW/LLMW treatment maintenance facility (cost module JA).

Cost component	Cost Items		Cost ($ x 1000) Small	Medium	Large
1.0	**Studies and bench scale test costs**				
	1.1 Manpower costs during research		$0	$0	$0
	1.2 Equipment costs		$0	$0	$0
	1.3 Installation costs		$0	$0	$0
	1.4 Project management before title I	(10 % of 1.1 through 1.3)	$0	$0	$0
	1.5 Contingency	(25 % of 1.1 through 1.4)	$0	$0	$0
	Subtotal 1.0		$0	$0	$0
2.0	**Demonstration costs**				
	2.1 Manpower costs during demonstration		$0	$0	$0
	2.2 Design cost	(30 % of 2.5)	$0	$0	$0
	2.3 Inspection cost	(7 % of 2.5)	$0	$0	$0
	2.4 Project management	(10 % of 2.5)	$0	$0	$0
	2.5 Construction cost				
	2.5.1 Building structure costs		$0	$0	$0
	2.5.2 Equipment costs		$0	$0	$0
	2.5.3 Indirect	(29 % of 2.5.1 & 2.5.2)	$0	$0	$0
	Subtotal of 2.5		$0	$0	$0
	2.6 Construction management costs	(17.1 % of 2.5)	$0	$0	$0
	2.7 Management Reserve	(10 % of 2.5)	$0	$0	$0
	2.8 Contingency	(25 % of 2.1 through 2.7)	$0	$0	$0
	Subtotal 2.0		$0	$0	$0
3.0	**Production facility construction costs**				
	3.1 Design cost	(25 % of 3.4)	$1,080	$1,755	$3,956
	3.2 Inspection cost	(7 % of 3.4)	$302	$491	$1,108
	3.3 Project management	(10 % of 3.4)	$432	$702	$1,582
	3.4 Construction cost				
	3.4.1 Building structure costs		$1,260	$2,550	$5,100
	3.4.2 Equipment costs		$2,087	$2,892	$7,167
	3.4.3 Indirect	(29 % of 3.4.1 & 3.4.2)	$971	$1,578	$3,557
	Subtotal of 3.4		$4,318	$7,020	$15,824
	3.5 Construction management	(17.1 % of 3.4)	$738	$1,200	$2,706
	3.6 Management Reserve	(10 % of 3.4)	$432	$702	$1,582
	3.7 Contingency	(25 % of 3.1 through 3.5)	$1,718	$2,792	$6,294
	Subtotal 3.0		$9,020	$14,662	$33,052
4.0	**Operations Budget Funded Activities (See Sect. 7)**				
	4.1 Conceptual design	(1.5 % of 3.0)	$135	$220	$496
	4.2 Safety assurance	(1 % of 3.0)	$90	$147	$331
	4.3 NEPA permitting ($ 6 Mill for EIS, $1 Mill for EA)		$0	$0	$0
	4.4 Preparation for operations	(100 % of 5.0)	$1,285	$2,588	$5,499
	4.5 Project Management	(10 % of 4.1 through 4.4)	$151	$296	$633
	Subtotal 4.0		$1,661	$3,251	$6,959
	Total Initial Cost (1.0,2.0,3.0 & 4.0)		**$10,681**	**$17,913**	**$40,011**
5.0	**Operating and maintainence costs**				
	5.1 Annual operating costs		$560	$1,400	$2,800
	5.2 Annual utility costs		$8	$18	$36
	5.3 Annual material costs		$12	$36	$75
	5.4 Annual maintainence costs		$448	$616	$1,488
	5.5 Contingency	(25 % of 5.1 through 5.4)	$257	$518	$1,100
	Subtotal 5.0		$1,285	$2,588	$5,499
	Total 20 year O & M cost (20 times Subtotal 5.0)		$25,700	$51,760	$109,980
6.0	Decontamination & Decommissioning		$1,710	$3,375	$6,750
7.0	**ROM Life cycle costs (20 years operation)**		**$38,091**	**$73,048**	**$156,741**

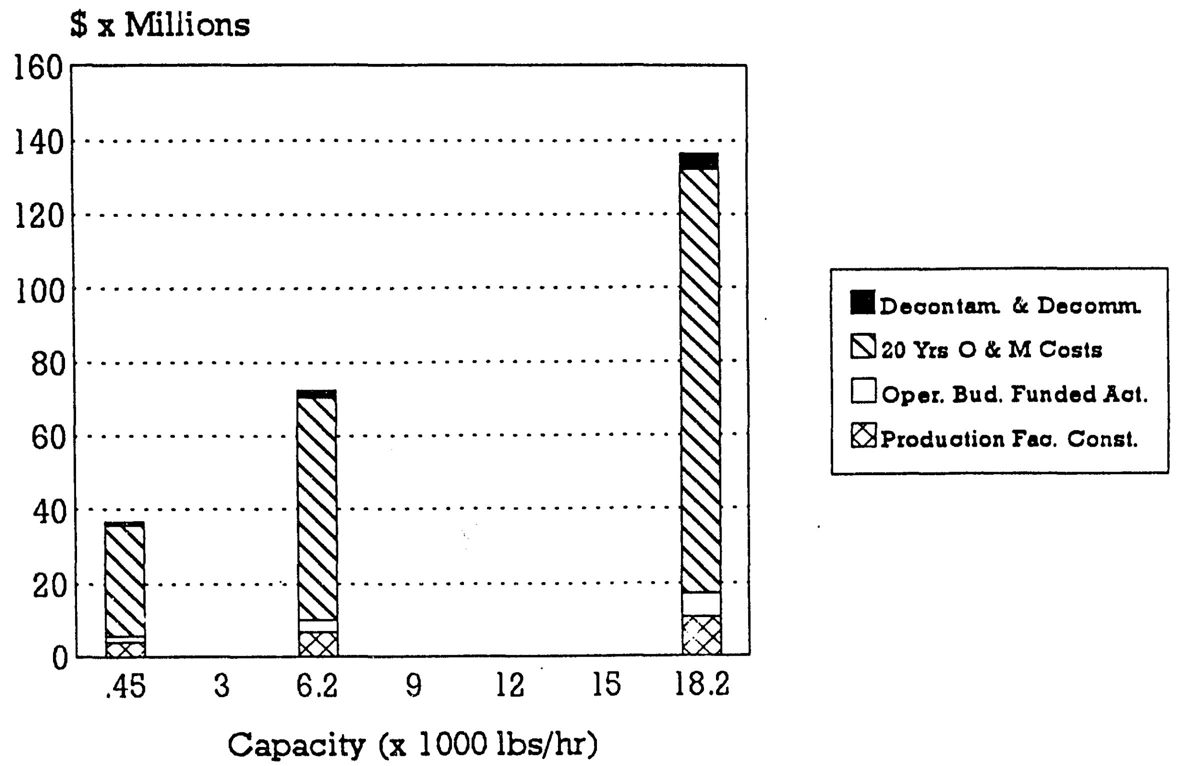


Figure 11-1. Cost versus capacity histogram for LLW/LLMW shredding and compaction facility (cost module JL).

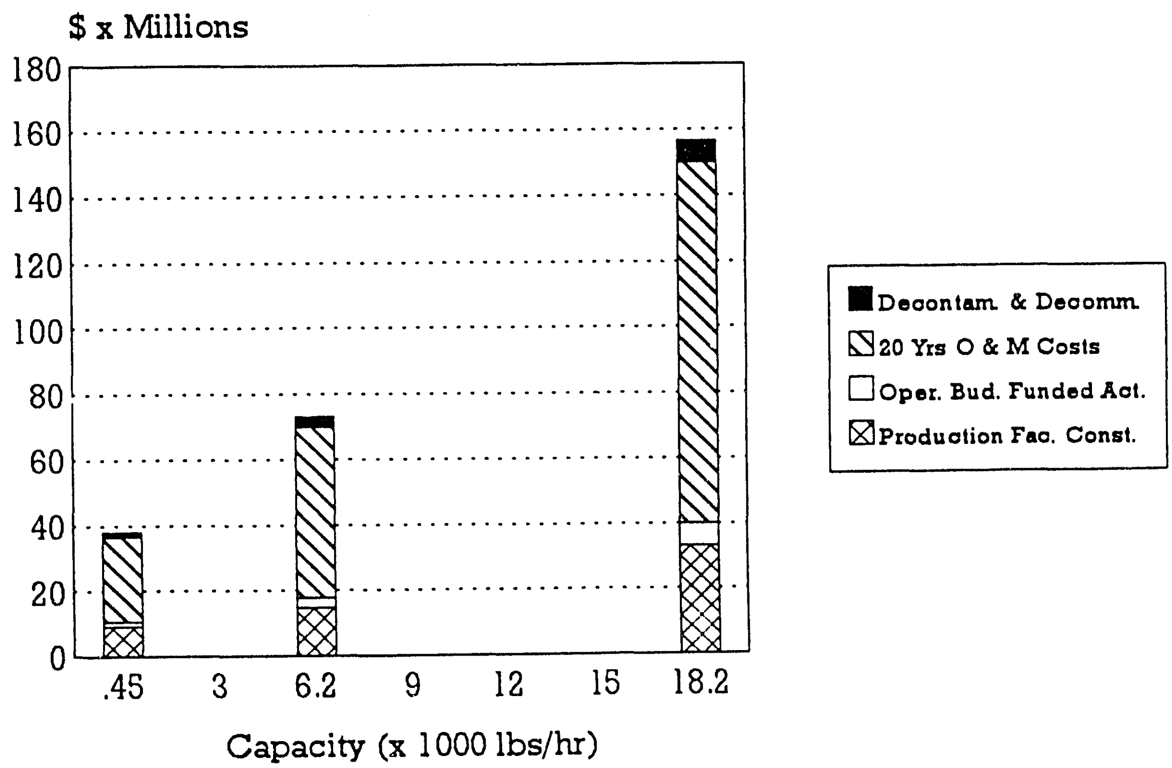


Figure 11-2. Cost versus capacity histogram for alpha-LLW/LLMW shredding and compaction facility (cost module JA).

12. STORAGE FRONT-END/BACK-END SUPPORT FACILITY (COST MODULE K)

12.1 Basic Information

The storage front-end/back-end support facility is used in conjunction with the storage facilities (cost modules L, M, and N) and supply all the necessary accommodations for storing LLW, LLMW, alpha-LLW/LLMW, and TRUW. The facilities combine receiving/inspection operations with administration, laboratory functions, and shipping/unloading capabilities similar to those outlined in Sections 3, 2, and 10, respectively. Unit operations are given in Figure 12-1.

12.2 Technical Bases and Requirements

12.2.1 Functional and Operational Description

Containers arrive on a transport vehicle and are unloaded using a forklift or overhead bridge crane, and placed in a staging area. The containers are visually examined, labeled, logged, recorded, and sent to inspection and assay. At the inspection/assay operation, the category of the received waste is verified against the results obtained from the back-end treatment facility. After inspection, the containers are moved to a storage area (refer to Section 13). The front-end/back-end facility is also used for shipping and loading containers that are ready for transport to disposal facilities.

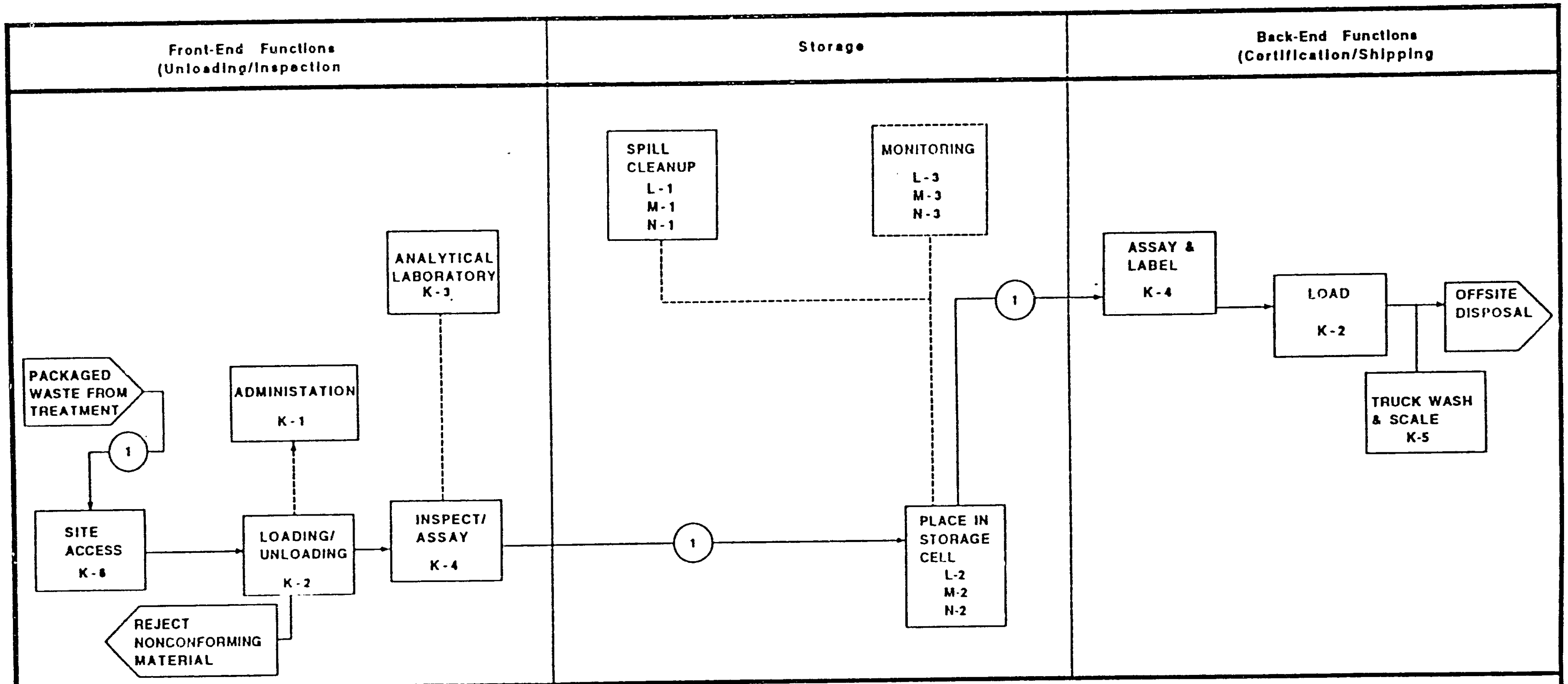
The technical bases and requirements for storage front-end/back-end support facilities are the same as outlined in Sections 2, 3, 10, and Appendix A, except that the assay/inspection and certification functions are for verification purposes only. In addition, the storage front-end/back-end support facility is equipped with a computer inventory system that tracks the incoming and outgoing waste, as well as types of sampling and analysis that may be performed at the staging area (nondestructive) or the laboratory. Secondary waste generated from sampling activities is treated and packaged.

12.2.2 Facility Integration

Facility input includes vehicles that carry waste from the treatment facility or forklift trucks that carry waste containers from storage areas (cost modules, L, M, and N in Section 13). Facility output includes containerized LLW, alpha-LLW/LLMW, TRUW, or LLMW, which is transferred to the storage bays or loaded onto trucks in containers for transport to disposal sites.

12.3 Cost Bases, Assumptions, and Assessments

General cost bases and assumptions are given in Appendix A. Facility specific items are discussed below.



Storage (Modules L,M,N)

	Node 1
Facility Size	(Ft/Hr
Small	5
Medium	11
Large	87

Front End/Back-End (Module K

	Node 1
Facility Size	(Ft/Hr)
Small	5
Medium	30
Large	87

Notes:
1.) Module K is for Front End/Back End Functions.
2.) Module L is LLW storage.
3.) Module M is for Alpha LLW/LLMW and TRUW storag
4.) Module N is for LLMW storage.

Figure 12-1. Storage front-end/back-end support and storage facility process functional diagram.

- Estimated operating staff are shown in Table 12-1. Staffing levels were estimated based on the number of personnel required to support approximately 10 separate support functions as identified in Appendix A. Storage front-end/back-end supoort staffing levels were also compared to disposal front-end facilities based on data obtained for the Illinois LLW Disposal Facility.[7]

- Major equipment capital cost items for this facility are the laboratory analytical equipment and overhead bridge crane.

- An allowance is made for the analytical instruments and components needed for a mixed waste laboratory. Mixed waste laboratory vendors have been consulted to ensure that the laboratory allowance is adequate. The crane cost is estimated based on vendor quotes.

- Small, medium, and large facility capacities and unit costs are shown in Table 12-2.

Table 12-1. Estimated operating staff for storage support facilities (cost module K).

Unit operation	Description	Small (FTE)	Medium (FTE)	Large (FTE)
K-1	Administration	11	23	38
K-2	Loading and unloading	4	16	32
K-3	Testing laboratory	4	12	24
K-4	Inspect and assay	2	6	12
K-5	Truck inspection and washout	1	2	4
K-6	Site access	1	2	4
	Total	23	61	114

Table 12-2. Capacities and unit cost information for storage front-end and/back-end facility (cost module K).[a]

Module	Module Description	Facility	Life Cycle Cost ($x1000)	Capacity (lbs/hr)	Unit Cost ($/lb)	Capacity (ft3/hr)	Cap(Tot Vol) (ft3x1000)	Unit Cost ($/ft3)
K	Storage support	Small	$155,073	560	$3.43	5	403	$384.61
K	Storage support	Medium	$319,997	3360	$1.18	30	2,419	$132.27
K	Storage support	Large	$611,128	9744	$0.78	87	7,016	$87.11

a. Average density used is 112 lbs/ft^3.

12.4 Cost Summaries

Cost summaries for the storage front-end/back-end support cost module are shown in Table 12-3. A histogram of the cost data is shown in Figure 12-2.

Staffing levels reflect waste input (unload and inspection) and waste output (certification/shipping) throughput requirements. For a large facility, staffing levels could support, as an example, 20 drums/hour input in addition to 20 drums/hour as output.

Table 12-3. PLCC estimate summary for storage front-end/back-end support facility (cost module K).

Cost component	Cost Items			Cost ($ x 1000) Small	Medium	Large
1.0	**Studies and bench scale test costs**					
	1.1 Manpower costs during research			$0	$0	$0
	1.2 Equipment costs			$0	$0	$0
	1.3 Installation costs			$0	$0	$0
	1.4 Project management before title I		(10 % of 1.1 through 1.3)	$0	$0	$0
	1.5 Contingency		(25 % of 1.1 through 1.4)	$0	$0	$0
	Subtotal 1.0			$0	$0	$0
2.0	**Demonstration costs**					
	2.1 Manpower costs during demonstration			$0	$0	$0
	2.2 Design cost		(30 % of 2.5)	$0	$0	$0
	2.3 Inspection cost		(7 % of 2.5)	$0	$0	$0
	2.4 Project management		(10 % of 2.5)	$0	$0	$0
	2.5 Construction cost					
	2.5.1	Building structure costs		$0	$0	$0
	2.5.2	Equipment costs		$0	$0	$0
	2.5.3	Indirect	(29 % of 2.5.1 & 2.5.2)	$0	$0	$0
	Subtotal of 2.5			$0	$0	$0
	2.6 Construction management costs		(17.1 % of 2.5)	$0	$0	$0
	2.7 Management Reserve		(10 % of 2.5)	$0	$0	$0
	2.8 Contingency		(25 % of 2.1 through 2.7)	$0	$0	$0
	Subtotal 2.0			$0	$0	$0
3.0	**Production facility construction costs**					
	3.1 Design cost		(18 % of 3.4)	$2,207	$3,078	$5,705
	3.2 Inspection cost		(7 % of 3.4)	$858	$1,197	$2,219
	3.3 Project management		(10 % of 3.4)	$1,226	$1,710	$3,169
	3.4 Construction cost					
	3.4.1	Building structure costs		$2,534	$4,496	$9,862
	3.4.2	Equipment costs		$6,972	$8,758	$14,706
	3.4.3	Indirect	(29 % of 3.4.1 & 3.4.2)	$2,757	$3,844	$7,125
	Subtotal of 3.4			$12,263	$17,098	$31,693
	3.5 Construction management		(17.1 % of 3.4)	$2,097	$2,924	$5,420
	3.6 Management Reserve		(10 % of 3.4)	$1,226	$1,710	$3,169
	3.7 Contingency		(25 % of 3.1 through 3.5)	$4,663	$6,502	$12,052
	Subtotal 3.0			$24,540	$34,219	$63,427
4.0	**Operations Budget Funded Activities (See Sect. 7)**					
	4.1 Conceptual design		(1.5 % of 3.0)	$368	$513	$951
	4.2 Safety assurance		(1 % of 3.0)	$245	$342	$634
	4.3 NEPA permitting ($ 6 Mill for EIS, $1 Mill for EA)			$0	$0	$0
	4.4 Preparation for operations		(100 % of 5.0)	$5,919	$13,075	$24,995
	4.5 Project Management		(10 % of 4.1 through 4.4)	$653	$1,393	$2,658
	Subtotal 4.0			$7,185	$15,323	$29,238
	Total Initial Cost (1.0,2.0,3.0 & 4.0)			**$31,725**	**$49,542**	**$92,665**
5.0	**Operating and maintainence costs**					
	5.1 Annual operating costs			$3,220	$8,540	$15,960
	5.2 Annual utility costs			$20	$39	$67
	5.3 Annual material costs			$129	$140	$1,037
	5.4 Annual maintainence costs			$1,366	$1,741	$2,932
	5.5 Contingency		(25 % of 5.1 through 5.4)	$1,184	$2,615	$4,999
	Subtotal 5.0			$5,919	$13,075	$24,995
	Total 20 year O & M cost (20 times Subtotal 5.0)			$118,380	$261,500	$499,900
6.0	Decontamination & Decommissioning			$4,968	$8,955	$18,563
7.0	**ROM Life cycle costs (20 years operation)**			**$155,073**	**$319,997**	**$611,128**

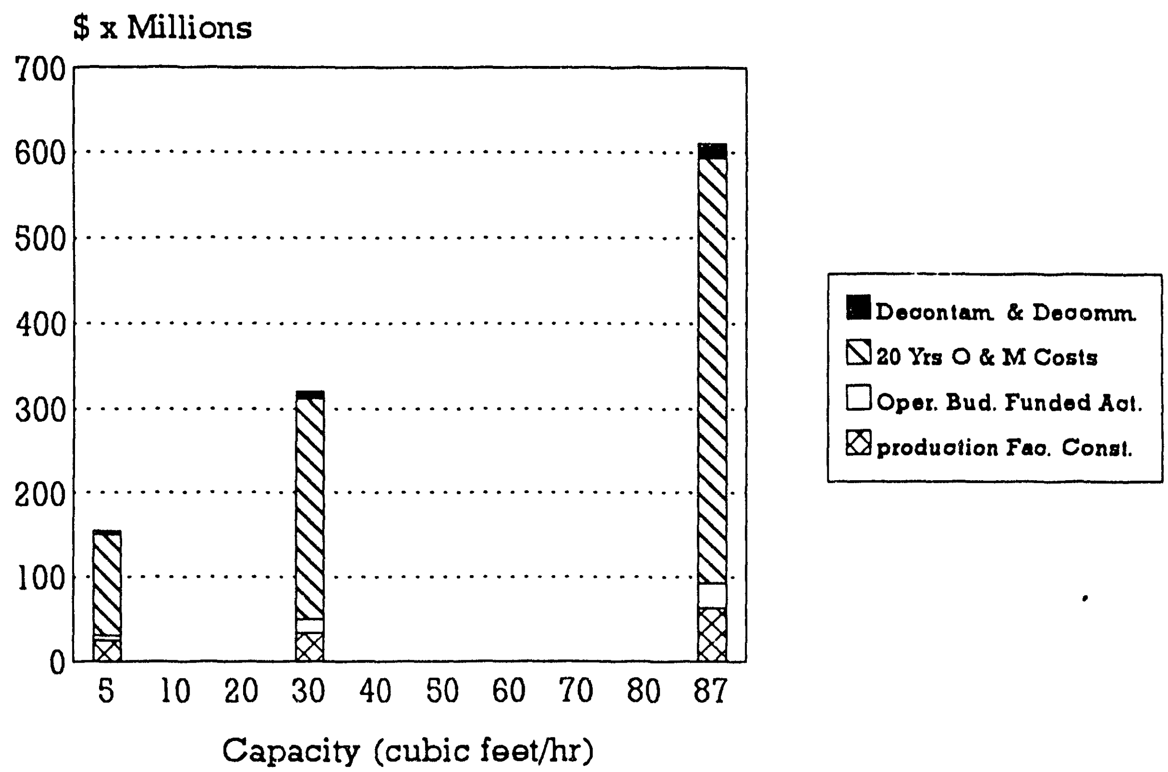


Figure 12-2. Cost versus capacity histogram for storage front-end/back-end support facilities (cost module K).

13. LLW/LLMW, ALPHA-LLW/LLMW, AND TRUW STORAGE FACILITY (COST MODULES L, M, N)

13.1 Basic Information

Cost module L is for LLW storage, M is for alpha-LLW/LLMW and TRUW storage, and N is for LLMW storage. At a PLCC level estimate, there is no significant difference in the cost of the three types of facilities. Therefore, only one PLCC estimate is generated for the three types of facilities. Each facility should be used in conjunction with the storage front-end/back-end support facility (see cost module K) or as an addition to an existing facility where similar functions are already available. Unit operations are given in Figure 12-1.

The facility consists of three unit operations. Waste that arrives from the assay/inspection is stored at a specified location. The facility is equipped with a cleanup unit operation for responding to potential spills. The facility also has permanent monitoring capabilities to ensure the integrity of the stored waste containers.

13.2 Technical Bases and Assumptions

13.2.1 Functional and Operational Description

The storage areas include features such as spill collection and a combination of sloping floors and sumps that achieve compliance with the storage requirements of the Resource Conservation and Recovery Act (RCRA). Designated storage areas are separated by 6-in. high (minimum) concrete berms that extend the length of the storage bays. In bays located along the outside walls, floors slope to the rear of the facility. Floors in the remainder of the bays are sloped to the center. Area monitors are included for both gamma and alpha radiation control.

13.2.2 Facilities Integration

Facility interfaces include packaged waste to and from the staging and/or assay/inspection area at the storage front-end/back-end support facility (cost module K).

13.3 Cost Bases, Assumptions, and Assessments

General cost bases and assumptions are given in Appendix A. Facility specific items are discussed below.

- The storage capacity has been sized to handle up to 20 years worth of waste input from treatment facilities prior to any waste being released for disposal.

- This cost module includes no major equipment capital cost items.

- Estimated operating staff are shown in Table 13-1.

Table 13-1. Estimated operating staff for storage areas (modules L, M, and N).

Unit operation	Description	Small (FTE)	Medium (FTE)	Large (FTE)
LMN-1	Spill clean-up	0	0	0
LMN-2	Place in storage	2	5	10
LMN-3	Monitoring	2	2	3
	Total	4	7	13

- The storage building is the only major (cost) element, which in turn, is dependent upon the size of the facility. Accordingly, a preconceptual design of the storage building with concrete walls and concrete roof was developed for each storage facility size (small, medium, and large). These designs were used to generate an estimate.

- Small, medium, and large facility capacities and unit costs are shown in Table 13-2.

Table 13-2. Capacities and cost information for storage facility (cost module L, M, and N).[a]

Module	Module Description	Facility	Life Cycle Cost ($x1000)	Capacity (lbs/hr)	Unit Cost ($/lb)	Capacity (ft3/hr)	Cap(Tot Vol) (ft3x1000)	Unit Cost ($/ft3)
L,M.N	Storage	Small	$51,856	560	$1.15	5	403	$128.61
L,M.N	Storage	Medium	$99,847	1232	$1.01	11	887	$112.56
L,M.N	Storage	Large	$405,883	9744	$0.52	87	7,016	$57.85

a. Average density used is 112 lbs/ft^3.

13.4 Cost Summaries

Cost summaries for the LLW/LLMW, alpha-LLW/LLMW, and TRUW storage cost modules are shown in Table 13-3. A histogram of the costs is shown in Figure 13-1.

Table 13-3. PLCC estimate summary for LLW/LLMW, alpha-LLW/LLMW, and TRUW facility (cost modules L, M, and N).

Cost component	Cost Items		Cost ($ x 1000) Small	Medium	Large
1.0	**Studies and bench scale test costs**				
	1.1 Manpower costs during research		$0	$0	$0
	1.2 Equipment costs		$0	$0	$0
	1.3 Installation costs		$0	$0	$0
	1.4 Prog. management before title I	(10 % of 1.1 through 1.3)	$0	$0	$0
	1.5 Contingency	(25 % of 1.1 through 1.4)	$0	$0	$0
	Subtotal 1.0		$0	$0	$0
2.0	**Demonstration costs**				
	2.1 Manpower costs during demonstration		$0	$0	$0
	2.2 Design cost	(30 % of 2.5)	$0	$0	$0
	2.3 Inspection cost	(7 % of 2.5)	$0	$0	$0
	2.4 Project management	(10 % of 2.5)	$0	$0	$0
	2.5 Construction cost				
	2.5.1 Building structure costs		$0	$0	$0
	2.5.2 Equipment costs		$0	$0	$0
	2.5.3 Indirect	(29 % of 2.5.1 & 2.5.2)	$0	$0	$0
	Subtotal of 2.5		$0	$0	$0
	2.6 Construction management costs	(17.1 % of 2.5)	$0	$0	$0
	2.7 Management Reserve	(10 % of 2.5)	$0	$0	$0
	2.8 Contingency	(25 % of 2.1 through 2.7)	$0	$0	$0
	Subtotal 2.0		$0	$0	$0
3.0	**Production facility construction costs**				
	3.1 Design cost	ALLOWANCE	$250	$250	$1,000
	3.2 Inspection cost	(7 % of 3.4)	$1,031	$1,975	$9,155
	3.3 Project management	(10 % of 3.4)	$1,473	$2,821	$13,078
	3.4 Construction cost				
	3.4.1 Building structure costs		$11,213	$21,478	$100,618
	3.4.2 Equipment costs		$209	$389	$763
	3.4.3 Indirect	(29 % of 3.4.1 & 3.4.2)	$3,312	$6,341	$29,400
	Subtotal of 3.4		$14,734	$28,208	$130,781
	3.5 Construction management	(17.1 % of 3.4)	$2,520	$4,824	$22,364
	3.6 Management Reserve	(10 % of 3.4)	$1,473	$2,821	$13,078
	3.7 Contingency	(25 % of 3.1 through 3.5)	$5,002	$9,520	$44,095
	Subtotal 3.0		$26,483	$50,419	$233,551
4.0	**Operations Budget Funded Activities (See Sect. 7)**				
	4.1 Conceptual design	(1.5 % of 3.0)	$397	$756	$3,503
	4.2 Safety assurance	(1 % of 3.0)	$265	$504	$2,336
	4.3 NEPA permitting ($ 6 Mill for EIS, $1 Mill for EA)		$0	$0	$0
	4.4 Preparation for operations	(100 % of 5.0)	$804	$1,384	$2,790
	4.5 Project Management	(10 % of 4.1 through 4.4)	$147	$264	$863
	Subtotal 4.0		$1,613	$2,908	$9,492
	Total Initial Cost (1.0,2.0,3.0 & 4.0)		$28,096	$53,327	$243,043
5.0	**Operating and maintainence costs**				
	5.1 Annual operating costs		$560	$980	$1,820
	5.2 Annual utility costs		$2	$4	$8
	5.3 Annual material costs		$35	$70	$320
	5.4 Annual maintainence costs		$46	$53	$84
	5.5 Contingency	(25 % of 5.1 through 5.4)	$161	$277	$558
	Subtotal 5.0		$804	$1,384	$2,790
	Total 20 year O & M cost (20 times Subtotal 5.0)		$16,080	$27,680	$55,800
6.0	Decontamination & Decommissioning		$7,680	$18,840	$107,040
7.0	**ROM Life cycle costs (20 years operation)**		$51,856	$99,847	$405,883

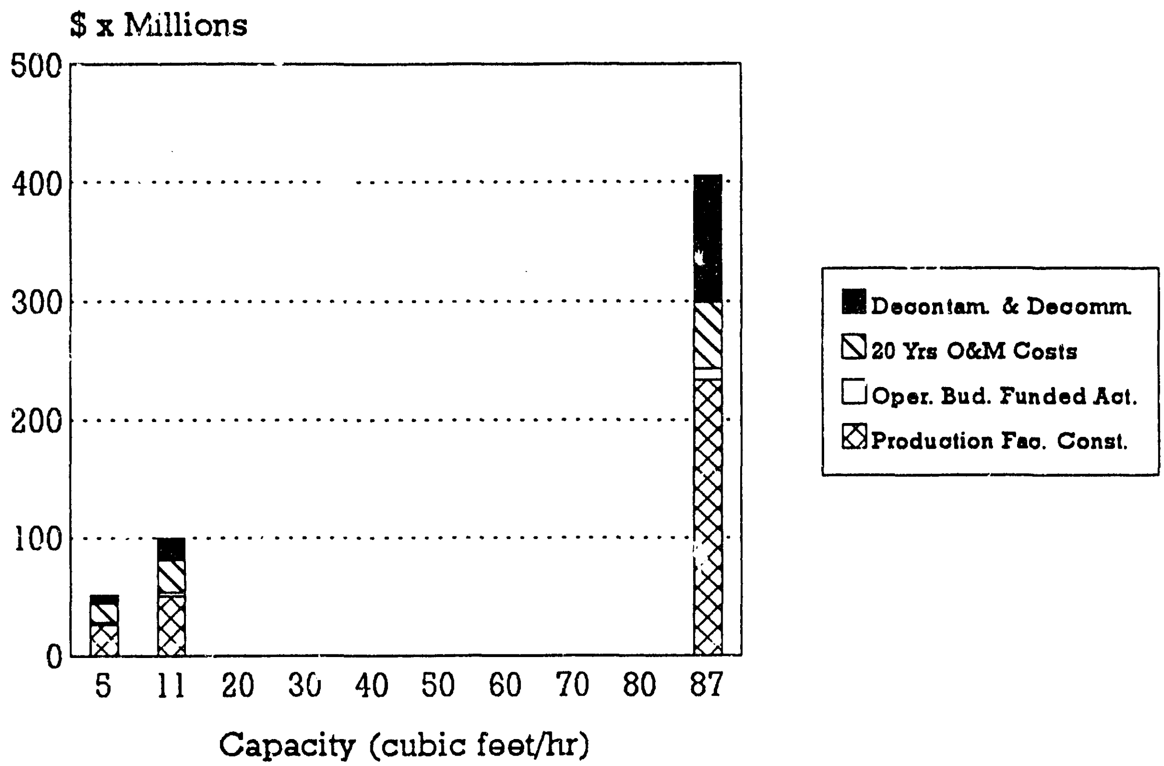


Figure 13-1. Cost versus capacity histogram for LLW, LLMW, alpha-LLW/LLMW, and TRUW storage facilities (cost modules L, M, and N).

14. DISPOSAL FRONT-END SUPPORT FACILITY (COST MODULE O)

14.1 Basic Information

The disposal front-end support facility is used in conjunction with the disposal facilities (cost modules P and Q) and provides all the necessary common functions for disposal of alpha-LLW/LLMW and LLW/LLMW. The disposal front-end support facility unit operations include truck loading/unloading areas, administrative offices, analytical laboratory facilities, and truck inspection and washdowns. Unit operations are given in Figure 14-1. In addition to small, medium, and large size facility, a minimum size disposal facility is estimated. The minimum size capacity is provided as a lower bound for the smallest economical engineering designed facility.

14.2 Technical Bases and Assumptions

14.2.1 Functional and Operational Description

All containers that arrive at the disposal front-end support facility are assumed to be 55-gal drums. The drums arrive in a transport vehicle, are unloaded using a forklift or overhead bridge crane, and placed in a staging area. The containers are visually examined, labeled, logged, recorded, and sent to inspection and assay. At the inspection/assay unit, the category of the received waste is verified against the results obtained from the back-end treatment and/or storage facilities. After inspection, the drums are sent to the disposal facility (modules P or Q).

The technical bases and requirements for all disposal front-end support facilities are also the same as those outlined in Sections 2, 3, and 10, and Appendix A, except that the assay/inspection and certification functions are for verification purposes only.

14.2.2 Facility Integration

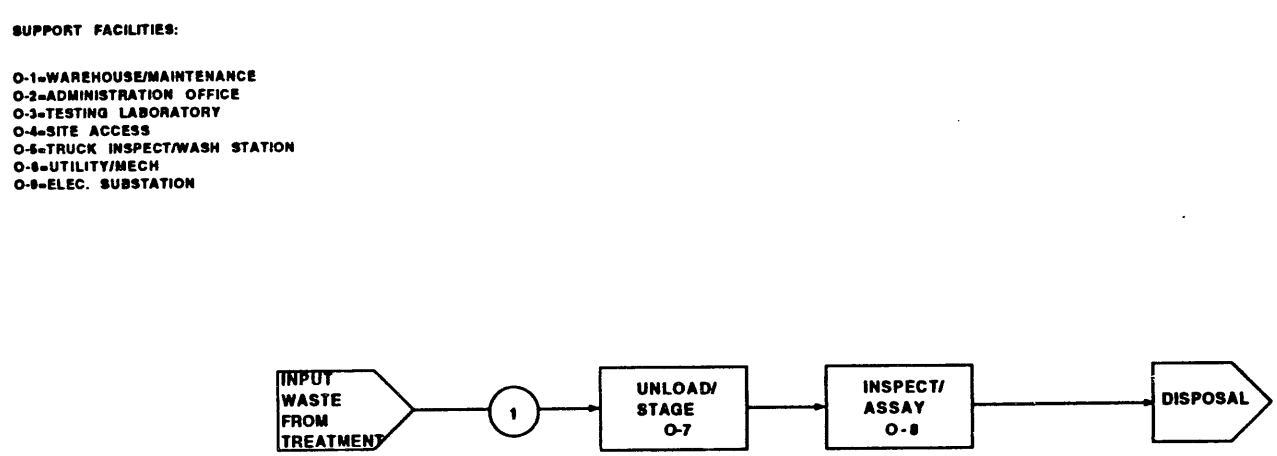
Facility input includes trucks containing packaged waste from either the treatment or storage facilities. O&M consumables including personal protective equipment must be purchased. Facility output consists of drums that are transferred to the disposal facilities.

14.3 Cost Bases, Assumptions, and Assessments

General cost bases and assumptions are given in Appendix A. Facility-specific items are discussed below.

- Major equipment and facility cost items for this facility are based on data obtained from the Illinois LLW Disposal Facility.[7]

- Estimated operating staff are shown in Table 14-1. Staffing levels were estimated based on the number of personnel required to support approximately 10 separate support functions as identified in Appendix A. Staffing levels also based on the data obtained from the Illinois LLW Disposal Facility (License Agreement, 1991).[7]



Node	1
	Input Waste CF/hr
SMALL	14.51
MEDIUM	45.90
LARGE	121.00

Figure 14-1. Disposal front-end facility process facility functional diagram.

Table 14-1. Estimated operating staff for disposal front-end facility (cost module 0).

Unit operation	Description	Minimum (FTE)	Small (FTE)	Medium (FTE)	Large (FTE)
O-1	Warehouse and maintenance	1	3	3	6
O-2	Administration/technical	5	24	35	50
O-3	Testing laboratory	2	7	10	15
O-4	Site access	4	12	18	31
O-5	Truck inspection and washout	2	6	6	12
O-6	Unload/stage	1	6	9	12
O-7	Inspect and assay	3	4	6	12
O-8	Utility and mechanical	1	2	2	3
O-9	Electrical substation	0	0	0	0
	Total	19	64	89	141

- A $1 million allowance is made for the analytical instruments and components needed for a mixed-waste laboratory. Mixed-waste laboratory vendors have been consulted to ensure that the laboratory allowance is adequate. The crane cost is estimated based on vendor quotes.

- Minimum, small, medium, and large facility capacities and unit costs are shown in Table 14-2.

Table 14-2. Capacities and cost information for disposal front-end facility (cost module 0).[a]

Module	Module Description	Facility	Life Cycle Cost ($x1000)	Capacity (lbs/hr)	Unit Cost ($/lb)	Capacity (ft3/hr)	Cap(Tot Vol) (ft3x1000)	Unit Cost ($/ft3)
O	Disposal Support	Minimum	$159,705	224	$8.84	2	161	$990.23
O	Disposal Support	Small	$328,104	1624	$2.51	14.5	1,169	$280.60
O	Disposal Support	Medium	$441,571	5152	$1.06	46	3,709	$119.04
O	Disposal Support	Large	$697,007	13552	$0.64	121	9,757	$71.43

a. Average density used is 112 lbs/ft^3.

14.4 Cost Summaries

Cost summaries for the disposal front-end support facility is shown in Table 14-3. A histogram for cost versus capacity is given in Figure 14-2.

Table 14-3. PLCC estimate summary for disposal common support facility (cost module 0).

Cost component	Cost Items		Cost ($ x 1000) Minimum	Small	Medium	Large
1.0	**Studies and bench scale test costs**					
	1.1 Manpower costs during research		$0	$0	$0	$0
	1.2 Equipment costs		$0	$0	$0	$0
	1.3 Installation costs		$0	$0	$0	$0
	1.4 Project management before title I	(10 % of 1.1 through 1.3)	$0	$0	$0	$0
	1.5 Contingency	(25 % of 1.1 through 1.4)	$0	$0	$0	$0
	Subtotal 1.0		$0	$0	$0	$0
2.0	**Demonstration costs**					
	2.1 Manpower costs during demonstration		$0	$0	$0	$0
	2.2 Design cost	(30 % of 2.5)	$0	$0	$0	$0
	2.3 Inspection cost	(7 % of 2.5)	$0	$0	$0	$0
	2.4 Project management	(10 % of 2.5)	$0	$0	$0	$0
	2.5 Construction cost					
	2.5.1 Building structure costs		$0	$0	$0	$0
	2.5.2 Equipment costs		$0	$0	$0	$0
	2.5.3 Indirect	(29 % of 2.5.1 & 2.5.2)	$0	$0	$0	$0
	Subtotal of 2.5		$0	$0	$0	$0
	2.6 Construction management costs	(17.1 % of 2.5)	$0	$0	$0	$0
	2.7 Management Reserve	(10 % of 2.5)	$0	$0	$0	$0
	2.8 Contingency	(25 % of 2.1 through 2.7)	$0	$0	$0	$0
	Subtotal 2.0		$0	$0	$0	$0
3.0	**Production facility construction costs**					
	3.1 Design cost	(18 % of 3.4)	$3,659	$3,659	$4,567	$7,626
	3.2 Inspection cost	(7 % of 3.4)	$1,423	$1,423	$1,776	$2,966
	3.3 Project management	(10 % of 3.4)	$2,033	$2,033	$2,537	$4,237
	3.4 Construction cost					
	3.4.1 Building structure costs		$9,872	$9,872	$11,978	$21,439
	3.4.2 Equipment costs		$5,888	$5,888	$7,689	$11,402
	3.4.3 Indirect	(29 % of 3.4.1 & 3.4.2)	$4,570	$4,570	$5,703	$9,524
	Subtotal of 3.4		$20,330	$20,330	$25,370	$42,365
	3.5 Construction management	(17.1 % of 3.4)	$3,476	$3,476	$4,338	$7,244
	3.6 Management Reserve	(10 % of 3.4)	$2,033	$2,033	$2,537	$4,237
	3.7 Contingency	(25 % of 3.1 through 3.5)	$7,730	$7,730	$9,647	$16,110
	Subtotal 3.0		$40,684	$40,684	$50,772	$84,785
4.0	**Operations Budget Funded Activities (See Sect. 7)**					
	4.1 Conceptual design	(1.5 % of 3.0)	$610	$610	$762	$1,272
	4.2 Safety assurance	(1 % of 3.0)	$407	$407	$508	$848
	4.3 NEPA permitting ($ 6 Mill for EIS, $1 Mill for EA)		$6,000	$6,000	$6,000	$6,000
	4.4 Preparation for operations	(100 % of 5.0)	$5,221	$13,202	$18,066	$28,470
	4.5 Project Management	(10 % of 4.1 through 4.4)	$1,224	$2,022	$2,534	$3,659
	Subtotal 4.0		$13,462	$22,241	$27,870	$40,249
	Total Initial Cost (1.0,2.0,3.0 & 4.0)		$54,146	$62,925	$78,642	$125,034
5.0	**Operating and maintainence costs**					
	5.1 Annual operating costs		$2,660	$8,960	$12,460	$19,740
	5.2 Annual utility costs		$1	$6	$19	$40
	5.3 Annual material costs		$282	$362	$362	$605
	5.4 Annual maintainence costs'		$1,234	$1,234	$1,612	$2,382
	5.5 Contingency	(25 % of 5.1 through 5.4)	$1,044	$2,640	$3,613	$5,694
	Subtotal 5.0		$5,221	$13,202	$18,066	$28,470
	Total 20 year O & M cost (20 times Subtotal 5.0)		$104,420	$264,040	$361,320	$569,400
6.0	Decontamination & Decommissioning		$1,139	$1,139	$1,609	$2,573
7.0	**ROM Life cycle costs (20 years operation)**		$159,705	$328,104	$441,571	$697,007

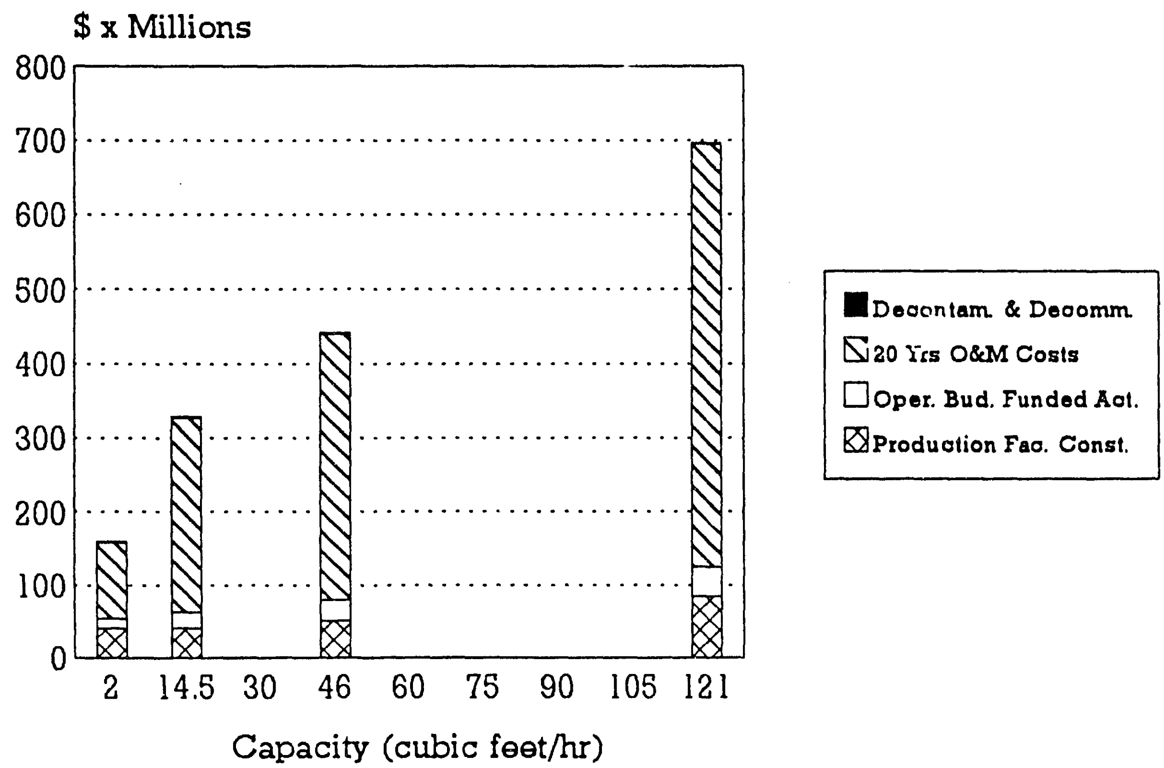


Figure 14-2. Cost versus capacity histogram for disposal front-end facility (cost module 0).

15. ENGINEERED DISPOSAL FACILITIES (COST MODULES P AND Q)

15.1 Basic Information

The engineered disposal facilities should be used in conjunction with the front-end support facility (see cost module O) or as an addition to existing facilities where similar functions are already available. The facility consists of engineered disposal units that are based on the Illinois LLW disposal facility[b] design, shown in Figure 5-1, which uses an earth mound concrete cell concept.[7] Engineered disposal facilities for radioactive (non-RCRA) waste and mixed (RCRA) waste are essentially the same with the exception that a mixed waste disposal unit has a double leachate collection system in compliance with the RCRA requirements. Cost module P is applicable to non-RCRA waste (LLW and alpha-LLW) while cost module Q is for RCRA mixed waste (LLMW and alpha-LLMW). Unit operations for both types of facilities are given in Figure 15-2.

The unit operations include receiving the inspected drums from the front-end facility, placing the drums into concrete canisters, and constructing the disposal units that will house incoming concrete waste canisters. Disposal unit construction includes foundation and monitoring system, concrete vaults, and earth-mound covers. Construction of the facilities is intended to be a continuous process concurrent with the placement of the canisters. Both disposal facilities (cost modules P and Q) are designed for long-term endurance and monitoring. In addition, the mixed waste disposal facility (module Q) is designed to meet RCRA standards and is equipped with a secondary leachate collection system.

15.2 Technical Bases and Assumptions

15.2.1 Functional and Operational Description

The drums received from the disposal front-end support facility are packaged into concrete canisters that are then sealed with grout. The canisters are transported to the disposal units for placement. Each disposal unit is comprised of a double row of concrete cells with an access aisle between the two rows. Concrete canisters that arrive from the packaging area are placed in a cell via crane or forklift in the access aisle and stacked three canisters high. Once the cell is full, it is backfilled with a sandy material and sealed with concrete. A concrete cover is concurrently constructed over the sealed cells.

The cells are capped with an earth mound layer that is engineered to withstand long-term environmental and weathering effects. The layered cap consists of sandy drain layers placed directly over the cells, an impervious clay layer, a high density polyethylene (HDPE) liner, and another drain layer to deter seepage into the cells. The top layer consists of either subsoil and vegetative material or subsoil, bedding, and riprap. The monitoring system includes sensors that will detect any leakage from the cells.

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b. Information obtained from *Illinois Low-Level Radioactive Waste Disposal Facility*, Executive Summary.

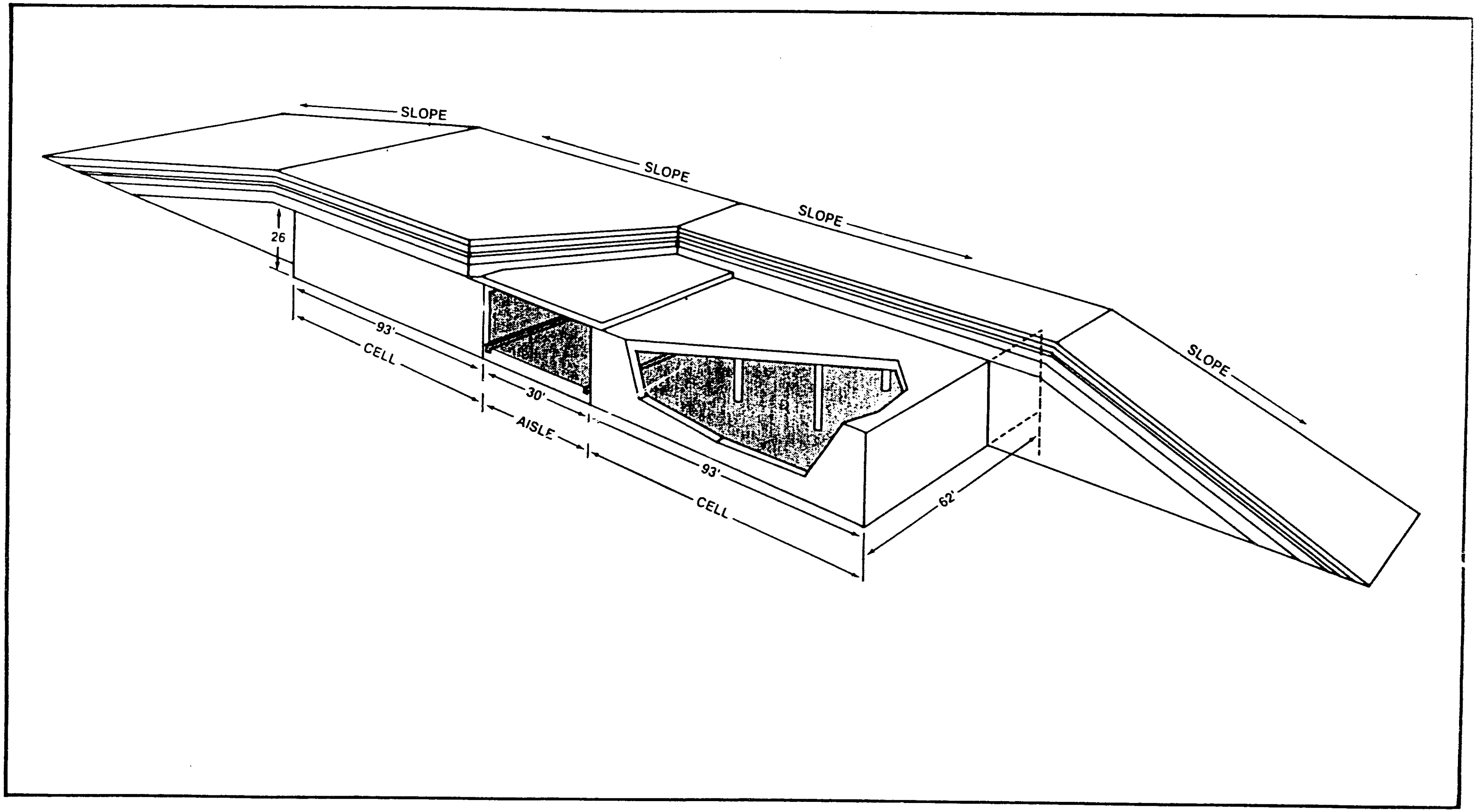
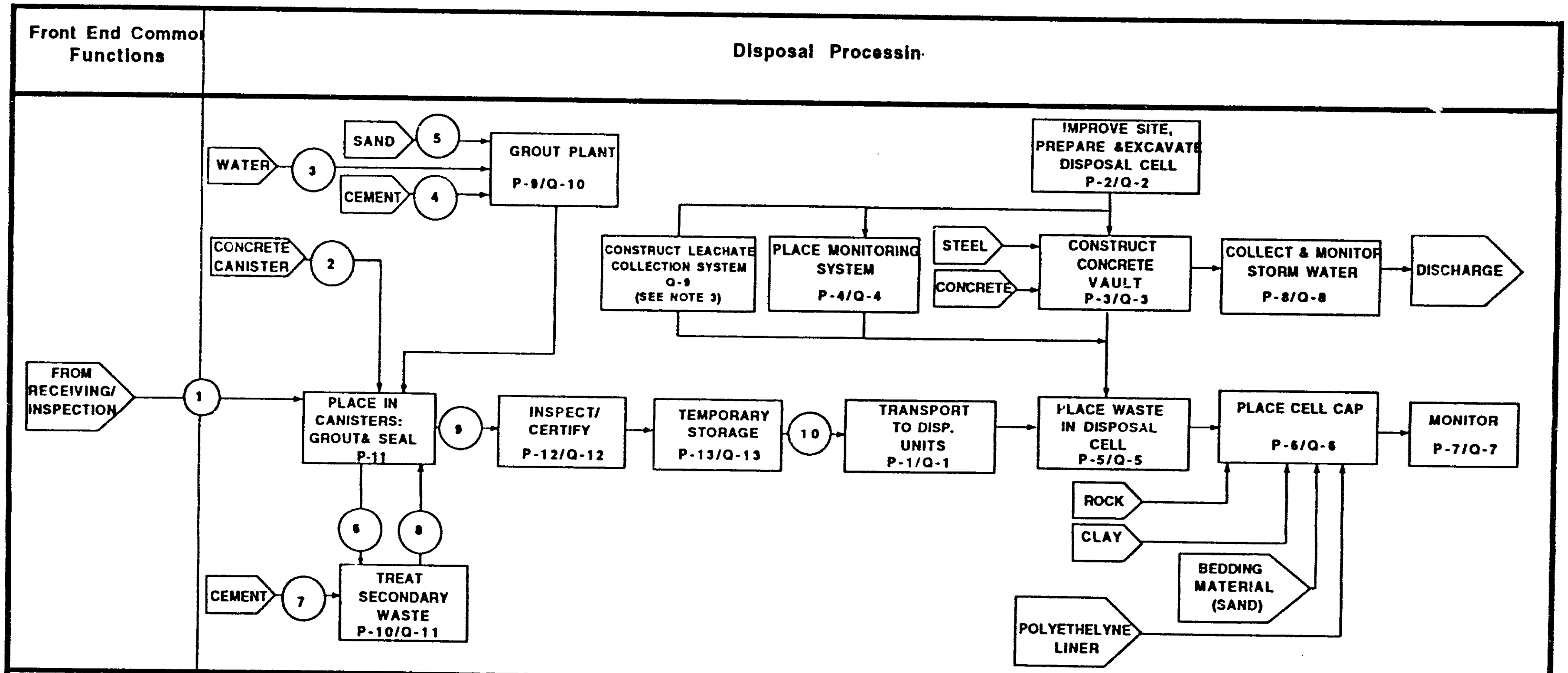


Figure 15-1. Disposal unit cutaway based on Illinois LLW disposal facility concept.



NOTES:
1.) CANISTER DELIVERY RATE AND PLACEMENT IS 0.25/HR,6.80/HR, & 2.11/HR FOR SMALL, MEDIUM, AND LARGE, RESPECTIVELY
2.) EXCAVATION, VAULT CONSTRUCTION, MONITOR SYSTEM INSTALLATION AND CELL COVER PLACEMENT ARE INCLUDED UNDER INITIAL CONSTRUCTION.
3.) LEACHATE COLLECTION SYSTEM IS REQUIRED ONLY FOR A MIXED WASTE DISPOSAL FACILITY (MODULE Q).

FLOWRATE CF/HR	Node / Facility Size	1 Input Cf/hr	2 Concrete Canister Canister/hr	3 Water Gal/hr	4 Cement Cf/hr	5 Sand Cf/hr	6 Secondary Waste Cf/hr	7 Cement for Secondary Cf/hr	8 Output Secondary Cf/hr	9 Output to Disposal Canister/hr	10 Disposal Canister/hr
	MINIMUM	2	0.03	1.5	0.12	1	0.02	0.01	0.04	0.04	0.04
	SMALL	14.51	0.25	10.28	0.94	7.83	0.15	0.08	0.29	14.80	14.80
	MEDIUM	45.90	0.79	32.51	2.98	24.75	0.46	0.32	0.92	46.82	46.82
	LARGE	121.00	2.07	85.69	7.86	65.25	1.21	0.70	2.42	123.42	123.42

Figure 15-2. Engineered disposal facilities process functional diagram.

The D&D includes facility demolition and the disposal unit maintenance. Disposal unit maintenance is planned in two stages, each with two substages: short-term maintenance comprised of closure and post-closure periods and long-term maintenance, which consists of active institutional care and passive institutional care.

Closure activities take place during the first 2 years after the facility ceases to accept waste. Closure includes decontamination of the facilities, initial demolition of buildings, site development, closure of the cells, site remediation, and monitoring of the cell performance and groundwater. Years 1 through 10 after the facility ceases to accept waste are designated as the post-closure period. During this period monitoring of the groundwater and cell performance will continue, as well as site remediation and development.

Active institutional care is planned for 11 to 100 years following the post-closure period. During this stage, any buildings not previously demolished are torn down and all site services are removed, in addition to ongoing monitoring activities from post-closure. The last stage, passive institutional care, extends from 101 to 300 years after the facility ceases to accept waste. Passive institutional care includes closure of the center aisles of the vaults, completion of the earth mound caps and site grading, removal of the retention ponds and retaining walls, and installation of passive drains. Long-term maintenance is discontinued after 300 years.

15.2.2 Facility Integration

Input interfaces include waste drums delivered from the front-end facility (refer to cost module O). O&M consumables including empty concrete canisters, grout, sand, and personnel protective equipment must be purchased. The facility is intended for permanent disposal of the waste and designed for long-term maintenance and monitoring as described above. No facility output is anticipated for a lengthy time period (at least 300 years).

15.3 Cost Bases, Assumptions, and Assessments

General cost bases and assumptions are given in Appendix A. Facility-specific items are discussed below.

- Major equipment capital cost items are a forklift and a crane for placement of the drums into canisters and placement of filled canisters into the concrete cells. Costs for these items are based on vendor quotes.

- Estimated operating staff are shown in Table 15-1. This staffing is based on data obtained from the Illinois LLW Disposal Facility[7] and a DOE conceptual design report (DOE/LLW-60T, 1987).[8]

- Construction of the disposal units is a major cost item. A preconceptual design of one disposal unit that applies to all facilities, including concrete cells and cover design, was developed based on the design of the Illinois LLW Disposal Facility. A unit cost per cell was developed based on data from the Illinois facility, and an estimate was generated according to the rate of incoming waste and number of cells required for each small, medium, and large facility.

Table 15-1. Estimated operating staff for disposal facility (cost modules P and Q).

Unit operation	Description	Minimum (FTE)	Small (FTE)	Medium (FTE)	Large (FTE)
P-1/Q-1	Transport to disposal units	1	2	3	3
P-2/Q-2	Prepare and excavate disposal cell	0	0	0	0
P-3/Q-3	Construct concrete vault	0	0	0	0
P-4/Q-4	Place monitoring system	0	0	0	0
P-5/Q-5	Place waste in disposal cell	2	9	9	18
P-6/Q-6	Place cell cap	0	0	0	0
P-7/Q-7	Monitor	1	2	2	4
P-8/Q-8	Collect and monitor storm water	1	2	2	4
Q-9	Construct leachate collect system	0	0	0	0
P-9/Q-10	Grout plant	5	8	8	16
P-10/Q-11	Treat secondary waste	1	2	3	4
P-11/Q-12	Place in canister—grout and seal	4	15	15	30
P-12/Q-13	Inspect certify	1	4	4	8
P-13/Q-14	Temporary storage	0	0	0	0
	Total	16	41	61	90

- Minimum small, medium, and large facility capacities and unit costs are shown in Table 15-2. Minimum size capacity is provided as a lower bound for the smallest economical engineering designed facility.
- Estimates are based on a disposal facility in accordance with NRC criteria, but a NRC license is not assumed.

Table 15-2. Capacities and cost information for engineering disposal facility (cost module P and Q).

Module	Module Description	Facility	Life Cycle Cost ($x1000)	Capacity (lbs/hr)	Unit Cost ($/lb)	Capacity (ft3/hr)	Cap(Tot Vol) (ft3x1000)	Unit Cost ($/ft3)
P	Engr. Disposal	Minimum	$327,121	224	$18.11	2	161	$2,028.28
P	Engr. Disposal	Small	$491,233	1624	$3.75	14.5	1,169	$420.12
P	Engr. Disposal	Medium	$886,506	5152	$2.13	46	3,709	$238.99
P	Engr. Disposal	Large	$2,146,360	13552	$1.96	121	9,757	$219.97
Q-RCRA	Engr. Disposal	Minimum	$334,328	224	$18.51	2	161	$2,072.97
Q-RCRA	Engr. Disposal	Small	$495,628	1624	$3.78	14.5	1,169	$423.87
Q-RCRA	Engr. Disposal	Medium	$897,026	5152	$2.16	46	3,709	$241.82
Q-RCRA	Engr. Disposal	Large	$2,168,827	13552	$1.98	121	9,757	$222.27

15.4 Cost Summaries

General cost summaries for the engineered disposal facilities are shown in Tables 15-3 and 15-4. Histograms for cost versus capacity are given in Figures 15-3 and 15-4.

Table 15-3. PLCC estimate summary for alpha-LLW and LLW engineered disposal facility (cost module P).

Cost component	Cost Items		Cost ($ x 1000) Minimum	Small	Medium	Large
1.0	Studies and bench scale test costs					
	1.1 Manpower costs during research		$0"	$0	$0	$0
	1.2 Equipment costs		$0	$0	$0	$0
	1.3 Installation costs		$0	$0	$0	$0
	1.4 Project management before title I	(10 % of 1.1 through 1.3)	$0	$0	$0	$0
	1.5 Contingency	(25 % of 1.1 through 1.4)	$0	$0	$0	$0
	Subtotal 1.0		$0	$0	$0	$0
2.0	Demonstration costs					
	2.1 Manpower costs during demonstration		$0	$0	$0	$0
	2.2 Design cost	(30 % of 2.5)	$0	$0	$0	$0
	2.3 Inspection cost	(7 % of 2.5)	$0	$0	$0	$0
	2.4 Project management	(10 % of 2.5)	$0	$0	$0	$0
	2.5 Construction cost					
	2.5.1 Building structure costs		$0	$0	$0	$0
	2.5.2 Equipment costs		$0	$0	$0	$0
	2.5.3 Indirect	(29 % of 2.5.1 & 2.5.2)	$0	$0	$0	$0
	Subtotal of 2.5		$0	$0	$0	$0
	2.6 Construction management costs	(17.1 % of 2.5)	$0	$0	$0	$0
	2.7 Management Reserve	(10 % of 2.5)	$0	$0	$0	$0
	2.8 Contingency	(25 % of 2.1 through 2.7)	$0	$0	$0	$0
	Subtotal 2.0		$0	$0	$0	$0
3.0	Production facility construction costs					
	3.1 Design cost	ALLOWANCE	$3,000	$3,000	$3,500	$10,000
	3.2 Inspection cost	(7 % of 3.4)	$7,083	$7,192	$16,988	$46,614
	3.3 Project management	(10 % of 3.4)	$10,118	$10,275	$24,269	$66,592
	3.4 Construction cost					
	3.4.1 Building structure costs		$74,162	$75,373	$182,854	$507,737
	3.4.2 Equipment costs		$4,275	$4,275	$5,279	$8,476
	3.4.3 Indirect	(29 % of 3.4.1 & 3.4.2)	$22,747	$23,098	$54,559	$149,702
	Subtotal of 3.4		$101,184	$102,746	$242,692	$665,915
	3.5 Construction management	(17.1 % of 3.4)	$17,302	$17,570	$41,500	$113,871
	3.6 Management Reserve	(10 % of 3.4)	$10,118	$10,275	$24,269	$66,592
	3.7 Contingency	(25 % of 3.1 through 3.5)	$34,672	$35,196	$82,237	$225,748
	Subtotal 3.0		$183,477	$186,254	$435,455	$1,195,332
4.0	Operations Budget Funded Activities (See Sect. 7)					
	4.1 Conceptual design	(1.5 % of 3.0)	$2,752	$2,794	$6,532	$17,930
	4.2 Safety assurance	(1 % of 3.0)	$1,835	$1,863	$4,355	$11,953
	4.3 NEPA permitting ($ 6 Mill for EIS, $1 Mill for EA)		$6,000	$6,000	$6,000	$6,000
	4.4 Preparation for operations	(100 % of 5.0)	$4,739	$11,691	$17,155	$36,809
	4.5 Project Management	(10 % of 4.1 through 4.4)	$1,533	$2,235	$3,404	$7,269
	Subtotal 4.0		$16,859	$24,583	$37,446	$79,961
	Total Initial Cost (1.0,2.0,3.0 & 4.0)		$200,336	$210,837	$472,901	$1,275,293
5.0	Operating and maintainence costs					
	5.1 Annual operating costs		$2,240	$6,160	$6,440	$12,180
	5.2 Annual utility costs		$3	$19	$59	$156
	5.3 Annual material costs		$622	$2,248	$6,089	$15,280
	5.4 Annual maintainence costs		$926	$926	$1,136	$1,831
	5.5 Contingency	(25 % of 5.1 through 5.4)	$948	$2,338	$3,431	$7,362
	Subtotal 5.0		$4,739	$11,691	$17,155	$36,809
	Total 20 year O & M cost (20 times Subtotal 5.0)		$94,780	$233,820	$343,100	$736,180
6.0	Decontamination & Decommissioning		$32,005	$46,576	$70,505	$134,887
7.0	ROM Life cycle costs (20 years operation)		$327,121	$491,233	$886,506	$2,146,360

Table 15-4. PLCC estimate summary for alpha-LLMW engineered disposal facility (cost module Q).

Cost component		Cost Items	Cost ($ x 1000) Minimum	Small	Medium	Large
1.0	Studies and bench scale test costs					
	1.1 Manpower costs during research		$0	$0	$0	$0
	1.2 Equipment costs		$0	$0	$0	$0
	1.3 Installation costs		$0	$0	$0	$0
	1.4 Project management before title I	(10 % of 1.1 through 1.3)	$0	$0	$0	$0
	1.5 Contingency	(25 % of 1.1 through 1.4)	$0	$0	$0	$0
	Subtotal 1.0		$0	$0	$0	$0
2.0	Demonstration costs					
	2.1 Manpower costs during demonstration		$0	$0	$0	$0
	2.2 Design cost	(30 % of 2.5)	$0	$0	$0	$0
	2.3 Inspection cost	(7 % of 2.5)	$0	$0	$0	$0
	2.4 Project management	(10 % of 2.5)	$0	$0	$0	$0
	2.5 Construction cost					
	2.5.1 Building structure costs		$0	$0	$0	$0
	2.5.2 Equipment costs		$0	$0	$0	$0
	2.5.3 Indirect	(29 % of 2.5.1 & 2.5.2)	$0	$0	$0	$0
	Subtotal of 2.5		$0	$0	$0	$0
	2.6 Construction management costs	(17.1 % of 2.5)	$0	$0	$0	$0
	2.7 Management Reserve	(10 % of 2.5)	$0	$0	$0	$0
	2.8 Contingency	(25 % of 2.1 through 2.7)	$0	$0	$0	$0
	Subtotal 2.0		$0	$0	$0	$0
3.0	Production facility construction costs					
	3.1 Design cost	ALLOWANCE	$3,000	$3,000	$3,500	$10,000
	3.2 Inspection cost	(7 % of 3.4)	$7,378	$7,378	$17,409	$47,504
	3.3 Project management	(10 % of 3.4)	$10,540	$10,540	$24,870	$67,863
	3.4 Construction cost					
	3.4.1 Building structure costs		$77,523	$77,523	$187,604	$517,737
	3.4.2 Equipment costs		$4,181	$4,181	$5,185	$8,332
	3.4.3 Indirect	(29 % of 3.4.1 & 3.4.2)	$23,694	$23,694	$55,909	$152,560
	Subtotal of 3.4		$105,398	$105,398	$248,698	$678,629
	3.5 Construction management	(17.1 % of 3.4)	$18,023	$18,023	$42,527	$116,046
	3.6 Management Reserve	(10 % of 3.4)	$10,540	$10,540	$24,870	$67,863
	3.7 Contingency	(25 % of 3.1 through 3.5)	$36,085	$36,085	$84,251	$230,011
	Subtotal 3.0		$190,964	$190,964	$446,125	$1,217,916
4.0	Operations Budget Funded Activities (See Sect. 7)					
	4.1 Conceptual design	(1.5 % of 3.0)	$2,864	$2,864	$6,692	$18,269
	4.2 Safety assurance	(1 % of 3.0)	$1,910	$1,910	$4,461	$12,179
	4.3 NEPA permitting ($ 6 Mill for EIS, $1 Mill for EA)		$6,000	$6,000	$6,000	$6,000
	4.4 Preparation for operations	(100 % of 5.0)	$4,716	$11,670	$17,134	$36,774
	4.5 Project Management	(10 % of 4.1 through 4.4)	$1,549	$2,244	$3,429	$7,322
	Subtotal 4.0		$17,039	$24,688	$37,716	$80,544
	Total Initial Cost (1.0,2.0,3.0 & 4.0)		$208,003	$215,652	$483,841	$1,298,460
5.0	Operating and maintainence costs					
	5.1 Annual operating costs		$2,240	$6,160	$6,440	$12,180
	5.2 Annual utility costs		$2	$19	$59	$156
	5.3 Annual material costs		$622	$2,248	$6,089	$15,280
	5.4 Annual maintainence costs		$909	$909	$1,119	$1,803
	5.5 Contingency	(25 % of 5.1 through 5.4)	$943	$2,334	$3,427	$7,355
	Subtotal 5.0		$4,716	$11,670	$17,134	$36,774
	Total 20 year O & M cost (20 times Subtotal 5.0)		$94,320	$233,400	$342,680	$735,480
6.0	Decontamination & Decommissioning		$32,005	$46,576	$70,505	$134,887
7.0	ROM Life cycle costs (20 years operation)		$334,328	$495,628	$897,026	$2,168,827

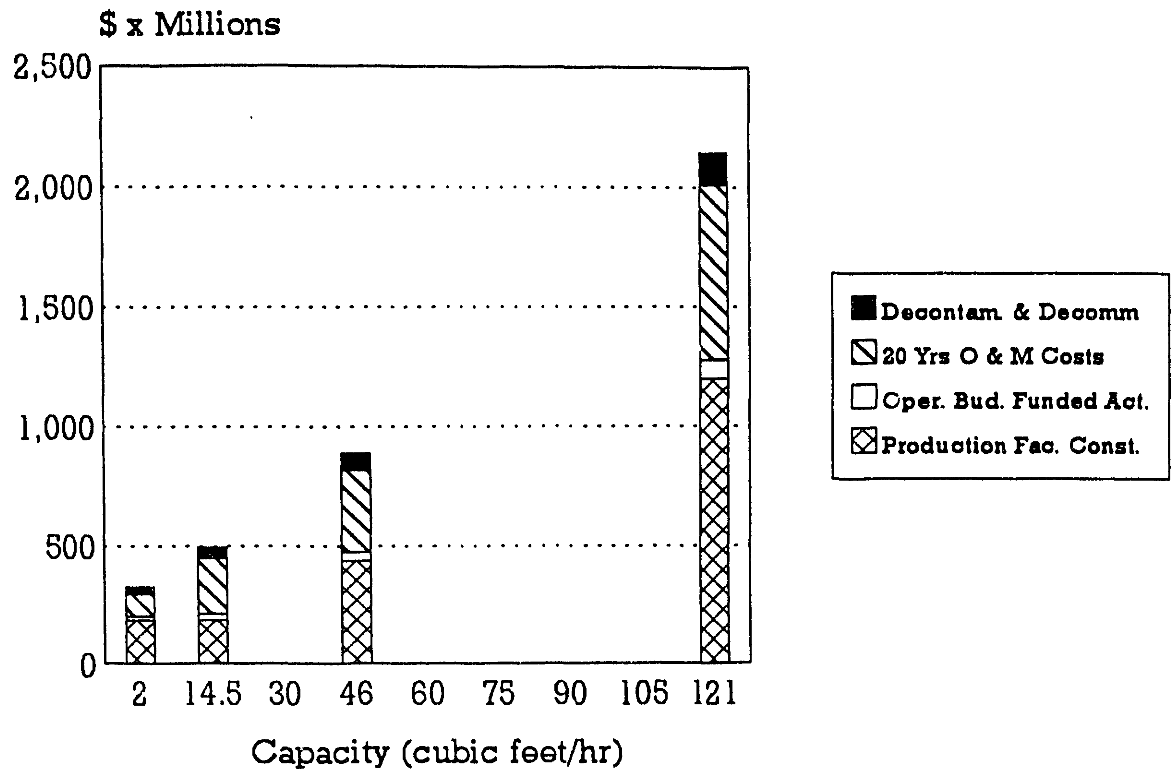


Figure 15-3. Cost versus capacity histogram for LLW and alpha-LLW engineered disposal facility (cost module P).

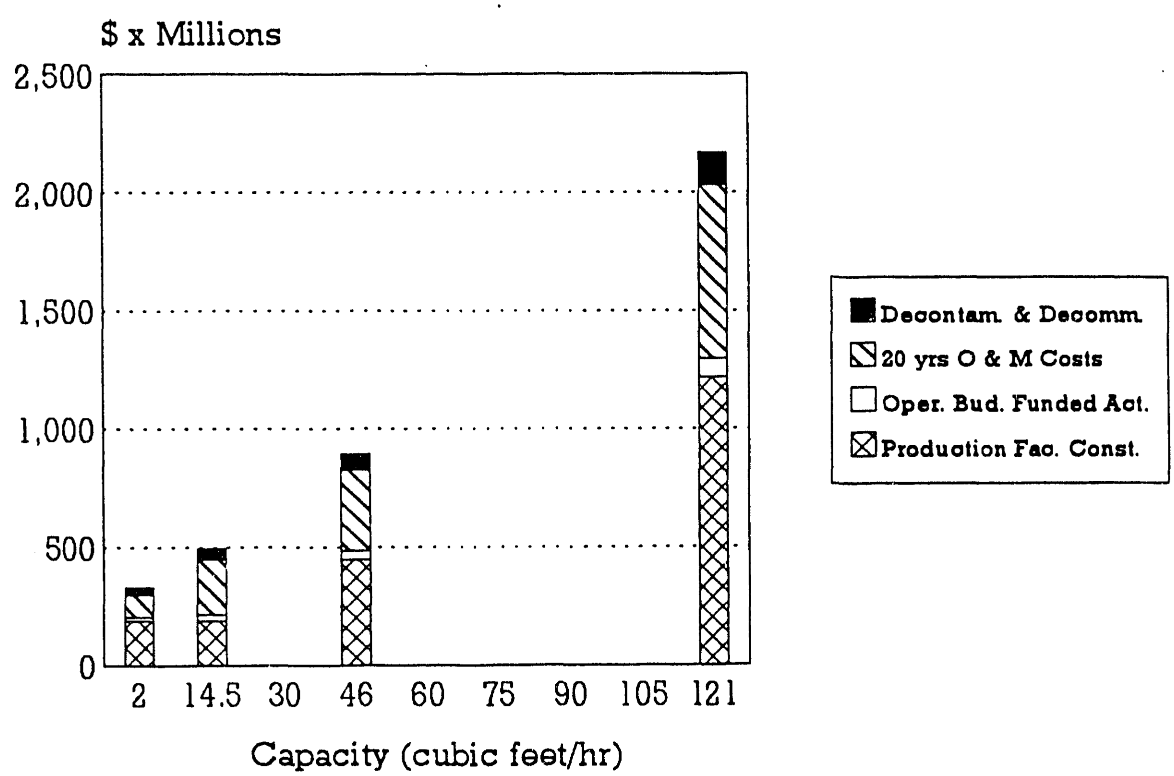


Figure 15-4. Cost versus capacity histogram for LLW and alpha-LLW engineered disposal facility (cost module Q).

16. SHALLOW LAND DISPOSAL FACILITY (COST MODULE R)

16.1 Basic Information

This facility consists of a shallow land trench disposal (without engineered features). The cost for a shallow land disposal consists of three components: front-end facility capital cost, disposal O&M cost, and site closure cost. Front-end facility capital cost is shown in Section 14 (cost module O), and should be added only if a new disposal facility is under consideration. Disposal of contact handled wastes at the INEL have historically ranged from $50/$ft^3$ (100,000 ft^3/yr) to 150/ft^3 (25,000 ft^3/year)[a]. Disposal costs have varied considerably because of varying annual disposal volumes. The site closure costs and average shallow disposal costs using INEL experience for disposal are given in Table 16-1. Site closure costs should be added to the shallow land disposal costs to obtain the total module R cost. As an alternative, shallow land disposal costs can be compared to rates from commercial disposal sites. Disposal fees at commercial sites include all of the three cost components. Figure 16-1 contains estimated disposal fees at four commercial disposal sites; Hanford, WA, Beatey, NV, Ward Valley, CA, (projected costs) and Barnwell, SC.

Table 16-1. Shallow land disposal closure and capacities and costs (cost module R).

Module	Module Description	Facility	Life Cycle Cost ($x1000)	Capacity (lbs/hr)	Unit Cost ($/lb)	Capacity (ft3/hr)	Cap(Tot Vol) (ft3x1000)	Unit Cost ($/ft3)
R-Disp	Shallow disposal	small	$75,000		INEL	6	500	$150.00
R-Disp	Shallow disposal	med/large	$100,000		INEL	25	2,000	$50.00
R-close	Closure	Minimum	$32,076	224	$1.78	2	198	$162.00
R-close	Closure	Small	$46,464	1624	$0.35	14.5	1,452	$32.00
R-close	Closure	Medium	$68,970	5152	$0.17	46	3,630	$19.00
R-close	Closure	Large	$132,132	13552	$0.12	121	10,164	$13.00

16.2 Technical Bases and Assumptions

Since shallow land trench disposal units are commonly used by both the DOE and the commercial nuclear industry, a preconceptual design of disposal units to develop O&M costs was not necessary. The technical bases for front-end facilities is given in Section 14. Bases for closure costs are the same as those given in Section 15.

16.3 Cost Bases, Assumptions, and Assessments

The cost data outlined in this section do not include surcharges that may have to be added to the standard unit rates to account for increased Curie content (remote handled waste), nonstandard packaging, excessive weight, and other parameters of the waste that requires special handling.

a. Based on RWMC contact handled LLW disposal costs calculated by Darris Bright of EG&G Idaho, and memorandum (JAL-5-92) from J. A. Logan regarding costs of LLW disposal.

The graph shown in Figure 16-1 illustrates costs for four commercial sites, including initial capital costs, O&M, and closure. Costs for all sites (except Barnwell) are expected to increase in the near future because of surcharges imposed by the Low-level Radioactive Waste Policy Amendment Act (LLRWPAA). Barnwell site includes surcharges imposed as a result of the LLRWPAA. The Ward Valley facility is considered to be representative of the type of facility design that the DOE may use for future shallow land disposal. The reader is cautioned that the commercial disposal rates include capital costs, which are separately included in this report under module 0.

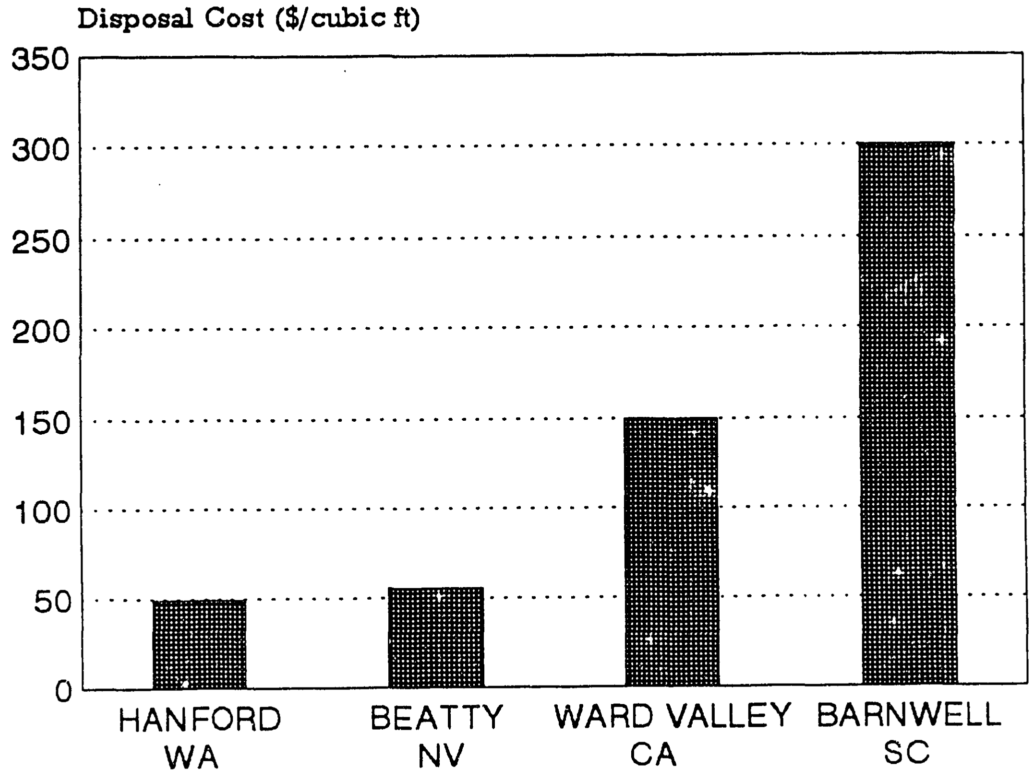


Figure 16-1. Cost comparison of commercial waste disposal facilities.

17. GEOLOGIC REPOSITORY FACILITY (COST MODULE S)

17.1 Basic Information

This facility consists of deep geologic repository for disposal of TRUW. A planning cost estimate is made based on rates quoted in Reference 9 for WIPP.

17.2 Technical Basis and Assumption

It is assumed that a deep geologic repository facility will be identical to the WIPP.

17.3 Cost Bases, Assumptions, and Assessments

A summary of the costs for disposal at WIPP is as follows:

- Although the WIPP facility is not open, it is designated as the future storage facility for transuranic wastes (> 100 nCi/g). The DOE has not formally established a disposal cost for transuranic waste at the WIPP facility.

- If cost versus capacity is used for WIPP, the disposal costs can be estimated at $740/ft^3 (the data below is from Reference 9).

Estimated WIPP capital costs to date	$1,000,000,000
Projected WIPP operating costs for 25 years	$3,750,000,000
Total	$4,750,000,000
Capacity for transuranic waste storage at WIPP Facility	6,450,000 ft^3
Estimated transuranic waste disposal cost at WIPP	$4.75 x 10E9 = $736/ft^3 6.5 x 10E6 ft^3 (round to $740/ft^3)

The above costs do not include additional costs that may be associated with disposal such as characterization and certification, packaging and transportation.

18. SCENARIO COSTING PROCEDURE

This section presents guidelines to the use of PLCC estimates in this report.

18.1 Waste Management Scenarios

A waste management scenario is a case study of the TSD facilities and activities needed for cradle-to-grave handling of a given waste. A typical scenario may consist of the following elements:

- Generated (or stored) waste from Site 1 is shipped to Site 2 where it will be treated at a treatment facility to produce a stabilized waste form.
- Treated waste is transferred to Site 3 for interim storage.
- After the interim storage period, the waste is shipped to Site 4 for final disposal.

The report presents PLCC estimates, which are referred to as cost modules, for each TSD facility. These cost modules allow analyses of two distinctive types of waste management scenarios:

- Augmented facilities: The addition of treatment, storage, and disposal capabilities to existing waste management facilities where some or all of the front-end/back-end handling and/or partial treatment functions are already in place.
- Stand alone facilities: Scenarios that require new facilities to provide cradle-to-grave waste management.

18.2 Cost Modules and Unit Operations

Each discrete TSD function is referred to as a cost module. There are a total of 26 modules, listed in Table 18-1. As shown, treatment cost modules are provided for two general categories of waste: LLW/LLMW and alpha-LLW/LLMW wastes. Cost modules for storage and disposal include LLW, LLMW, alpha-LLW/LLMW, and TRUW facilities.

Each facility is broken down into separate subfunctions, referred to as unit operations. Unit operations assume inclusion of all buildings, equipment, and accessories needed to accomplish the given subfunction.

18.3 Scenario Costing Options

PLCC estimates in this report can be used to develop costs for waste management scenarios by two different methods: modular or unit operation.

- Modular method: This method is used when the required facilities of a given scenario are compatible with those given in this report. The user simply determines which waste management facilities are needed, the capacity required for each facility, and transportation

Table 18-1. WMFCI cost modules.

Cost module designation	Facility description	Application
A	LLW/LLMW and Alpha-LLW/LLMW Treatment Front-End Support	Treatment front-end support functions, such as administration, analytical laboratory, security, and environmental compliance, that may be added to a LLW/LLMW or an alpha-LLW/LLMW treatment facility.
B	LLW/LLMW and Alpha-LLW/LLMW Treatment Receiving and Inspection	Treatment front-end functions: truck bay for unloading, staging area, waste container inspection for radiological and physical properties (for characterization), temporary container storage that may be added to a LLW/LLMW or an alpha-LLW/LLMW treatment facility.
CA	Alpha-LLW/LLMW Treatment Open, Dump and Sort	Alpha-LLW/LLMW front-end treatment functions: opening of containers, dumping, and sorting container contents.
CL	LLW/LLMW Treatment Open, Dump, and Sort	Same functions as for cost module CA except for LLW/LLMW.
DA	Alpha-LLW/LLMW Incineration	Incineration of alpha-LLW/LLMW combustible and semicombustible solids, organic liquids, and sludge.
DL	LLW/LLMW Incineration	Same functions as cost module DA except for LLW/LLMW.
EA	Alpha-LLW/LLMW Metal Melting	Melting of alpha-LLW/LLMW metals including steel, copper, aluminum, and lead.
EL	LLW/LLMW Metal Melting	Same functions as module EA except for LLW/LLMW.
FA	Alpha-LLW Shredding and Compaction	Shredding and compaction of alpha-LLW combustible, semicombustible, and noncombustible waste. Waste must not be subject to LDR requirements.
FL	LLW Shredding and Compaction	Same functions as module FA except for LLW.
GA	Alpha-LLW/LLMW Solidification	Solidification of inorganic liquids and noncombustible alpha-LLW/LLMW.
GL	LLW/LLMW Solidification	Same functions as cost module GA except for LLW/LLMW.
HA	Alpha-LLW/LLMW Vitrification	Vitrification of noncombustible alpha-LLW/LLMW.

Table 18-1. (continued).

Cost module designation	Facility description	Application
HL	LLW/LLMW Vitrification	Same functions as cost module HA except for LLW/LLMW.
I	Alpha LLW/LLMW Certification/ Shipping	Packaged waste inspection, radiological and physical characterization, temporary storage, and truck loading/shipping.
JA	Alpha LLW/LLMW Treatment Maintenance	Maintenance facilities for repair of failed equipment and parts that are part of an alpha-LLW/LLMW treatment facility.
JL	LLW/LLMW Treatment Maintenance	Same functions as for cost module JA except for LLW/LLMW.
K	Storage Front-end/Back-end Support	Unloading, receiving, and inspection of incoming containers; loading and shipping of outgoing containers; radiological and physical characterization of waste containers.
L	LLW Storage	Storage of LLW containers.
M	Alpha-LLW/LLMW or TRUW Storage	Storage of alpha-LLW/LLMW and TRUW containers.
N	LLMW Storage	Storage of LLMW containers.
O	Disposal Front-end Support	Unloading, receiving, and inspection of incoming waste containers and transport of containers to disposal facilities.
P	NonRCRA Waste Engineered Disposal	Packaging of alpha-LLW or LLW containers into concrete canisters and disposal in aboveground earth-mound concrete cells.
Q	RCRA Waste Engineered Disposal	Packaging of alpha-LLMW or LLMW containers into concrete canisters and disposal in aboveground earth-mound concrete cells with double liner and leachate collection system.
R	LLW Shallow Land Disposal	Disposal of LLW in shallow land trenches.
S	TRUW Geologic Repository Disposal	Disposal of TRUW in a deep geologic repository such as WIPP.

volumes and distances. Based on this information, the user calculates the total waste management costs following the procedure in Section 18.5.

- Cost component method: PLCC estimate for each facility is comprised of six cost components (see Appendix A). The cost component method should be used if the reader has access to an updated cost data on a given component. The reader may simply replace the updated costs in the appropriate table and calculate a new PLCC estimate by adding the six components. Once a modified PLCC estimate is determined, the cost for the overall scenario is calculated in the same manner as the modular method.

18.4 Information Required to Cost a Scenario

To use either the modular or unit operation method, the following items must be known to the user:

1. Waste radiological category: The user must be knowledgeable about radioactive waste categories as defined in DOE orders (e.g., 5280.2A), since the waste must be classified into one of the following general categories:

    a. TRUW: Generally a defense related radioactive waste with transuranic concentration above 100 nCi/g.

    b. Alpha-LLW or Alpha-LLMW: Generally defense related radioactive wastes that have a transuranic concentration in the range of 10-100 nCi/g. Alpha-LLMW is the same as alpha-LLW with the exception that it is subject to control under RCRA.

    c. LLW or LLMW: Wastes generated from nuclear reactor operation or nuclear research. Defense related LLW or LLMW has a transuranic concentration below 10 nCi/g. LLMW is the same as LLW with the exception that it is subject to control under RCRA.

2. Waste treatment category: The user must have sufficient knowledge about the waste properties to select one of the five treatment facilities described in this report. Various waste categories are described in Appendix A.

3. Input waste flow rate(s): The user must know the weight of the waste to be treated. Input waste is converted to pounds per hour (lbs/h) by dividing the total weight by 80,640 hours for a 20-year life cycle. The 80,640 hours is the total processing hours based on 24 hours per day, 240 days per year, for 20 years at 70% availability.

4. Facility locations and transportation distances: The user must know which DOE site(s) will house the facilities and determine whether the facilities will be a stand-alone or augmented type.

18.5 Scenario Costing Procedure

The scenario costing procedure (schematically shown in Figure 1-3) allows the user to develop the overall cost of a given scenario by following seven steps: (a) define scenarios, (b) define parameters, (c) develop treatment costs, (d) develop storage costs, (e) develop disposal costs, (f) develop transportation costs, and (g) develop PLCC costs. Each of these seven steps are described below. A worksheet is provided in Appendix A to assist in developing PLCC costs from this procedure.

18.5.1 Define Scenarios

The user must develop a strategy for cradle-to-grave management of the given waste stream by establishing the information listed below (see Figure 1-3 for a block diagram of a sample scenario).

- Waste source and location: Define waste streams, characteristics, and location where the waste is generated or stored.

- Treatment facility types and location: Define types and location of treatment facilities needed for each waste.

- Interim storage period and location: Define types and location of interim storage facilities needed for each waste.

- Disposal type and location: Define types and location of disposal facilities needed for each waste.

- For each treatment, storage, and disposal facility, the user must determine whether the facilities will be stand alone or augmented to an existing operation that has common support functions.

18.5.2 Define Parameters

Parameters required for each scenario include the following:

- Treatment facility input waste feed rates: The basic requirements for the scenario are input waste feed rates. The total weight of the input waste (in pounds) is then established for each type of facility. The total weight must be divided by 80,640 hours to establish facility capacity in lbs/h.

- Treatment facility output waste flow rates: Output (treated) waste flow rates for each type of treatment facility should be determined in ft^3/h. The treatment facility input waste feed rate (lbs/h) is multiplied by the output waste multiplication weight factor (see Table 18-2) to obtain the output waste mass flow rate (lbs/h). Then, the output flow rate is divided by the treated waste density to get waste volumetric flow rate (ft^3/h).

Table 18-2. Waste treatment weight conversion factors.

Treatment facility	Output waste conversion weight factor	Treated waste density (lb/ft^3)
Incineration		
Solidified waste ash (in concrete)	0.493	112
Metal melting/recovery		
Metals (cast ingots)	1.000	—[a]
Solidified waste sludge and slag (concrete)	0.306	112
Shredding/compaction		
Compacted waste (in overpack)	1.142	10-70
Solidified liquid waste	0.209	112
Solidification		
Solidified solid, liquid, sludge waste (in concrete)	2.963	112
Vitrification waste		
Vitreous waste (rock/glass material)	0.958	187
Solidified liquid and sludge waste (in concrete)	0.224	112

a. Same as the absolute density of the metal.

- Storage facility input/output waste flow rates: Input waste flow rate is determined based on the scenario and is generally equal to the waste output from the treatment facilities. Waste output rate is also dependent on the scenario and is generally the same as the input rate, but can be adjusted to suit other requirements of the scenario. Flow rates should be developed in ft^3/h.

- Disposal facility input waste flow rates: Input waste flow rate is determined based on the scenario and should be generally the same as the waste output from the treatment facilities. Waste output rate from storage facilities must also be considered. Flow rates should be developed in ft^3/h.

- Transportation distances: Transportation distances (in miles) should be calculated for the TSD facility incoming wastes.

Once the parameters are established for the various facilities in the scenario, the user should proceed with developing costs as described in Sections 18.5.3 through 18.5.7. Summary cost/capacity tables for all treatment, storage, and disposal modules are provided in Tables 18-3, 18-4, and 18-5. These tables may be referenced to develop PLCC costs for treatment, storage, and disposal facilities in the following sections.

Table 18-3. Summary costs and capacities for treatment facilities.

Mod.	Module Description	Facility	Life Cycle Cost ($x1000)	Capacity (lbs/hr)	Unit Cost ($/lb)	Capacity (ft3/hr)	Cap(Tot Vol) (ft3x1000)	Unit Cost ($/ft3)
A	Treatment Support	Small	$128,897	200	$7.99	6	461	$279.72
A	Treatment Support	Medium	$290,158	5,600	$0.64	160	12,902	$22.49
A	Treatment Support	Large	$530,763	12,500	$0.53	357	28,800	$18.43
B	Treatment Rec./Insp.	Small	$62,612	200	$3.88	6	461	$135.88
B	Treatment Rec./Insp.	Medium	$128,900	5,600	$0.29	160	12,902	$9.99
B	Treatment Rec./Insp.	Large	$204,179	12,500	$0.20	357	28,800	$7.09
CL	Front-end Treatment	Small	$170,095	200	$10.55	6	461	$369.13
CL	Front-end Treatment	Medium	$689,326	5,600	$1.53	160	12,902	$53.43
CL	Front-end Treatment	Large	$1,522,432	12,500	$1.51	357	28,800	$52.86
CA	Front-end Treatment	Small	$216,026	200	$13.39	6	461	$468.81
CA	Front-end Treatment	Medium	$1,182,462	4,500	$3.26	129	10,368	$114.05
CA	Front-end Treatment	Large	$1,419,910	7,700	$2.29	220	17,741	$80.04
DL	Incineration	Small	$296,245	200	$18.37	6	461	$642.89
DL	Incineration	Medium	$453,292	1,000	$5.62	29	2,304	$196.74
DL	Incineration	Large	$624,390	2,000	$3.87	57	4,608	$135.50
DA	Incineration	Small	$364,684	150	$30.15	4	346	$1,055.22
DA	Incineration	Medium	$536,989	1,000	$6.66	29	2,304	$233.07
DA	Incineration	Large	$732,819	2,000	$4.54	57	4,608	$159.03
EL	Metal Melting	Small	$140,950	50	$34.96	1	115	$1,223.52
EL	Metal Melting	Medium	$293,306	1,600	$2.27	46	3,686	$79.56
EL	Metal Melting	Large	$335,527	2,500	$1.66	71	5,760	$58.25
EA	Metal Melting	Small	$194,798	60	$40.26	2	138	$1,409.13
EA	Metal Melting	Medium	$372,028	600	$7.69	17	1,382	$269.12
EA	Metal Melting	Large	$469,314	1,000	$5.82	29	2,304	$203.70
FL	Shred/Compact	Small	$100,758	300	$4.16	9	691	$145.77
FL	Shred/Compact	Medium	$120,979	1,000	$1.50	29	2,304	$52.51
FL	Shred/Compact	Large	$235,121	4,000	$0.73	114	9,216	$25.51
FA	Shred/Compact	Small	$111,222	100	$13.79	3	230	$482.73
FA	Shred/Compact	Medium	$126,232	1,000	$1.57	29	2,304	$54.79
FA	Shred/Compact	Large	$255,361	1,500	$2.11	43	3,456	$73.89
GL	Solidification	Small	$162,181	400	$5.03	11	922	$175.98
GL	Solidification	Medium	$260,896	1,000	$3.24	29	2,304	$113.24
GL	Solidification	Large	$451,794	2,000	$2.80	57	4,608	$98.05
GA	Solidification	Small	$200,672	70	$35.55	2	161	$1,244.25
GA	Solidification	Medium	$311,764	700	$5.52	20	1,613	$193.31
GA	Solidification	Large	$431,332	1,200	$4.46	34	2,765	$156.01
HL	Vitrification	Small	$316,401	300	$13.08	9	691	$457.76
HL	Vitrification	Medium	$430,303	1,000	$5.34	29	2,304	$186.76
HL	Vitrification	Large	$587,311	2,000	$3.64	57	4,608	$127.45
HA	Vitrification	Small	$359,866	300	$14.88	9	691	$520.64
HA	Vitrification	Medium	$490,069	1,200	$5.06	34	2,765	$177.25
HA	Vitrification	Large	$655,339	2,000	$4.06	57	4,608	$142.22
I	Cert./Shipment	Small	$69,315	450	$1.91	4	324	$213.94
I	Cert./Shipment	Medium	$127,960	6,235	$0.25	56	4,489	$28.50
I	Cert./Shipment	Large	$239,201	18,200	$0.16	163	13,104	$18.25
JL	Treatment Maint.	Small	$36,887	450	$1.02	4	324	$113.85
JL	Treatment Maint.	Medium	$72,588	6,235	$0.14	56	4,489	$16.17
JL	Treatment Maint.	Large	$136,592	18,200	$0.09	163	13,104	$10.42
JA	Treatment Maint.	Small	$38,091	450	$1.05	4	324	$117.56
JA	Treatment Maint.	Medium	$73,048	6,235	$0.15	56	4,489	$16.27
JA	Treatment Maint.	Large	$156,741	18,200	$0.11	163	13,104	$11.96

Table 18-4. Summary costs and capacities for storage facilities.

Module	Module Description	Facility	Life Cycle Cost ($x1000)	Capacity (lbs/hr)	Unit Cost ($/lb)	Capacity (ft3/hr)	Cap(Tot Vol) (ft3x1000)	Unit Cost ($/ft3)
K	Storage support	Small	$155,073	560	$3.43	5	403	$384.61
K	Storage support	Medium	$319,997	3360	$1.18	30	2,419	$132.27
K	Storage support	Large	$611,128	9744	$0.78	87	7,016	$87.11
L,M,N	Storage	Small	$51,856	560	$1.15	5	403	$128.61
L,M,N	Storage	Medium	$99,847	1232	$1.01	11	887	$112.56
L,M,N	Storage	Large	$405,883	9744	$0.52	87	7,016	$57.85

Table 18-5. Summary costs and capacities for disposal facilities.

Module	Module Description	Facility	Life Cycle Cost ($x1000)	Capacity (lbs/hr)	Unit Cost ($/lb)	Capacity (ft3/hr)	Cap(Tot Vol) (ft3x1000)	Unit Cost ($/ft3)
O	Disposal Support	Minimum	$159,705	224	$8.84	2	161	$990.23
O	Disposal Support	Small	$328,104	1624	$2.51	14.5	1,169	$280.60
O	Disposal Support	Medium	$441,571	5152	$1.06	46	3,709	$119.04
O	Disposal Support	Large	$697,007	13552	$0.64	121	9,757	$71.43
P	Engr. Disposal	Minimum	$327,121	224	$18.11	2	161	$2,028.28
P	Engr. Disposal	Small	$491,233	1624	$3.75	14.5	1,169	$420.12
P	Engr. Disposal	Medium	$886,506	5152	$2.13	46	3,709	$238.99
P	Engr. Disposal	Large	$2,146,360	13552	$1.96	121	9,757	$219.97
Q-RCRA	Engr. Disposal	Minimum	$334,328	224	$18.51	2	161	$2,072.97
Q-RCRA	Engr. Disposal	Small	$495,628	1624	$3.78	14.5	1,169	$423.87
Q-RCRA	Engr. Disposal	Medium	$897,026	5152	$2.16	46	3,709	$241.82
Q-RCRA	Engr. Disposal	Large	$2,168,827	13552	$1.98	121	9,757	$222.27
R-Disp	Shallow disposal	small	$75,000		INEL	6	500	$150.00
R-Disp	Shallow disposal	med/large	$100,000		INEL	25	2,000	$50.00
R-close	Closure	Minimum	$32,076	224	$1.78	2	198	$162.00
R-close	Closure	Small	$46,464	1624	$0.35	14.5	1,452	$32.00
R-close	Closure	Medium	$68,970	5152	$0.17	46	3,630	$19.00
R-close	Closure	Large	$132,132	13552	$0.12	121	10,164	$13.00
S	Geologic Disposal	all	$4,750,000		WIPP	80	6,450	$736.43

18.5.3 Develop Treatment Costs

Treatment facility costs consist of three facility categories; front-end support, treatment, and back-end support facilities. If the desired treatment facility is an addition to an existing facility, then only the cost for the treatment facility must be developed. However, if the facility is new, then costs for the front-end and back-end support functions must also be included.

Once the type of facilities have been established, the user can obtain PLCC estimates by selecting one of the cost modules that is closest to the required capacity from the cost modules presented in Table 18-3 for these facilities.

18.5.4 Develop Storage Costs

Storage costs consist of two categories: front-end/back-end support and storage facilities. If the desired storage facility is an addition to an existing facility, then only the cost for the storage facility must be developed. However, if a the facility is new, then costs for the front-end/back-end support facilities must also be included.

Once the type of facilities have been established, the user can obtain PLCC estimates for the front-end/back-end facility by selecting one of the cost modules that is closest to the required capacity from the cost-versus-capacity graphs presented for these facilities. The storage cost should be obtained by selecting one of the cost modules from Table 18-4 that is closest to the required capacity and multiply the storage unit rate (Table 12-2) of this module by the total volume of waste.

18.5.5 Develop Disposal Cost

Disposal costs consist of two categories; front-end support and disposal facilities. The procedure to determine disposal costs is the same one used to determine the storage cost. Use Table 18-5 to obtain cost and capacity information.

18.5.6 Develop Transportation Costs

Transportation costs are calculated by multiplying the volume of the waste to be shipped by the following factors:

- Up to 30 miles: $1.00/$ft^3$
- 30 to 300 miles: $1.72/$ft^3$
- 300 to 500 miles: $2.26/$ft^3$

18.5.7 Total PLCC Costs

Add items from 18.5.1–18.5.6 to yield the total PLCC estimates for the selected waste management scenario.

18.6 Limitations

WMFCI is a useful tool for developing PLCC estimates of DOE site-wide waste management scenarios. Costs are developed for initial project planning, demonstration, design, construction of production facility, 20-year operation and maintenance, and decommissioning and closure. Only facilities subject to the following key conditions are appropriate for the cost data presented in WMFCI:

1. Facilities designated as a Major Project or Major System Acquisition (MSA) project as defined in DOE Order 4700.1 Project Management System. To apply WFMCI, each project must go through the DOE acquisition process defined by this order. Key milestones for the designation process and a schedule for typical waste management facility licensing, construction, and operation are given in Figure 18-1.

2. Facilities are subject to

    a. Environment, safety, and health requirements including NEPA and safety assurance reviews according to DOE orders and regulations (See Environmental Compliance Guide, DOE/EV-1032). Activities include the preparation of an Environmental Impact Statement, Safety Analysis Report, and related activities.

    b. RCRA Permitting—TSD permit.

    c. Other permits such as National Air Emission Standard for Hazardous Air Pollutants, Clean Air Act, and State and local permits.

    c. General Design criteria given in DOE Order 6430.1A.

3. The five treatment cost modules were strategically selected such that a majority of waste streams from a typical DOE site can be addressed. However, there is a wide range of DOE special waste streams that may not be specifically treatable by the given processes. In such situations, the unit operations of the given facility must be revised to develop costs for special waste streams.

4. LCC estimates are based on conditions at the INEL. Cost differences from site specific cost factors are assumed to be within the variance limits of this cost estimate. Table 18-6 provides a guide for comparing DOE site cost factors relative to the INEL.[e]

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e. Cost factors are based from the report titled *Mixed Waste Treatment Project Process Systems and Facilities Design Study and Cost Estimates* and verbal confirmation by Brian Marais from Bechtel. Data used to generate the rate table are based on a combination of Means Construction Cost Data and Bechtel historical cost data.

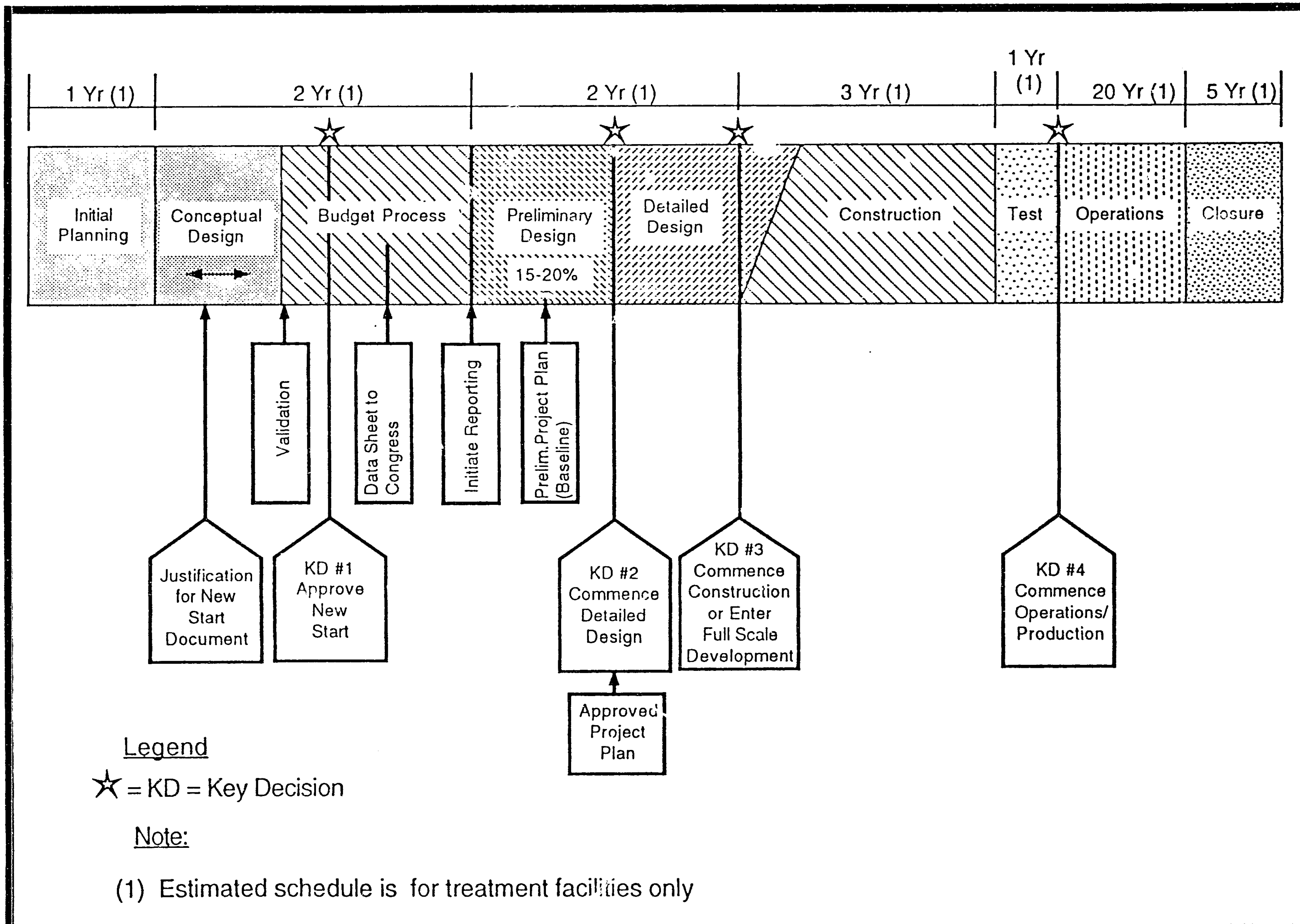

Figure 18-1. Key events in the acquisition process.

Table 18-6. Site specific cost factors.

Site (index area)	Material index[a]	Installation index[a]	State sale tax rate	Cost factor (CF) relative to INEL[b]
INEL (Boise)	98.9	88.4	5.5%	1.0
Los Alamos National Laboratory (Albuquerque)	101.7	82.7	4.75%	0.983
Lawrence Livermore National Laboratory (Stockton)	99.2	116.8	8.25%	1.130
Oak Ridge (Knoxville)	98.1	72.4	5.5%	0.935
Portsmouth (Columbus)	99.5	95.9	5.0%	1.031
Rocky Flats (Denver)	101.1	86.9	3.0%	0.998
Hanford (Spokane)	103.5	99.7	6.5%	1.054
Savannah River (Columbia)	97.8	65.1	5.0%	0.906

a. From Means Construction Cost Data—1990.

b. Based on 45% equipment, 20% material, and 35% installation costs.

19. REFERENCES

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6. Roads, A. S., "A Performance Assessment of Radioactive Waste Encapsulated in Iron-Enriched Basalt and Disposed at the Idaho National Engineering Laboratory's Radioactive Waste Management Complex," *Proceedings at Spectrum 92 International Topical Meeting, Nuclear and Hazardous Waste Management, Volume 2, page 1442, August 23-27, 1992, Boise, Idaho.*

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8. "Conceptual Design Report—Alternative Concepts for Low-Level Radioactive Waste Disposal" - National Low-Level Waste Management Program, June 1987, DOE/LLW-60T.

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Appendix A

Methodology, Assumptions, and Bases

Appendix A

Methodology, Assumptions, and Bases

The cost estimating methodology, assumptions, and technical bases that are used to develop planning life-cycle cost (PLCC) estimates are presented below. Specific additional assumptions and bases for each cost module are given in the main body of this report and EG&G Idaho internal report, "Waste Management Facility Cost Information Estimating Data" (WTD-92-049).

A.1 COST ESTIMATING METHODOLOGY

The cost estimating approach, shown in Figure 1-2 of the text, is based on the development of well documented PLCC estimates for various facility capacities. Initially, a capacity range for each type of facility was established by studying the stored and newly generated wastes at various existing DOE sites. Data from the study defined baseline capacities for three different facility sizes (small, medium, and large). These capacities are facility specific and have been defined in the main body of this report under the appropriate sections.

Using the three capacities, a preconceptual design package for each cost module was developed and used as the basis for PLCC cost estimates. Each preconceptual design package includes a process functional diagram with mass flow rates, scoping study layout, and summary functional and operational requirement (F&OR). The design packages utilize as much of the data from existing or planned DOE facilities as possible. New designs were generated only if existing data were not available.

The process functional diagrams and scoping study layout drawings were developed to the individual unit operations level. After unit operations were defined, major equipment lists and building square footage requirements were established for each unit operation and released for cost estimating.

Costs for each facility are divided into six components, each of which is estimated separately. Equipment costs were obtained by soliciting budgetary costs from the suppliers, using existing data, or making engineering judgements. Building costs were estimated by multiplying the unit operation square footage by the building cost unit rates. After the five components are estimated, they are added to obtain the total facility PLCC estimate.

To facilitate cost estimating flexibility, the front-end/back-end functions (e.g., receiving/staging/storage, incoming waste assay/inspection, incoming waste open/dump/sort, outgoing waste assay/certification, and support facilities such as administration, maintenance shop, analytical laboratory) of each treatment, storage, and disposal facility are estimated as separate cost modules. This approach allows consideration of scenarios that involve existing facilities where some or all of the front-end/back-end functions are already in place.

A.2 WMFCI MODEL

To develop the Waste Management Facility Cost Information (WMFCI) model, cost estimating data were entered into an interlinked spreadsheet in Lotus 123 software. The model outlines detailed costs, cost factors, and unit rates for each cost module. A hard copy of the spreadsheets is included in EG&G Idaho report WTD-92-046.

A.3 TECHNICAL BASES AND ASSUMPTIONS

Technical assumptions that apply to all cost modules in this report are discussed in the following sections. Facility specific assumptions are given in the main body of this report.

A.3.1 Input Waste Characteristics

It is assumed that waste that does not have free water is received at the treatment facilities in drums, boxes, or metal bins. Liquid wastes are piped into the treatment facilities. Received waste will fall in one of the following three categories (see Figure A-1):

- Dry active waste (DAW): Dry active waste consists of discarded components, disposed garments, housekeeping waste, dirt, debris, metals, and similar material. It is assumed that DAW, when shipped to the treatment facilities in containers, are generally composed of 25% combustibles, 25% semicombustibles (a mixture of 50% combustibles with 50% noncombustibles) 10% noncombustibles, 8.5% metals, 30% homogeneous, 1.5% special waste. The composition of the combustibles portion of DAW are shown in Table A-1. Various solid waste categories are as follows:

  - DAW-1, Combustible solids: Combustible solids include waste paper, wood, plastics, clothing, rubber, etc.

  - DAW-2, Semicombustible solids: Semicombustibles include benelex and plexiglass, cemented or uncemented dry organic sludge, volatile organic chemical (VOC) contaminated soil/debris, asphalt, graphite, molds, insulation spent filters, etc.

  - DAW-3, Noncombustible solids: Noncombustible solids include ash, soil, concrete, brick, construction debris, etc.

  - DAW-4, Contaminated metals: This waste includes ferrous and nonferrous metal waste that is delivered to the treatment facilities in bulk forms, separate from and in addition to loose metal waste, which is mixed with other DAW categories. Subcategories are as follows:

    - DAW-4a, Bulk metals: Bulk metals include steel, metal, aluminum, copper, special metals, etc.

    - DAW-4b, Lead: This category includes lead bricks, gloves, leaded rubber, lead slabs, etc.

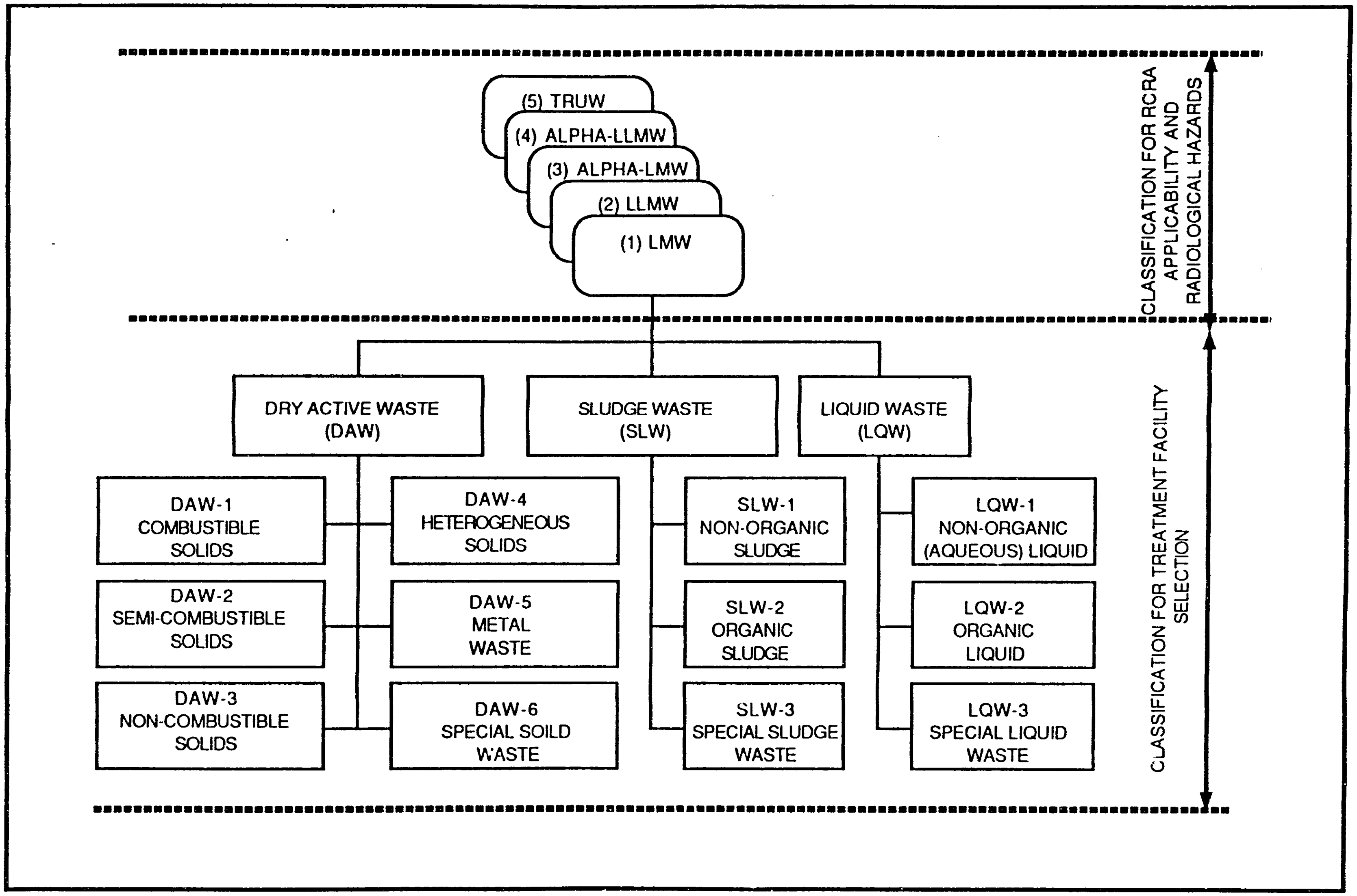

Figure A-1. Waste categories used for PLCC estimates.

Table A-1. Composition of the combustible portion of DAW.

Waste type	Percent	Heating value BTU/lb
Wood	0.87	8,420
Paper	61.87	7,709
Polyethylene	15.60	19,949
Cloth	14.70	7,200
Graphite	.15	10,000
Rubber	1.02	12,800
Cardboard	.29	8,374
Teflon	.09	0
Metal	1.00	2,869
Cement	.29	0
Sand	1.06	0
PVC plastic	2.49	8,831
Total	100.00	

- DAW-5, Heterogeneous waste: Heterogeneous waste includes any DAW container that requires special sorting and processing operations. For example, the contents of some containers may include compressed gas cylinders that must be removed to meet safety requirements.

- DAW-6, Special wastes: Special wastes are certain items that have physical, chemical or radiological properties incompatible with the five treatment facilities. Treatment of these items to meet the waste form requirements is outside the scope of the normal process provided for each facility. It is assumed that special waste will be handled by special treatment schemes devised on a case-by-case basis.

- Sludge Waste: Sludge wastes (SLW) are dewatered water treatment filter cakes, ion exchange resins, and other wet solids that have a minimum of 30% absorbed water content (usually no free water). A further breakdown of this waste is as follows:

  - SLW-1, Organic sludge: Organic sludge includes wet sludge and dewatered ion-exchange resins and filter-cakes.

  - SLW-2, Inorganic sludge: Inorganic sludge includes wet sludge, inert salt cakes, inert filtrate cakes, or ion exchange media.

- SLW-3, Special waste: Same as special waste discussed above.

- Liquid waste: Liquid waste (LQW) normally has a high concentration of dissolved and suspended solids (assumed to be 20% for this study) and can be divided according to the following categories:

  - LQW-1, Organic liquid: Organic liquid includes low or high boiling point petroleum hydrocarbons, oil, or other volatile organic liquids.

  - LQW-2, Inorganic liquid: Inorganic liquid includes evaporator concentrates or concentrated liquids and sludge from filtering off-gas scrubber liquids.

  - LQW-3, Special waste: Same as DAW-6.

Additional assumptions regarding the waste radioactivity, hazardous material contents are as follows:

- When wastes are considered mixed waste, the applicable LDR treatment requirements (BDATs) are either solidification, incineration, or vitrification.

- Transuranic waste (TRUW) has a transuranic concentration of greater than 100 nCi/g.

- Alpha-low level waste (LLW) are defense related wastes from Rocky Flats or similar facilities and have a transuranic concentration between 10-100 nCi/g. Alpha-low-level mixed waste (LLMW) is the same as alpha-LLW with the exception that it is controlled under Resource Conservation and Recovery Act (RCRA).

- LLW are nuclear reactor and research related wastes as defined in DOE Order 5280.2A. Defense related LLW have a transuranic concentration of less than 10 nCi/g. LLMW are the same as LLW with the exception that they contain land disposal restrictions (LDR) components and are controlled under RCRA.

- Wastes that contain materials that can jeopardize the safety of processing operations either exist in small quantities and can be safely handled or can be segregated for handling and processing as special material. Waste material in this category includes containers that have free liquids and compressed gas cylinders.

- Remotely handled wastes (e.g., waste containers with gamma radiation surface dose rate above 200 mrem/h) are considered special wastes and would not meet the waste acceptance criteria. If such material are contained inside of a shielded container, they will be separated from the routine waste handled at the treatment facilities. These special wastes are treated by special techniques (e.g., shielded portable units) on a case-by-case basis.

A.3.2 Output Waste Form

The following assumptions apply to the physical and chemical properties assumed for the output of the treatment plants:

- *Waste Form 1—Leach resistant high integrity glass/rock*: Produced by vitrification plants, this waste form is a leach-resistant, high-integrity glass-or rock-like material. The waste form also complies with transportation package (TRAMPAC) transuranic transportation packaging criteria. Because of its high quality, this waste form furthermore meets the less stringent requirements for Waste Forms 2 and 3, discussed below.

- *Waste Form 2—LDR compliance required*: This waste form is produced by the incineration and solidification plants and complies with the LDR requirements. If incineration is used, organics are destroyed and inorganics are fixed in a solidified matrix. If a solidification plant is used, only inorganics are fixed and other methods for destruction of organics, in compliance with LDR, must be used. It is assumed that this waste form will be suitable for a RCRA shallow land disposal facility.

- *Waste Form 3—Repackaged Waste*: This waste form, which is produced by shredding/compaction plants, consists of repackaged dry active waste. If the waste is LLW, it will be suitable for shallow land disposal. If it is LLMW, alpha-LLW, or alpha-LLMW, it complies with the requirements and acceptance criteria of a deep geological repository, such as Waste Isolation Pilot Plant (WIPP). Waste Form 3 does not meet any of the above waste form requirements and would not meet the LDR requirements.

It is assumed that the output waste from all treatment plants will be packaged in 55 gal drums with the exception that the shredding/compaction plant output will be packaged in 85 gal drum over-packs.

A.3.3 Facility Design Requirement Assumptions

A.3.3.1 General Assumptions

The facility preconceptual designs follow these general assumptions:

- The treatment, storage, and disposal facilities for LLW, LLMW, alpha-LLW and alpha-LLMW are classified as a Radioactive Liquid Waste or Radioactive Solid Waste Facility per Section 1323 and 1324 of DOE Order 6430.1A. All buildings that handle radioactive waste are classified as a moderate hazard facility according to University of California Research Laboratories (UCRL) 15910.

- The facilities are designed in accordance with applicable regulations. Specifically, RCRA places design conditions on the storage and treatment process, and performance specifications on the thermal and waste stabilization processes. All equipment has high-quality, low-maintenance features to keep personnel exposure as low as reasonably achievable (ALARA). Remote operations are used to the greatest extent practical.

- The individual unit operations for treatment and storage facilities are sized to handle at least 125% of the mass flow rates shown on the process functional diagram.

- Public, employee, and environmental exposures to hazardous and radioactive material will be ALARA.

- The scoping layout of the facilities for each concept is based on the following assumptions:

  - Surge capacity for indoor storage of the incoming drums, boxes, bins, and packaged waste is 2-4 weeks.

  - The preconceptual design for processing alpha-LLW/LLMW is based on a conservative assumption that errors in alpha radiation measurement will result in processing waste with higher than 100 nCi/g transuranic content. Hence, an alpha cell arrangement is used for the layouts.

- Due to the very low concentration of plutonium in alpha-LLW/LLMW, it is assumed that special design for criticality safety will not be required, and facilities will not be subject to health and safety risks associated with criticality.

- Special designs to mitigate health and safety risks associated with pyrophoric and flammable and toxic gas wastes are not provided.

A.3.3.2 Treatment Facility Support Functions

Support functions included for all treatment facility cost modules include but are not limited to

- Heating, ventilating, and air conditioning (HVAC) nonprocess

- Fire protection

- Electrical (including emergency)

- Process control and data logging

- Radiation instrumentation

- Bulk chemical and additive supply and storage

- Storm water runoff control

- Waste water treatment (hazardous, radioactive, and sanitary).

Input from the site includes utilities, service water, normal and emergency power, and communications. Laboratory and personnel decontamination areas are designed to handle radioactive material.

Structures housing personnel and nonradioactive components are designed per Uniform Building Code. Laboratory and personnel decontamination areas are designed for handling radioactive material.

A.3.3.3 Common Facility Support Functions

Support functions for all common facility cost modules include but are not limited to

- Security
- Personnel decontamination (radioactive and hazardous)
- Noncontaminated maintenance
- Health physics
- Sanitary facilities
- Work control/personnel support
- Interior and external (public relations) communications
- Spill or emergency response provisions (hazardous and radioactive)
- Analytical laboratory
- Environmental field sampling
- Environmental regulatory reporting and records management.

Every facility described in this report includes the following interfaces: facility communication, alarm systems including telephone, evacuation, fire, security alarm, and public address systems. All treatment processes are programmed for automatic shut down if the fire system or the evacuation alarm is activated.

A.3.3.4 LLW/LLMW General Assumptions

Scoping study layouts are shown in EG&G Idaho internal report, "Waste Management Facility Cost Information Estimating Data," WTD-92-046 (Feizollahi, F. and Shropshire, D., 1992). To facilitate ease of maintenance and reduce employee exposures, each of the main process unit operations are located in a dedicated room. Major components are controlled from a centralized control room. Each facility includes space for support functions such as electrical, HVAC, and mechanical and utility systems.

A.3.3.5 Alpha-LLW/LLMW General Assumptions

Scoping study layouts are shown in EG&G Idaho report, Waste Management Facility Cost Information Estimating Data, WTD-92-046. As with LLW/LLMW, each main process unit operation is located in a dedicated room to facilitate ease of decontamination and maintenance. Process equipment are located in a single alpha cell. Waste enters from one end of the cell and leaves from the opposite end. The front of the cell faces an operating gallery where windows and remote access devices are provided to allow remote operation of the equipment. An equipment pull-out and maintenance gallery is provided in the back end of the cell. Failed components are removed from the cell via air-lock doors and brought to the maintenance gallery for decontamination and maintenance. Each facility includes space for support functions such as electrical, HVAC, mechanical and utility systems.

Properly designed and constructed facilities tailored to each treatment method is considered an effective method for treatment and stabilization, removal of contamination from metals, volume reduction of solid waste, stabilization of liquid and solid LLW/LLMW and alpha-LLW/LLMW, and conversion of noncombustible waste to a high integrity, leach resistant glass/rock-like material.

A.3.4 Facility Operation

The following assumptions are made for the facility operations:

- Facility operates 24 hours/day, 5 days/week, 240 days/year, and assumes 70% plant availability during operation. This is equal to 168 days/year, or 4,032 hours/year of operation.

- The operational time span for each facility is 20 years.

A.4 COST BASES AND ASSUMPTIONS

The following general assumptions are made for the PLCC estimates contained in this report:

- Estimates for new facility construction are based on the conditions for the Idaho National Engineering Laboratory (INEL) site including utility, labor and the related design, construction, operation, and management factors.

- PLCC estimates are developed based on 1992 dollars. The time value of money or escalation for expenditures occurring at different time frames has not been considered in the estimates.

The costs for each facility are divided into these five components: studies and bench scale tests, demonstration, production facility construction, operating and maintenance, and decontamination and decommissioning. Methodology and assumptions used in developing the cost components are given below.

A.4.1 Planning Studies and Tests

Estimated planning costs for the planning studies and bench-scale tests for each facility consists of three subcomponents: manpower, equipment testing, and equipment installation. Manpower is defined as the effort needed for initial paper studies, bench scale tests, and secondary paper studies. Study durations and manpower estimates for these efforts were obtained from tables contained in an existing report (F. Feizollahi, et. al., Preliminary Stored Waste Systems Design Study for low-level TRU Waste Treatment Report, EGG-WTD-10254, 1992). Equipment budgetary costs and associated installation costs for lab equipment, such as mixers and prototype ovens used in tests, were obtained from the same reference.

The planning studies and tests cost component was estimated assuming a cost of $150,000 per full-time equivalent (FTE) for scientists and engineering manpower.

Table A-2 containing a development, testing, and evaluation cost estimating spreadsheet for a medium-sized incineration facility is included as an example.

A.4.2 Demonstration

The demonstration cost component consists of nine subcomponents. Cost estimates for three of the subcomponents (manpower during demonstration, building structure, and equipment) were obtained from an existing report (Feizollahi, 1992). The remaining six subcomponents (design, inspection, project administration, indirect, construction management, and contingency) were determined by using percentage factors provided by EG&G Idaho. These factors are the same as those used for the production facility (see Section A.4.3 below), and are as follows:

- Design, inspection, project administration, indirect, construction management, and contingency costs subcomponents are developed using percentage guidelines. This approach facilitates development of PLCC estimates suitable for relative comparison of various options. The percentages are historical averages experienced by DOE contractors at the INEL for the types of activities covered by waste management facilities. In addition,

    - Contingency on all costs is 25%.

    - Design cost, applied to construction cost total, is 30% during the demonstration phase. During the production phase, it is 18% for LLW/LLMW and 25% for alpha-LLW/LLMW facilities. Design costs for the storage and disposal facilities are 18% of the cost for 1 year's capacity of storage or disposal structures.

    - Inspection cost, applied to construction cost total, is 7%.

    - Project management cost, applied to construction cost total, is 10%.

    - Indirect cost, applied to total building plus equipment and installation costs, is 29%.

Table A-2. Development, testing, and evaluation cost estimates for incineration facility.

ALPHA

	UNIT OPERATION	Primary Paper Evaluation Research Manpower	Bench Scale Studies Research Manpower	Sec. Paper Evaluation Research Manpower	Total Research Manpower	MEDIUM Bench Scale Studies Equipment $1000	Bench Scale Studies Installation $1000	Pilot Plant Mock-up Test Demo. Manpower	Pilot Plant Mock-up Test Bldg. $1000	Pilot Plant Mock-up Test Equip. $1000
DA-1	Prepare & Feed Incoming Waste	1			1			3	50	100
DA-2	Incinerator	2			2			10	100	500
DA-3	Prepare & Feed for Solidification									
DA-4	Solidify	1	3	2	6	50	150			
DA-5	Drum Capping & Washing									
DA-6	Off-Gas Treatment	2			2			3	30	150
DA-7	Prepare & feed Lime									
DA-8	Treat Liquid Waste									
DA-9	Store & Feed Binder									
DA-10	Elec. Dist & MCC									
DA-11	Heating, Ventilation & Exhaust									
DA-12	Other Equipment									
	Unit Cost ($ / Unit)				$150,000			$150,000		
	Total Cost				1,650	50	150	2,400	180	750
	Post Totals to Table DA-6, Item				1.1	1.2	1.3	2.1	2.5.1	2.5.2

TABLE DL-2 : Development, Testing & Evaluation Cost Estimates – INCINERATION

LLW/LLMW

	UNIT OPERATION	Primary Paper Evaluation Research Manpower	Bench Scale Studies Research Manpower	Sec. Paper Evaluation Research Manpower	Total Research Manpower	MEDIUM Bench Scale Studies Equipment $1000	Bench Scale Studies Installation $1000	Pilot Plant Mock-up Test Demo. Manpower	Pilot Plant Mock-up Test Bldg. $1000	Pilot Plant Mock-up Test Equip. $1000
DL-1	Prepare & Feed Incoming Waste	1			1			3	50	100
DL-2	Incinerator	2			2			10	100	500
DL-3	Prepare & Feed for Solidification									
DL-4	Solidify	1	3	2	6	50	150			
DL-5	Drum Capping & Washing									
DL-6	Off-Gas Treatment							3	30	150
DL-7	Prepare & feed Lime									
DL-8	Treat Liquid Waste									
DL-9	Store & Feed Binder									
DL-10	Elec. Dist & MCC									
DL-11	Heating, Ventilation & Exhaust									
DL-12	Other Equipment									
	Unit Cost ($/Unit)				$150,000			$150,000		
	Total Cost				1,350	50	150	2,400	180	750
	07:41 AM Post Totals to Table DL-6, Item				1.1	1.2	1.3	2.1	2.5.1	2.5.2

- Construction management (CM) costs applied only to production construction costs total, are 17.1%.

- Construction management reserve is 10%.

Major assumptions used for developing the budgetary cost estimates for the demonstration cost component are given below.

- The demonstration equipment cost estimates are budgetary and based on industrial equipment, which costs less than the final equipment that will be provided for the production facility. Accordingly, it is assumed that material used in test assemblies will be fabricated from commonly available industrial equipment.

- In the vitrification system, the demonstration melter train (i.e., melter, off-gas treatment, and slag cooling/packaging) will be tested in an existing building as a single assembly.

- In the open, dump, and sort facilities, remotely operated devices needed for container opening, dumping, sorting, crushing, and shredding will be demonstrated in a simulated cell environment as an integrated single assembly.

- Incineration demonstration including its off-gas will be carried out in a contract pilot-plant and will be assembled in an existing building.

- All other demonstrations, such as liquid waste treatment, alpha assay instruments, and decontamination, will be performed by vendors. An example of the demonstration cost spreadsheet is shown in Table A-2.

A.4.3 Production Facility Construction

The production facility cost consists of nine subcomponents. Two of the subcomponents, equipment and installation, are estimated in this report and included in the cost model tables. The costs are based on an equipment list developed from the information provided in the F&ORs and process functional diagrams. Then, equipment budgetary purchase costs are estimated using either vendor budgetary quotations, historical cost information, or engineering judgements. Installation costs are estimated for each piece of equipment and include labor, construction equipment, small tools, and supplies. Whenever vendor quotes were based on off-the-shelf equipment, they were multiplied by an appropriate adjustment factor to allow for NQA-1 and other more complex requirements of the specific process. Table A-3 containing equipment purchase and installation costs for a medium-sized incineration facility is included as an example.

A third subcomponent, building cost, is developed by multiplying the estimated building space required for each unit operation by a set of unit rates provided by EG&G Idaho and Morrison Knudsen Corporation (MK). The allocated building space estimates are developed from the scoping study layout sketches presented in the attachments. The estimates include allocated space in separate categories to account for different hazard levels. The estimated square footage and the calculated building cost estimates for each unit operation are listed in the cost model tables. Table A-4

Table A-3. Equipment purchase and installation budgetary cost estimate for incineration facility.

			MEDIUM						
		FAC.		MATLS. & EQUIP.			INST. COSTS		
	DESCRIPTION	CAT.	HP	QTY	Unit Cost $1000's	Amount $1000's	Unit Cost $1000's	Amount $1000's	Total U.O.
DL-1	**Prepare & Feed Incoming Waste**								
	-Bin Hoist / Pusher	B	5	1	33	66	8	8	74
	-Disch. & Oversize Load Hopper (100 CF)	B	1	1	25	50	7	7	57
	-Primary Shreeder (.25,1.5,2 TPH)	B	250	1	200	400	30	30	430
	-Secondary Shredder (.5,1.5,3 TPH)	B	60	1	175	350	30	30	380
	-Live Bottom Bulk Storage	B	1	1	25	50	7	7	57
	-Tertiary Shredder (1,2,4 TPH)	B				0		0	0
	-Conveyor / Canister Handler	B	5	1	40	80	10	10	90
	-Manipulate Crane - 10 TN	B	15	1	400	800	100	100	900
	-Organic Liquid Feed	B		Lot	75	150	15	15	165
	-Liquid Waste Feed	B		Lot	75	150	15	15	165
	-Allowance for Structural Steel - TN	B		4	1	8	1	4	12
	-Allowance for Piping / Mechanical	A		Lot	20	60	8	8	68
	-Control Panel - FT	D		8	10	96	1	8	104
	-Allowance for Electrical / Control	D		Lot	216	259	43	43	302
	-Calibration, Testing & Startup	D		Lot	15	18	72	72	90
						0			
	Total Prepare & Feed Incoming Waste					2537		357	2894
DA-1	**Prepare & Feed Incoming Waste**								
	-Bin Hoist / Pusher	B	5	1	33	99	8	8	107
	-Disch. & Oversize Load Hopper (100 CF)	B	1	1	25	75	7	7	82
	-Primary Shreeder (.25,1.5,2 TPH)	B	250	1	200	600	30	30	630
	-Secondary Shredder (.5,1.5,3 TPH)	B	60	1	175	525	30	30	555
	-Live Bottom Bulk Storage (400 CF)	B	1	1	25	75	7	7	82
	-Tertiary Shredder (1,2,4 TPH)	B				0		0	0
	-Conveyor / Canister Handler	B	5	1	40	120	10	10	130
	-Manipulate Crane - 10 TN	B	15	1	400	1200	100	100	1300
	-Organic Liquid Feed	B		Lot	75	225	15	15	240
	-Liquid Waste Feed	B		Lot	75	225	15	15	240
	-Allowance for Structural Steel - TN	B		4	1	12	1	4	16
	-Allowance for Piping / Mechanical	A		Lot	20	60	8	8	68
	-Control Panel - FT	D		8	10	120	1	8	128
	-Allowance for Electrical / Control	D		Lot	22	33	4	4	37
	-Calibration, Testing & Startup	D		Lot	15	23	72	72	95
	-Air Locks	E		2	124	248	39	78	326
						0			
	Total Prepare & Feed Incoming Waste					3640		396	4036
DL-2	**Incinerator**								
	-Incinerator					0		0	0
	-Ventilation Blower (1000,4500,6000 SCFM)		15			0		0	0
	-Complete Package per Above Detail	E		Lot	1200	1200	241	241	1441
	-Allowance for Structural Steel - TN	B		5	1	10	1	5	15
	-Allowance for Piping / Mechanical	A		Lot	120	360	48	48	408
	-Control Panel - FT	D		10	10	120	1	10	130
	-Allowance for Electrical / Control	D		Lot	266	319	53	53	372
	-Calibration, Testing & Startup	D		Lot	15	18	192	192	210
	Total Incinerator					2027		549	2576
DA-2	**Incinerator**								
	-Incinerator					0		0	0
	-Ventilation Blower (1000,4500,6000 SCFM)		15			0		0	0
	-Complete Package per Above Detail	E		Lot	1200	1200	241	241	1441
	-Allowance for Structural Steel - TN	B		5	1	15	1	5	20

Table A-3. (continued).

	DESCRIPTION	FAC. CAT.	MEDIUM						
			HP	MATLS. & EQUIP.			INST. COSTS		
				QTY	Unit Cost $1000's	Amount $1000's	Unit Cost $1000's	Amount $1000's	Total U.O.
	–Allowance for Piping / Mechanical	A		Lot	120	360	48	48	408
	–Control Panel – FT	D		2	10	30	1	2	32
	–Allowance for Electrical / Control	D		Lot	266	399	53	53	452
	–Calibration, Testing & Startup	D		Lot	15	23	192	192	215
	–Air Locks	E		2	124	248	39	78	326
	Total Incinerator					2275		619	2894
DL–3	**Prepare & Feed for Solidification**								
	–Ash Hopper/De–lumper (100,300,500 CF)	B	2	1	150	300	30	30	330
	–Pneumatic Conveyor	B	5	1	50	100	10	10	110
	–Allowance for Piping / Mechanical	A		Lot	20	60	8	8	68
	–Control Panel – FT	D		4	10	48	1	4	52
	–Allowance for Electrical / Control	D		Lot	46	55	11	11	66
	–Calibration, Testing & Startup	D		Lot	10	12	30	30	42
	Total Prep & Feed for Solidification					575		93	668
DA–3	**Prepare & Feed for Solidification**								
	–Ash Hopper/De–lumper (100,300,500 CF)	B	2	1	150	450	30	30	480
	–Pneumatic Conveyor	B	5	1	50	150	10	10	160
	–Allowance for Piping / Mechanical	A		Lot	20	60	8	8	68
	–Control Panel – FT	D		4	10	60	1	4	64
	–Allowance for Electrical / Control	D		Lot	46	69	14	14	83
	–Calibration, Testing & Startup	D		Lot	10	15	30	30	45
	–Air Locks	E		1	124	124	39	39	163
	Total Prep & Feed for Solidification					928		135	1063
DL–4	**Solidify**								
	–Conveyor – Roller (24"x15')								
	–Binder Feed Prep								
	–Binder Feed Hopper								
	–Waste Feed Prep								
	–Waste Feed Hopper								
	–Binder / Waste Mixing Station								
	–Drum Tumbler								
	–Weigh Station								
	–Drum Capping & Cap Removal								
	–Dust Collection & Ventilation								
	–Allowance for Structural Steel – TN								
	–Complete Package per Above Detail	B		Lot	200	400	72	72	472
	–Allowance for Electrical / Control	D		Lot	80	96	16	16	112
	–Calibration, Testing & Startup	D		Lot	10	12	72	72	84
	Total Solidify					508		160	668
DA–4	**Solidify**								
	–Conveyor – Roller (24"x15')								
	–Binder Feed Prep								
	–Binder Feed Hopper								
	–Waste Feed Prep								
	–Waste Feed Hopper								
	–Binder / Waste Mixing Station								
	–Drum Tumbler								
	–Weigh Station								
	–Drum Capping & Cap Removal								
	–Dust Collection & Ventilation								
	–Allowance for Structural Steel – TN								
	–Complete Package per Above Detail	B		Lot	200	600	72	72	672

Table A-3. (continued).

	DESCRIPTION	FAC. CAT.	HP	MEDIUM					
				MATLS. & EQUIP.			INST. COSTS		
				QTY	Unit Cost $1000's	Amount $1000's	Unit Cost $1000's	Amount $1000's	Total U.O.
	– Allowance for Electrical / Control	D		Lot	80	120	16	16	136
	– Calibration, Testing & Startup	D		Lot	10	15	72	72	87
	– Air Locks	E		1	124	124	39	39	163
	Total Solidify					859		199	1058
DL–5	**Drum Capping & Washing**								
	– Drum Wash Unit	A		2	25	150	5	10	160
	– Drum Conveying System	B		2	10	40	2	4	44
	– Control Panel – FT	D		2	10	24	1	2	26
	– Allowance for Electrical / Control	D		Lot	9	11	2	2	13
	– Calibration, Testing & Startup	D		Lot	2	2	42	42	44
	Total Drum Capping & Washing					227		60	287
DA–5	**Drum Capping & Washing**								
	– Drum Wash Unit	A		2	25	150	5	10	160
	– Drum Conveying System	B		2	10	60	2	4	64
	– Control Panel	D		2	10	30	1	2	32
	– Allowance for Electrical / Control	D		Lot	9	14	2	2	16
	– Calibration, Testing & Startup	D		Lot	2	3	42	42	45
	– Air Locks	E		2	124	248	39	78	326
	Total Drum Capping & Washing					505		138	643
DL–6	**Off–Gas Treatment**								
	– Gas Cooler								
	– Wet Scrubber								
	– Quenching Tower								
	– Mist Eliminator								
	– Heat Exchanger								
	– Condensor								
	– Scrubber Liquid Collection Tank								
	– Reheater								
	– HEPA Filter								
	– Glycol Cooling System								
	– Main Off–Gas Blower								
	– Exhaust Stack								
	– Complete Package per Above Detail	E		Lot	1620	1620	324	324	1944
	– De–Nox Unit	E		Lot	200	200	20	20	220
	– Environmental / Rad. Monitoring	E		Lot	600	600	120	120	720
	– Allowance for Valves, Pumps & Piping	A		Lot	242	726	97	97	823
	– Control Panel – FT	D		8	10	96	1	8	104
	– Allowance for Electrical / Control	D		Lot	534	641	107	107	748
	– Calibration, Testing & Startup	D		Lot	15	18	224	224	242
	Total Off–Gas Treatment					3901		900	4801
DA–6	**Off–Gas Treatment**								
	– Gas Cooler								
	– Wet Scrubber	2							
	– Quenching Tower								
	– Mist Eliminator								
	– Heat Exchanger								
	– Condenser	1							
	– Scrubber Liquid Collection Tank								
	– Reheater								
	– HEPA Filter								
	– Glycol Cooling System	1							

Table A-3. (continued).

	DESCRIPTION	FAC. CAT.	HP	MEDIUM: MATLS. & EQUIP.: QTY	MATLS. & EQUIP.: Unit Cost $1000's	MATLS. & EQUIP.: Amount $1000's	INST. COSTS: Unit Cost $1000's	INST. COSTS: Amount $1000's	Total U.O.
	– Main Off – Gas Blower	10							
	– Exhaust Stack								
	– Complete Package per Above Detail	E		Lot	1620	1620	324	324	1944
	– De – Nox Unit	E		Lot	200	200	20	20	220
	– Environmental / Rad. Monitoring	E		Lot	600	600	120	120	720
	– Allowance for Valves, Pumps & Piping	A		Lot	242	726	97	97	823
	– Control Panel – FT	D		8	10	120	1	8	128
	– Allowance for Electrical / Control	D		Lot	534	801	107	107	908
	– Calibration, Testing & Startup	D		Lot	15	23	224	224	247
	– Air Locks	E		3	124	372	39	117	489
	Total Off – Gas Treatment					4462		1017	5479
DL – 7	**Prepare & feed Lime**								
	– Package System	E		Lot	250	250	50	50	300
	– Control Panel	D		2	10	24	1	2	26
	– Allowance for Electrical / Control	D		Lot	52	62	10	10	72
	– Calibration, Testing & Startup	D		Lot	5	6	36	36	42
	Total Prepare & Feed Lime					342		98	440
DA – 7	**Prepare & feed Lime**								
	– Package System	E		Lot	250	250	50	50	300
	– Control Panel	D		2	10	30	1	2	32
	– Allowance for Electrical / Control	D		Lot	52	78	10	10	88
	– Calibration, Testing & Startup	D		Lot	5	8	36	36	44
	Total Prepare & Feed Lime					366		98	464
DL – 8	**Treat Liquid Waste**								
	– Surge Storage Tank					0		0	0
	– Precipitation Tank					0		0	0
	– Sludge Holding Tank					0		0	0
	– Sludge Pump					0		0	0
	– Filtrate Water Recirc Pump					0		0	0
	– Media Filter					0		0	0
	– Activated Alumina Column					0		0	0
	– Ion Exchange Column					0		0	0
	– Granulated Activated Carbon Column					0		0	0
	– Discharge Storage Tank					0		0	0
	– Complete Package per Above Detail	E		Lot	800	800	160	160	960
	– Allowance for Valves & Piping	A		Lot	150	450	70	70	520
	– Control Panel – FT	D		8	10	96	1	8	104
	– Allowance for Electrical / Control	B			192	0	38	0	0
	– Calibration, Testing & Startup	D		Lot	40	48	168	168	216
	Total Treat Liquid Waste					1346		238	1584
DA – 8	**Treat Liquid Waste**								
	– Surge Storage Tank					0		0	0
	– Precipitation Tank					0		0	0
	– Sludge Holding Tank					0		0	0
	– Sludge Pump					0		0	0
	– Filtrate Water Recirc Pump					0		0	0
	– Media Filter					0		0	0
	– Activated Alumina Column					0		0	0
	– Ion Exchange Column					0		0	0
	– Granulated Activated Carbon Column					0		0	0

Table A-3. (continued).

			MEDIUM						
		FAC.		MATLS. & EQUIP.			INST. COSTS		
	DESCRIPTION	CAT.	HP	QTY	Unit Cost $1000's	Amount $1000's	Unit Cost $1000's	Amount $1000's	Total U.O.
	–Discharge Storage Tank					0		0	0
	–Complete Package per Above Detail	E		Lot	800	800	160	160	960
	–Allowance for Valves & Piping	A		Lot	150	450	70	70	520
	–Control Panel – FT	D		8	10	120	1	8	128
	–Allowance for Electrical / Control	D		Lot	192	288	38	38	326
	–Calibration, Testing & Startup	D		Lot	40	60	63	63	123
	Total Treat Liquid Waste					1718		339	2057
DL–9	**Store & Feed Binder**								
	–Package System	E		Lot	250	250	50	50	300
	–Control Panel – FT	D		2	10	24	1	2	26
	–Allowance for Electrical / Control	D		Lot	52	62	10	10	72
	–Calibration, Testing & Startup	D		Lot	5	6	36	36	42
	Total Store & Feed Binder					342		98	440
DA–9	**Store & Feed Binder**								
	–Package System	E		Lot	250	250	50	50	300
	–Control Panel – FT	D		2	10	30	1	2	32
	–Allowance for Electrical / Control	D		Lot	52	78	10	10	88
	–Calibration, Testing & Startup	D		Lot	5	8	36	36	44
	Total Store & Feed Binder					366		98	464
DL–10	Elec. Dist & MCC								
DA–10	Elec. Dist & MCC								
DL–11	Heating, Ventilation & Exhaust								
DA–11	Heating, Ventilation & Exhaust								
DL–12	**Other Equipment**								
	–Fire Suppression System (Shredder Area)	E		Lot	70	70	15	15	85
	–Radiation Monitoring System	E		Lot	350	350	60	60	410
	–Fire Suppression System (Other Area)	E		Lot	65	65	12	12	77
	–Emergencey Shower & Decon Station	E		Lot	30	30	6	6	36
	–Sump Pump	A		Lot	10	30	3	3	33
	–Service & Instrument Air	E		Lot	190	190	50	50	240
	–Stand By Emergency Power System	D		Lot	230	276	40	40	316
	–					0			
	–					0			
	Total Other Equipment					1011		186	1197
DA–12	**Other Equipment**								
	–Fire Suppression System (Shredder Area)	E		Lot	70	70	15	15	85
	–Radiation Monitoring System	E		Lot	700	700	60	60	760
	–Fire Suppression System (Other Area)	E		Lot	65	65	12	12	77
	–Emergencey Shower & Decon Station	E		Lot	30	30	6	6	36
	–Sump Pump	A		Lot	10	30	3	3	33
	–Service & Instrument Air	E		Lot	190	190	50	50	240
	–Stand By Emergency Power System	D		Lot	230	345	40	40	385
	Total Other Equipment					1430		186	1616

Table A-4. Building and equipment material and installation cost estimate summary for incineration facility.

Estimate Summary – INCINERATION – ALPHA

		MEDIUM								
		Building Area					Material & Equipment Costs			Total
	UNIT OPERATION	Low Hazard sq.ft	Medium Hazard sq.ft	Maint. Area sq.ft	Process Area sq.ft	Total Area Cost $1000	Purchase Cost $1000	Installation Cost $1000	Total Cost $1000	Cost per Unit Oprtn. $1000
DA-1	Prepare & Feed Incoming Waste		600	600	900	2,322	3,640	396	4,036	6,358
DA-2	Incinerator		1,000	1,000	1,500	3,870	2,275	619	2,894	6,764
DA-3	Prepare & Feed for Solidification		300	300	450	1,161	928	135	1,063	2,224
DA-4	Solidify		300	300	450	1,161	859	199	1,058	2,219
DA-5	Drum Capping & Washing		300	300	450	1,161	505	138	643	1,804
DA-6	Off-Gas Treatment		1,800	1,800	2,700	6,966	4,462	1,017	5,479	12,445
DA-7	Prepare & feed Lime	600				108	366	98	464	572
DA-8	Treat Liquid Waste		600		900	1,602	1,718	339	2,057	3,659
DA-9	Store & Feed Binder	1,050				189	366	98	464	653
DA-10	Elec. Dist & MCC	1500				270				270
DA-11	Heating, Ventilation & Exhaust		2400			1,008				1,008
DA-12	Other Equipment					0	1,430	186	1,616	1,616
	Total Cost					19,818			19,774	39,592
		Post Totals to Table DA-6, Item				3.4.1			3.4.2	

Estimate Summary – INCINERATION

		MEDIUM								
		Building Area					Material & Equipment Costs			Total
	UNIT OPERATION	Low Hazard sq.ft	Medium Hazard sq.ft	Maint. Area sq.ft	Process Area sq.ft	Total Area Cost $1000	Purchase Cost $1000	Installation Cost $1000	Total Cost $1000	Cost per Unit Oprtn. $1000
DL-1	Prepare & Feed Incoming Waste		1,200			504	2,537	357	2,894	3,398
DL-2	Incinerator		2,000			840	2,027	549	2,576	3,416
DL-3	Prepare & Feed for Solidification		600			252	575	93	668	920
DL-4	Solidify		600			252	508	160	668	920
DL-5	Drum Capping & Washing		600			252	227	60	287	539
DL-6	Off-Gas Treatment		3,600			1,512	3,901	900	4,801	6,313
DL-7	Prepare & feed Lime	400				72	342	98	440	512
DL-8	Treat Liquid Waste		1,200			504	1,346	238	1,584	2,088
DL-9	Store & Feed Binder	400				72	342	98	440	512
DL-10	Elec. Dist & MCC	1650				297				297
DL-11	Heating, Ventilation & Exhaust		1600			672				672
DL-12	Other Equipment					0	1,011	186	1,197	1,197
	Total Cost					5,229			15,555	20,784
		Post Totals to Table DL-6, Item				3.4.1			3.4.2	

containing building and equipment material and installation estimate cost summary for an incineration facility is included as an example.

The building unit rates costs are representative of the building and its support systems, including utilities, fire protection, and site development costs. The alpha cell space building costs include high-efficiency particulate air (HEPA) filter systems. Special equipment and any additional mechanical or electrical systems necessary for operation of the equipment have not been included in the building unit rate costs. The unit rates do not include the construction contractor direct and indirect costs and the appropriate overheads and profit.

The remaining six cost subcomponents (design, inspection, project administration, indirect, construction management, and contingency) are determined using percentage factors. These percentages, building unit rates, and other major assumptions used to develop the production facility construction costs are the same as listed in Section A.4.2, above.

- The building unit rate costs listed below are for treatment facilities and based on similar facilities at the INEL.
  - Low hazards areas (e.g., areas for support and nonprocess functions including office, and incoming and outgoing packaged waste storage and handling spaces) are $180/ft^2$.
  - Moderate hazard building space including areas used for LLW/LLMW waste processing and alpha-LLW/LLMW operating galleries is $420/ft^2$.
  - Alpha cell space with double confinement barrier used for alpha-LLW/LLMW equipment maintenance galleries is $1200/ft^2$.
  - Alpha cell space with triple confinement barriers used to house alpha-LLW/LLMW processing equipment is $1,500/ft^2$.
- Building costs for storage facilities are based on similar preconceptual facility designs by MK. The following costs apply:
  - Loading/unloading and office areas at the front-end/back-end facility are $180/ft^2$.
  - The lab area for the front-end/back-end support facility are $420/ft^2$.
  - Small, medium, and large storage warehouses are $73/ft^2$, $57/ft^2$, and $47/ft^2$, respectively.
- Building costs for disposal facilities are based similar facilities at the Illinois LLW site. The hazard categories and their associated costs are as follows:
  - Low Hazard I space for administration/offices, warehouse and maintenance, material storage for the grout plant, unload/staging area, storage building, canister storage at the waste packaging building, utilities/mechanical building, and electrical substation. The cost is $165/ft^2$.

- Low Hazard II space for the site access building and truck wash station, as well as the lab, is $231/ft^2.

- Medium Hazard building space, which includes the waste packaging area, grout plant, assay, inspection, certification, secondary treatment, and waste packaging, is estimated at $346/ft^2.

- Stainless steel equipment is selected to allow for easy decontamination and maintenance. Stainless steel is specified even when materials considerations indicated that cheaper construction would be appropriate. Therefore, the estimate assumes the most expensive equipment or factors.

- The process areas for alpha-LLW/LLMW are located in an alpha cell with triple confinement barriers.

- Maintenance areas for alpha-LLW/LLMW are located in an alpha cell with double confinement barriers.

- Process and maintenance areas for LLW and LLMW process equipment are located in a moderate hazard rated building with approximately 12 in. of concrete walls for shielding.

- Facility construction cost estimates in this report do not include the infrastructure (utilities, roads or site development).

A.4.4 Operation and Maintenance

Operation and maintenance (O&M) cost is comprised of four subcomponents: operating manpower, utilities, materials, and maintenance. Operating manpower is estimated for each unit operation by assuming an appropriate operating crew for that unit. The estimated operating FTE requirements for each unit operation is presented in cost model tables in the attachments. PLCC estimates for the utility cost subcomponents, summarized in the cost model tables, include electric power, natural gas or No. 2 fuel oil, as appropriate. These costs are estimated by multiplying the equipment horsepower and energy consumption rates for each facility by the given energy cost unit rates (see below).

The material cost subcomponents includes consumables such as shipping/disposal containers, additives, chemicals, and personnel protective equipment. These are estimated for each facility based on the process flow rates given in the preconceptual design packages and are listed in the tables included in the cost model.

The maintenance cost subcomponent is divided into maintenance labor and maintenance replacement equipment cost. These costs, presented in the tables in the cost model, are obtained by assuming that the annual maintenance equipment cost is 7% of the original equipment capital cost and that the annual maintenance labor cost is 250% of the maintenance equipment cost.

General assumptions used to develop the operation and maintenance costs are given below:

- The following utility and operating rates are established based on INEL site for the development of life cycle costs:
  - Electricity @ $0.035/kWh
  - Propane @ $0.60/gal
  - No. 2 fuel oil @ $0.80 per gal.
- Present day costs are used for preparation of the O&M cost estimates.
- A contingency factor of 25% is applied to the project subtotal O&M costs.
- Operating staff labor rate is $140,000/FTE.
- Unprocessed waste is packaged in drums, boxes, or metal bins at the originating facility before shipment to the treatment plants. Hence, cost for packaging of unprocessed waste is not included in the estimates.
- Additive soil cost for the vitrification facility is negligible.
- The O&M costs are based on a facility operating schedule of three 8-hour shifts, 5 days/week, and 240 days/year.
- Portland cement binder cost for solidification is $0.05/lb.
- Shipping/disposal container is 55 gal drums at $25/each or 85 gal drums at $40/each.

A.4.5 Operating Budget Funded Activities

In accordance with DOE orders, there are a number of activities that can not be charged to the Line Item Construction Projects funds. A breakdown of these activities and preliminary cost estimates are given below. It is assumed that the level of effort required for some of these activities are the same for all major facilities, except common support facilities.

Project activities to be funded by operating budgets and the estimated costs are

- Conceptual design at 1.5% of construction cost.
- Project management prior to Title I design at 10% of the National Environmental Policy Act (NEPA) conceptual design safety assurance and preparation for operation costs.
- Environmental and permitting (NEPA documentation including environmental impact statements, Federal, state, and local permits) estimated at $6,000,000 for each waste treatment and disposal facility that requires a full NEPA process including preparation,

review and approval of an environmental impact statement. Smaller projects such as shredding/compaction and storage facilities are assumed to require only an environmental assessment report followed by a finding of no significant impact and are estimated at $1,000,000. Since front-end and back-end support facilities are assumed to be constructed along with the main facilities, no permitting/NEPA cost allowances are required.

- Safety assurance documentation (safety analysis, reliability, availability and maintainability analysis, probabilistic risk assessment, hazards analysis, criticality reviews, and radiation analysis) at 1.5% of the construction cost.

- Preparation for operation (operations procedure, operating personnel staffing, training and testing, readiness reviews, spare parts, and material) is assumed to start 3 years before the facility begins production operation. Based on the experience at the TSCA incinerator at Oak Ridge National Laboratory, the cost for the preoperation activity is assumed to be approximately 100% of the annual operating cost. This accounts for 15% for the first year of preoperation, 25% in the second year, and 60% in the last year.

A.4.6 Decommissioning

Decontamination and decommissioning costs for treatment facilities are based on a recent cost study conducted by EG&G Idaho for the buried transuranic waste (R. Schlueter, et al., *Low-Level and Transuranic Waste Transportation Disposal and Facility Decommissioning Cost Sensitivity Analysis*, WTD-10092, 1992). Based on this study, a cost of $\$450/ft^3$ average unit rate for treatment facilities is used. Decontamination and decommissioning costs for storage facilities are estimated at $\$50/ft^2$. The calculated costs are shown in the cost model tables. Table A-5 containing decontamination and decommissioning costs for an incineration facility is included as an example.

A.4.7 Transportation Costs

Transportation costs are based on a recent cost study conducted by EG&G Idaho for the buried transuranic waste (Schlueter, 1992). Transportation costs are calculated based on the system input or output waste volumes, whichever is appropriate.

A.4.8 Cost Summaries

Cost summaries are presented according to the six components described in this appendix. Also shown in cost summary tables are cost subcomponents and the appropriate multiplication factors. These tables have been included in Sections 2 through 17 of main report.

Table A-5. Decontamination and decommissioning cost estimates for an incineration facility.

ALPHA

	UNIT OPERATION	MEDIUM Building Area Low Hazard sq.ft	Medium Hazard sq.ft	Maint. Area sq.ft	Process Area sq.ft	D&D Cost (X $1000)
DA-1	Prepare & Feed Incoming Waste	0	600	600	900	945
DA-2	Incinerator	0	1000	1000	1500	1,575
DA-3	Prepare & Feed for Solidification	0	300	300	450	473
DA-4	Solidify	0	300	300	450	473
DA-5	Drum Capping & Washing	0	300	300	450	473
DA-6	Off-Gas Treatment	0	1800	1800	2700	2,835
DA-7	Prepare & feed Lime	600	0	0	0	270
DA-8	Treat Liquid Waste	0	600	0	900	675
DA-9	Store & Feed Binder	1050	0	0	0	473
DA-10	Elec. Dist & MCC	1500	0	0	0	675
DA-11	Heating, Ventilation & Exhaust		2400			1,080
DA-12	Other Equipment	0	0	0	0	0
	Total Cost					9,947
		Post Totals to Table DA-6, Item				6.0

LLW/LLMW

	UNIT OPERATION	MEDIUM Building Area Low Hazard sq.ft	Medium Hazard sq.ft	Maint. Area sq.ft	Process Area sq.ft	D&D Cost (X $1000)
DL-1	Prepare & Feed Incoming Waste	0	1200	0	0	540
DL-2	Incinerator	0	2000	0	0	900
DL-3	Prepare & Feed for Solidification	0	600	0	0	270
DL-4	Solidify	0	600	0	0	270
DL-5	Drum Capping & Washing	0	600	0	0	270
DL-6	Off-Gas Treatment	0	3600	0	0	1,620
DL-7	Prepare & feed Lime	400	0	0	0	180
DL-8	Treat Liquid Waste	0	1200	0	0	540
DL-9	Store & Feed Binder	400	0	0	0	180
DL-10	Elec. Dist & MCC	1650	0	0	0	743
DL-11	Heating, Ventilation & Exhaust	0	1600	0	0	720
DL-12	Other Equipment	0	0	0	0	0
	Total Cost					6,233
		Post Totals to Table DL-6, Item				6.0

Appendix B

Scenario Costing Worksheet

Appendix B

Scenario Costing Worksheet

B.1 SCENARIO COSTING STEPS

B.1.1 Step 1—Define Scenarios

Step 1.1—Define waste sources and generator locations. Enter data in Table B-1 per the following instructions (use one table for each location):

a. Enter in the first row heading the location of the facility where the waste is generated or stored.

b. For each category of waste, enter the quantity (lbs) in the appropriate cell in the table. If input waste is in cubic feet or cubic meter, multiply by the appropriate density to get total waste quantity in lbs.

Step 1.2—Define types and location of treatment facilities and their input waste quantities. Use Table B-2 as a guide in selecting a treatment facility that is suitable for a given waste category. Enter data in Table B-3 per the following instructions (use one table for each location):

a. Enter in the table first row heading the location where the treatment facility is to be located.

b. Place a checkmark under the "Req'd" column in front of each required facility.

c. Enter input waste quantity from step 1-1 in front of the required facility and under the "input waste quantity" column.

d. If a facility is a stand-alone facility (i.e., it is not being augmented to an existing operational facility), select the appropriate front-end and back-end support facilities and enter input waste quantities in front of the required facilities under the "input waste quantity" column.

Step 1.3—Define types and location of storage facilities. Enter data Table B-4 per the following instructions (use one table for each location):

a. Enter in the table first row heading the location where the facility will be located.

b. Place a checkmark under the "Req'd" column in front of the required storage facility.

c. If a facility is a stand-alone facility (i.e., it is not being augmented to an existing operational facility), select the front-end/back-end support facility and place a checkmark under the "Req'd" column in front of the front-end/back-end support facility.

Table B-1. Waste sources information for each location.

Generator or Storage Location:____________________

Waste Category (1)	Low-Level Waste (lbs)	Low Level Mixed Waste (lbs)	Alpha-Low-level Waste (lbs)	Alpha-Low Level Mixed Waste (lbs)	Transuranic Waste (lbs)
DAW-1, Combustible Solids					
DWA-2, Semi-Combustible Solids					
DAW-3, Non-Combustible Solids					
DAW-4, Heterogeneous Solids					
DAW-5, Metal Waste					
DAW-6, Special Solid Waste					
SLW-1, Non-Organic Liquid					
SLW-2, Organic Liquid					
SLW-3, Special Liquid Waste					
LQW-1, Non-Organic Sludge					
LQW-2, Organic Sludge					
LQW-3, Special Sludge Waste					
Total					

Ships Waste To: (give treatment facility locations & total volume to be shipped to each facility)

(1) ____________________ (2) ____________________

(3) ____________________ (4) ____________________

(1) See Appendix A for a description of various waste categories.

Table B-2. Treatment facility selection guide.

Treatment Type	DAW-1 Combust. Solids	DAW-2 Semi-Combust. Solids	DAW-3 Non-Combust. Solids	DAW-4 Heterog-eneous Solids	DAW-5 Metal Waste	DAW-6 Special Solid Waste	SLW-1 Non-Organic Sludge	SLW-2 Organic Sludge	SLW-3 Special Sludge Waste	LQW-1 Non-Organic Liquid	LQW-2 Organic Liquid	LQW-3 Special Liquid Waste
Incineration	(1)	(1)	NR	70% of total (3)	NR	NR	NR	(1)	NR	NR	(1)	NR
Metal Melting	NR	NR	NR	8.5% of total (3)	(1)	NR	NR	NR	NR	NR	NR	NR
Shredder/ Compaction	(2)	(2)	(2)	(2)	(2)	NR	NR	NR	NR	NR	NR	NR
Solidification	NR	NR	(1)	20% of total (3)	NR	NR	(1)	(2)	NR	(1)	(2)	NR
Vitrification	NR	NR	(1)	20% of total (3)	NR	NR	(1)	NR	NR	(1)	NR	NR
Special Treatment	NR	NR	NR	1.5% of total (3)	NR	(1)	NR	NR	(1)	NR	NR	(1)

(1). Generally recommended for both RCRA and non-RCRA waste (LLW/LLMW and alpha-LLW/LLMW).

(2). Generally recommended for non-RCRA waste (LLW and alpha-LLW) only.

(3). This percentage breakdown is based on the assumption used in this report. If available, the reader should use actual site specific data.

NR Generally not recommended for the given waste stream

Table B-3. Treatment facilities information.

Treatment Facility Location: ____________________

Receives Waste From: (give generator or stored waste locations & total volume to be shipped per facility)

(1) ____________________, (2) ____________________,

(3) ____________________, (4) ____________________.

Facility	Req'd.	Input Waste Quantity (lb)	Input Waste (lbs/hr)	Output Waste (ft^3/hr)	PLCC Estimate ($)
Treatment Front-End Support Facilities					
Administration (Mod. A)					
Unloading/Shipping(Mod. B)					
Open, Dump, & Sort (Mod. CL)					
Open, Dump, & Sort (Mod. CA)					
Treatment Facilities					
Incinerator (Mod. DL)					
Incinerator (Mod. DA)					
Metal Melting (Mod. EL)					
Metal Melting (Mod EA)					
Shredder/Compaction (Mod FL)					
Shredder/Compaction (Mod FA)					
Solidification (Mod GL)					
Solidification (Mod GA)					
Vitrification (Mod. HL)					
Vitrification (Mod. HA)					
Treatment Back End Support Facilities					
Shipping/Certification (Mod. I)					
Maintenance Shop (Mod. JL)					
Maintenance Shop (Mod. JA)					
Total					

Ships Waste To: (give storage or disposal locations & total volume to be shipped to each facility)

(1) ____________________ (2) ____________________

(3) ____________________ (4) ____________________

Table B-4. Storage facilities information.

Storage Facility Location:________				
Receives Waste From: (give treatment facility locations & total volume to be shipped per facility) (1)________ (2)________ (3)________ (4)________				
Facility	Req'd.	Input Waste (ft^3/hr)	Output Waste (ft^3/hr)	PLCC Estimate ($)
Storage Front-End/Back-End Support Facilities				
Admin./Unloading/Shipping(Mod. K)				
Storage Facilities				
LLW Storage (Mod. L)				
Alpha-LLW/LLMW Storage (Mod. M)				
TRUW Storage (Mod. M)				
LLMW Storage (Mod N)				
Total				
Ships Waste To: (give disposal locations & total volume to be shipped to each facility) (1)________ (2)________ (3)________ (4)________				

Step 1.4—Define types and location of disposal facilities. Enter data in Table B-5 per the following instructions (use one table for each location):

a. Enter in the table first row heading the place where the facility will be located.

b. Place a checkmark under the "Req'd" column in front of the required disposal facility.

c. If a facility is a stand-alone facility (i.e., it is not being augmented to an existing operational facility), select the front-end support facility and place a checkmark under the "Req'd" column in front of the front-end support facility.

B.2.1 Step 2—Define Parameters

Step 2.1—Calculate treatment facility input and output flow rates. For each treatment facility including all front-end and back-end support facilities, perform calculations and enter data in Table B-3 per the following instructions:

a. Enter in the blank space in the table second row heading the origin of the generated or stored waste that will be sent to the treatment facility and the total waste to be shipped from each origin.

Table B-5. Disposal facilities information.

Disposal Facility Location:____________________

Receives Waste From: (give treatment or storage facility locations & total volume to be shipped per facility)

(1) ____________________ (2) ____________________

(3) ____________________ (4) ____________________

Facility	Req'd.	Input Waste (ft^3/hr)	PLCC Estimate ($)
Disposal Front-End Support Facilities			
Admin./Unloading/Shipping(Mod. O)			
Disposal Facilities			
Non-RCRA Engineered Disposal(Mod. P)			
RCRA Engineered Disposal (Mod. Q)			
Shallow Land Disposal (Mod. R)			
Geologic Disposal (Mod N)			
Total			

b. Divide each treatment facility input waste quantity (in lbs) by 80,640 hours to get input waste flow rate (in lbs/h). Enter this number in front of the selected facility under the designated column.

c. Multiply each treatment and back-end facilities input flow rates by the conversion factors given in Table 18-2 to obtain "output waste" flow rates (in ft^3/h). Enter this number in front of the selected treatment and back-end treatment facilities under the designated column. (Note: this step is not required for the front-end facilities.)

d. Enter in the blank space in the last row of the table the destination of the treated waste and the total waste to be shipped to each destination.

Step 2.2—Calculate storage facility input and output flow rates. For each storage facility including the front-end/back-end support facility, perform calculations and enter data in Table B-4 per the following instructions:

a. Enter in the blank space in the table second row heading the origin of the treated waste that will be sent to the storage facility and the total waste to be shipped from each origin.

b. Add the output flow rates of the treatment facilities that will be sending waste to the storage facility. Enter this number in front of the selected facilities under the "input waste" column.

c. Enter in the blank space in the last row of the table the destination of the stored waste and the total waste to be shipped to each destination.

Step 2.3—Calculated Disposal facility input flow rates. For each disposal facility including the front-end support facility, perform calculations and enter data in Table B-5 per the following instructions:

a. Enter in the blank space in the table second row heading of the table the origin of the treated or stored waste that will be sent to the disposal facility and the total waste to be shipped from each origin.

b. Add the output flow rates of the treatment and storage facilities that will be sending waste to the disposal facility. Enter this number in front of the selected facilities under the "input waste" column.

Step 2.4—Calculate transportation distances. Enter data in Table B-6 per the following instructions (use one matrix for each scenario):

a. For each treatment facility enter the location of the generator or storage facility sending waste for treatment and the total volume of the incoming waste. Enter the distance (in miles) between the generator or storage and treatment facilities.

b. For each storage facility enter the location of the treatment facility sending waste for storage and the total volume of the incoming waste. Enter the distance (in miles) between the treatment and storage facilities.

c. For each disposal facility enter the location of the treatment or storage facility sending waste for disposal and the total volume of the incoming waste. Enter the distance (in miles) between the treatment or storage and disposal facilities.

Table B-6. Transportation information for each scenario.

Waste Description	Waste Volume (ft^3)	Transport From (Location)	Transport to (Location)	Mileage	Mileage Unit cost ($)	Total Cost ($)
Waste to Treatment Facilities (Tables B-1 and B-3)						
Waste to Storage Facilities (Table B-4)						
Waste To Disposal Facilities (Table B-5)						
Total						

B.3.1 Step 3—Develop Treatment PLCC Estimates

For each of the treatment facilities identified in Table B-3 refer to an appropriate cost histogram in Sections 2 to 11 of the report. Obtain PLCC estimate from this histogram by selecting one of the cost modules which is the closest to the required capacity. Enter this cost in Table B-3 under the designated column in front of the given treatment facility.

B.4.1 Step 4—Develop Storage PLCC Estimates

Fore each storage facility identified in Table B-4, refer to an appropriate cost histogram in Sections 12 and 13 of the report. Obtain a PLCC estimate from this histogram by selecting one of the cost modules closest to the required capacity. Enter this cost in Table B-4 under the designated column in front of the given storage facility.

B.5.1 Step 5—Develop Disposal PLCC Estimates

For each disposal facility identified in Table B-5, refer to an appropriate cost histogram in Sections 14 through 17 of the report. Obtain a PLCC estimate from this histogram by selecting one of the cost modules closest to the required capacity. Enter this cost in Table B-5 under the designated column in front of the given disposal facility.

B.6.1 Step 6—Develop Transportation Cost Estimates

In Table B-6, multiply volume of the waste to be shipped by the factors given in Section 18.5.6. Enter total cost in the designated column in Table B-6.

B.7.1 Step 7—Total PLCC Estimates

Enter total costs from Tables B-3, B-4, B-5 and B-6 in Table B-7. Add the totals to obtain total cost for the scenario.

Table B-7. Total scenario PLCC estimate.

Location	Total Cost ($)
Treatment Facilities (Table B-3)	
Location: ______________	
Location: ______________	
Location: ______________	
Location: ______________	
Location: ______________	
Storage Facilities (Table B-4)	
Location: ______________	
Location: ______________	
Location: ______________	
Disposal Facilities (Table B-5)	
Location: ______________	
Location: ______________	
Location: ______________	
Transportation (Table B-6)	
Total	

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