ECONOMICS OF RADIOACTIVE WASTE MANAGEMENT AT OAK RIDGE NATIONAL LABORATORY, ARGONNE NATIONAL LABORATORY, AND BROOKHAVEN NATIONAL LABORATORY

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FOREWORD

This material has been prepared for consideration by the Panel on Economics of Radioactive Waste Management, sponsored by the International Atomic Energy Agency, Vienna, December 13 - 18, 1965. The information is presented separately for Oak Ridge National Laboratory, Argonne National Laboratory, and Brookhaven National Laboratory, and is organized for each site to conform as nearly as possible to the outline of the I.A.E.A. Questionnaire.

Waste management costs are not kept by these laboratories in a manner compatible with that suggested in the Questionnaire. Existing records of manpower and costs were used with the best judgment of the waste managers at each site to estimate as many of the incremental costs as possible. As a consequence these costs are believed to represent good estimates based on actual operating experience, but they are not exact numbers and should not be interpreted or used as such.

The compilers wish to acknowledge the assistance of the following persons in the course of gathering the information: R. Carter, K. E. Cowser, J. H. Gann, J. R. Gissel, L. C. Lasher, C. T. Long, and E. J. Witkowski of Oak Ridge National Laboratory; S. G. Pearsall of Brookhaven National Laboratory; and J. R. Novak. J. Sedlet, and L. Wallis of Argonne National Laboratory.

PART ONE: OAK RIDGE NATIONAL LABORATORY

1. INFORMATION ABOUT THE MAJOR WASTE-PRODUCING OPERATIONS AT THE SITE

Oak Ridge National Laboratory (ORNL) is a research and development center employing 4000 persons in a group of laboratories, chemical pilot plants, radioisotope production plants, nuclear reactors, and supporting facilities in its main area (1.6 km long by 0.8 km wide). Of the 4000 employees, it is estimated that approximately 900 are scientific and technical personnel engaged in work that results in the production of radioactive waste. The estimated distribution of these persons according to the nature of their work and the liquid and solid wastes they produce is given in Table 1. These figures are based on a 12-month period considered to be representative of current operations.

2. INFORMATION ABOUT THE WASTES AND THEIR MANAGEMENT (REF. 1, 2, 3, 4).

2.1 - 2.3 Classifications and Characteristics of ORNL Wastes and Methods of Handling Them

High-Activity Liquid Waste (more than 3×10^{-3} μc/ml). This waste is now diluted and combined with intermediate activity waste, but soon will be stored in two new 190-m^3 stainless steel tanks with water cooling coils and jackets. Production principally from chemical pilot plants and radioisotope processing is expected to average less than 10 m^3 per year.

Intermediate-Activity Liquid Waste (between 3×10^{-3} μc/ml and 3×10^{3} μc/ml). These wastes are discharged by the producers at a rate of 20 to 40 m^3/day from chemical laboratories, hot cells, and pilot plants into any of 17 underground stainless-steel monitoring tanks, each located near a waste source (Fig. 1). The wastes are neutralized with NaOH in the tanks and the liquid level in each tank is telemetered and continuously recorded in the Waste Monitoring Control Center. At proper intervals the waste is transferred by pumps and steam jets through 2-in. stainless-steel pipe into three, 640-m^3 underground concrete tanks. After a two-month period for decay of short-lived radionuclides, they

Table 1. Waste-Producing Operations at ORNL During 12-Month Period: July 1964 - June 1965

	Number Persons Producing Waste	Production of Liquid Wastes				Production of Solid Wastes,[c] % of Volume
		Intermediate Activity[a]		Low Activity[b]		
		% of Volume	% of Activity	% of Volume	% of Activity	
Chemical & Metallurgical Research & Development Laboratories & Hot Cells	635	30	25	59	16	65
Solid States Laboratories & Hot Cells	100	24	2	11	6	9
Reactor Operations	50	12	1	16	38	8
Chemical Pilot Plant	25	20	2	7	6	12
Radioisotope Development & Production	90	14	70	7	34	6

a Based on a total volume of intermediate-activity waste of 1.72×10^4 m^3 containing 1.82×10^5 curies of radioactivity.

b Based on a total volume of low-activity waste of 8.36×10^5 m^3 containing 15.1 curies of radioactivity.

c Based on a total volume of 4026 m^3 of solid wastes.

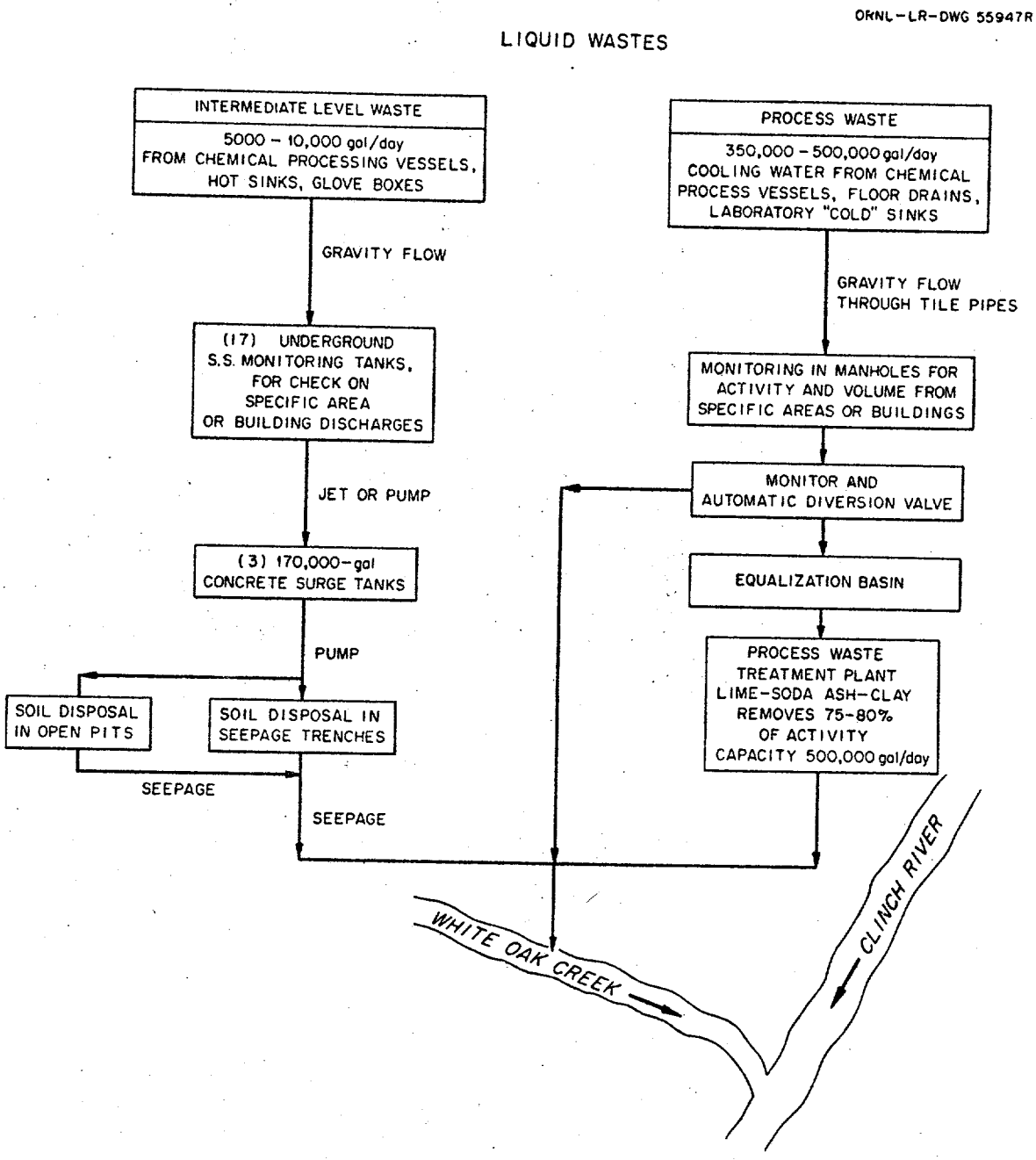

Fig. 1. ORNL Liquid Waste Flowsheet.

are sampled for radiochemical analysis and pumped through 2-in. cast-iron pipe to soil seepage trenches in the disposal area.

The radioactive nuclides in this waste are mainly ^{137}Cs, ^{90}Sr, ^{106}Ru, ^{60}Co, and rare earths. During the past five years, the radioactivity levels and volumes have varied as shown in Table 2. Sodium nitrate and hydroxide comprise about 75% of the non-radioactive chemical content, and total solids range from 5 to 10 g/liter.

Low-Activity Liquid Waste (less than 3×10^{-3} μc/ml). This waste arises from vessel cooling systems, floor drains, reactor fuel storage canals, and laboratory sinks. It is similar in non-radioactive chemical content to the local tap water (alkalinity of 94 mg/liter, total hardness of 130 mg/liter, and pH of 7.3). Annual variations in volume and radiochemical content are given in Table 3.

The waste from the different sources flows by gravity through underground terra-cotta pipes to a diversion box (Fig. 1), equipped with flow measuring equipment, a proportional sampler, and radiation-detection devices. Signals from these instruments are telemetered to the Waste Monitoring Control Center where they are continuously recorded. At the diversion box, the waste can be routed to a 3800-m^3 equalization basin for processing through the Process Waste Treatment Plant; or if the radioactivity level is less than 1.3×10^{-4} μ curies/ml, it can be sent directly to the creek, without processing, by means of an automatically controlled valve. Large volumes too radioactive for treatment can be pumped to a 11,000-m^3 emergency impoundment basin in the disposal area.

In addition to the diversion box, there are nine monitoring stations in the main tributaries of the low-activity waste system. Each station is equipped with flow and radioactivity-measuring devices, the signals of which are telemetered and recorded at the Waste Monitoring Control Center. A proportional sampler is also installed at each station. Proportional samples taken at the diversion box are analyzed for gross beta activity every four hours; samples from the tributary monitors are analyzed only monthly for inventory purposes or when abnormal discharges occur.

Table 2. Volumes and Radionuclide Content of ORNL Intermediate-Activity Liquid Waste[a]

Year	Volume, m^3	Major Radionuclide Constituents, curies/yr.					
		Total Sr[b]	106-Ru	137-Cs	60-Co	Rare Earths	Total
1960	11,800	-	-	-	-	-	25,030
1961	11,800	2,880	1,590	26,010	-	1,850	32,330
1962	17,300	2,940	2,680	35,570	280	1,730	43,200
1963	17,600	16,730	3,210	100,350	1,590	-	121,880
1964	17,500	22,750	430	147,960	330	-	171,470

a Sodium nitrate and hydroxide represent about 75% of the non-radioactive salt content of these wastes. Other inerts include Al, Fe, SO_4, and Cl. Total solids average 5 to 10 g/liter.

b "Total Sr" is greater than 90% ^{90}Sr.

Table 3. Characteristics of Process Waste [2]

Period	Waste Generated	Waste Treated		Radionuclides in Waste Treated (curies/liter x 10^{-7})		
	10^3 m^3/day	10^3 m^3/day	(liters/min)	$^{89+90}Sr$	^{137}Cs	Rare Earths
Sept. 1957 to Sept. 1959	2.9	1.5	1020	1.5	1.7	1.8
1960	1.9	1.7	1160	1.5	8.3	5.2
1961	1.4	1.3	900	0.51	0.11	0.53
1962	1.7	1.6	1150	0.34	0.23	0.15
1963	2.3	1.8	1250	0.27	0.098	----
1964	2.3	1.9	1320	0.37	0.15	----
Jan. 1965 to Aug. 1965	1.7	1.4	990	0.22	0.097	----

Low-activity waste containing, generally, greater than 1.3×10^{-4} μc/ml of radioactivity are treated by a horizontal-flow water-softening plant.[5,6] The capacity of the plant is about 2000-m^3/day, and lime, soda ash, and clay are used to remove from 50 to 85% of the radioactive contaminants (Table 4). Sludge containing the separated radionuclides is transported by truck to a disposal pit excavated in a local shale formation. The decontaminated effluent is released to the creek.

Radioactive Solid Waste. This waste is mainly contaminated paper and glassware and occasionally concrete, wood, and even large pieces of equipment. Waste is collected in special covered and leak-proof garbage cans inside buildings and large, lead-lined "pans" outside; sent to the burial ground in the disposal area in special trucks; and dumped into trenches 3 m wide by 5 m deep dug in shale by earth-moving equipment. The trenches are backfilled to cover the waste by three or more feet of earth. Packages of high-level wastes are buried separately in vertical auger holes. All waste-handling equipment and personnel are carefully surveyed to avoid over-exposure and the spread of contamination. Monitoring wells surrounding the burial ground detect radioactive seepage.

In addition to waste produced at ORNL, waste is received from other sites for burial. Information on the types and amounts of radioisotopes is generally lacking in these as well as ORNL wastes. Waste volumes and land area consumed by burial at ORNL during the 12-month period, July 1964 through June 1965, is as follows:

	Number Package Units	Volume, m^3	Land Area, hectares
Oak Ridge (ORNL and other local operations)	4192	4327	
Off-site	5387	1012	
Total	9579	5339	0.72

Decontamination Laundry and Equipment Decontamination. These two facilities processing contaminated materials do not contribute to the waste streams described above. The laundry washes items contaminated to a level no greater than 50 mrad/hr, and reuse is limited to those

Table 4. Average Percentage Removal of Radionuclides by Treatment System[2]

Period	$^{89+90}Sr$	Rare Earths	^{137}Cs	^{106}Ru	^{60}Co	Gross Beta Activity
Sept. 1957 - Feb. 1958	77	79	---	---	---	---
Mar. 1958 - Aug. 1959	84	86	---	---	---	---
Sept. 1957 - Sept. 1958	---	---	21	49	65	66
Oct. 1958 - Aug. 1959	---	---	86	76	78	88
Jan. 1960 - June 1961	72	81	81	72	42	---
July 1961 - Dec. 1964	74	71[a]	75	75	73	---
Jan. 1965 - Aug. 1965	86	---	81	[b]	67	88

[a] Average through December 1962.

[b] Detected infrequently in untreated waste.

reading less than 0.75 β-γ mrad/hr/650 cm^2, and no detectable α activity. Items not meeting these criteria are buried. The waste effluent from the laundry is routinely checked for radio activity content and discharged directly to the creek.

The decontamination facility handles portable items of equipment which have been surface-contaminated not in excess of a level permitting direct methods of cleaning. A wide range of equipment is processed including shipping containers, lead brick, laboratory furniture and supplies, and vehicles. The wastes are discharged to a seepage trench immediately adjacent to the facility without treatment.

Management of the wastes from these two facilities is not further considered in this presentation.

Environmental Monitoring. As can be seen from Fig. 2, the entire lower basin of White Oak Creek serves as a waste disposal facility for ORNL. The creek receives effluents from the sanitary sewage disposal plant and from the low-activity waste treatment plant, seepage from burial grounds and waste pits and trenches, and run-off from storm sewers. An earth dam across the creek about 0.6 km above its confluence with the Clinch River (Fig. 2, No. 7) permits short-term (1 week) impounding of water. To detect accidental releases and to maintain an inventory of released radioisotopes, the creek is monitored at seven points (Numbers 1 through 7, Fig. 2). These monitoring stations measure the total flow and provide a proportional sample. Samples normally cover an operating period of one month and are analyzed for $^{89+90}Sr$, ^{137}Cs, ^{106}Ru, and gross-beta activity.

In addition to the monitoring described above, there is a program of off-site monitoring of the major streams outside the ORNL area. Water and bottom sediment samples are taken regularly at a number of selected sites along the Clinch and Tennessee Rivers and analyzed for radionuclide content.[7]

2.4 Personnel Distribution

The estimated personnel distribution in the ORNL waste management operations for fiscal year 1965 is given in Table 5.

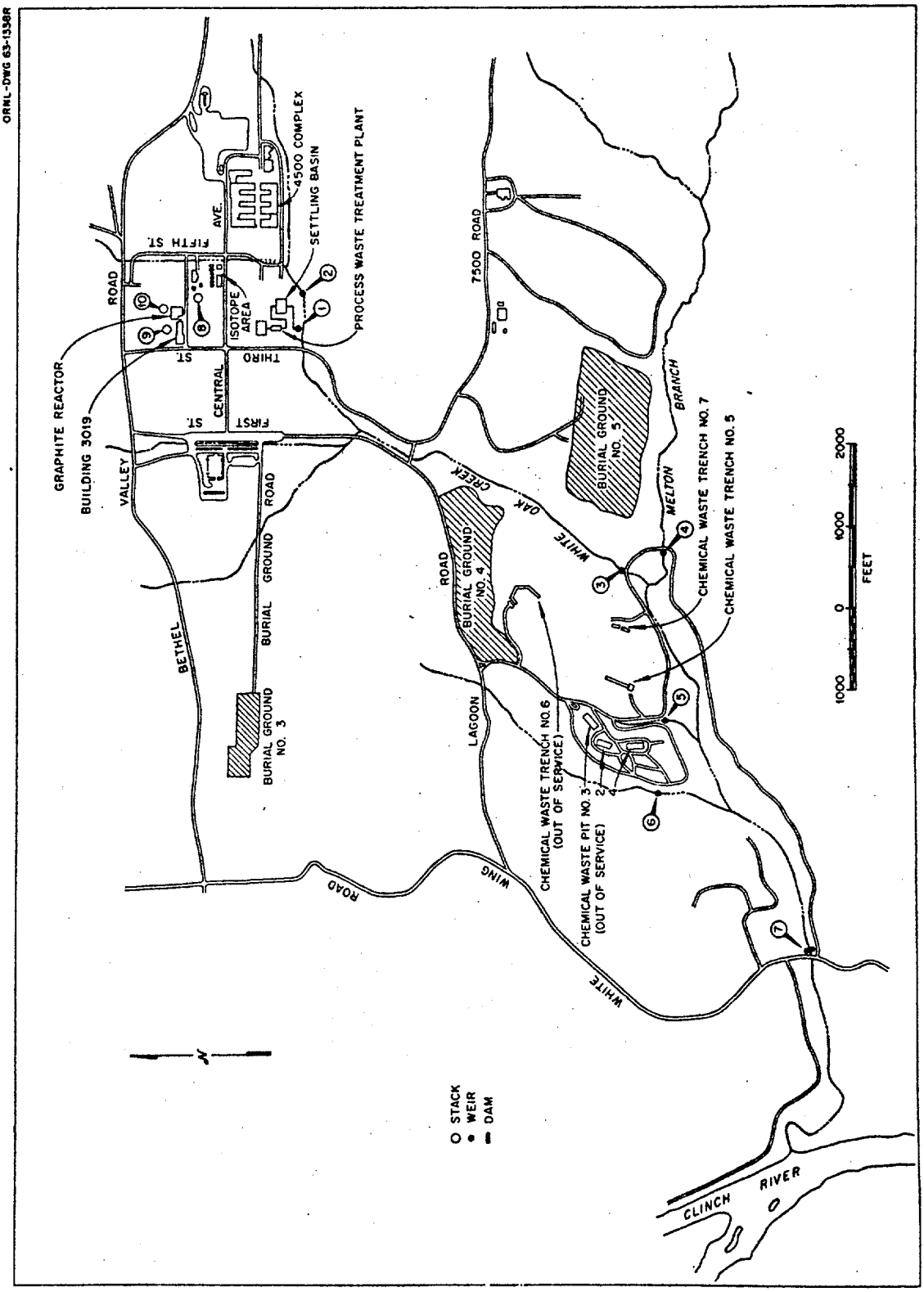

Fig. 2. Location Plan for ORNL Waste Monitoring Stations.

Table 5. Estimated Personnel Distribution in ORNL Waste Management for FY-1965 (Man-years)

	Intermediate Level Liquid Waste	Low Level Liquid Waste	Solid Waste
General Direction and Support (Supervision, stenographic, clerical)	1.7	1.7	1.5
Collection & Sampling	1.1	1.0	1.0
Transport	0.5	0.5	2
Treatment	1.0	1.0	-
Monitoring	0.5	0.5	0.25
Analytical	1.5	1.5	-
Disposal	-	0.1	3
Environmental Monitoring			
On-Site	0.5	0.5	0.1
Off-Site	1.0	1.0	0.5
Maintenance	3.2	3.2	0.5
Total	11.0	11.0	8.85

2.5 Materials and Utilities Requirements

Materials and utilities requirements are described in Table 6.

2.6 Overhead

Costs pertaining to radiation protection, medical control, and other general services are considered under "overhead." For a description of "overhead," see item 3.1 (below).

2.7 Research and Development

There is at the present time no research and development effort devoted to waste operations. In the past, however, there has been substantial work done on environmental studies, particularly on the geology, minerology, and hydrology of the ORNL liquid and solid waste disposal areas and on the Clinch River. In addition, studies were made to improve the operating efficiency of the low-level waste water treatment plant. The effort (scientific and technical) on these three programs is estimated to have been as follows:

Soil Disposal Studies (1958 - 64):[8, 9]	15-1/2 man-years
Clinch River Studies (1960 - 65):[10]	23-1/2 man-years
Low-Level Waste Treatment Plant (1959 - 61):[5,6]	3-1/2 man-years

3. INFORMATION ABOUT THE ACCOUNTANCY SYSTEM

3.1 Operating Costs

Waste management costs are kept in two separate accounts at ORNL: one for management of liquid and gaseous wastes; the other for solid wastes. Costs are compiled and published monthly by the Laboratory Budget and Accounting Division. Reports for the last quarter of fiscal year 1965, showing the total costs for the period, July 1964 through June 1965, are given in Tables 7 and 8. The significant items in these tables may be explained as follows:

Table 6. Materials and Utilities Requirements at ORNL for FY-1965

	Intermediate Level Liquid Waste	Low Level Liquid Waste	Solid Waste
General Direction & Support	Office Supplies, Data Processing	Office Supplies, Data Processing	Office Supplies, Data Processing
Collection & Sampling	Power	Power	Shielded Containers, Radiation Meters
Transport	Power, Steam	Power, Sludge Truck	Trucks
Treatment	68 tons NaOH	80 t lime 140 t Na_2CO_3 26 t Clay	-
Monitoring	Survey Meters and Counters	Survey Meters and Counters	Survey Meters and Counters
Analytical	Chem. Reagents, Lab. Equipment	Chem. Reagents, Lab. Equipment	-
Disposal	-	Truck	Concrete, Tile, Pipe
Maintenance	Instrument & Equip. Parts	Instrument & Equip. Parts	Equipment Parts

Table 7. Operating Cost Report for Liquid and Gaseous Waste Disposal.

NO.3057

OPERATING COST REPORT

JACOX

ACCOUNT TITLE LIQUID +GASEOUS WASTE DISPOSAL 060 DIV 28

AEC ACTIVITY NO 12 40 00 00 0 FISCAL YEAR 65 ACCT. NUMBER 3632-0000

		APR		MAY		JUN		FY TO DATE	
		$	MM	$	MM	$	MM	$	MY
SHOPS, MAINT., INSTRUMENTATION & INSP. ENGR.	54L	4581	7.34	4779	7.91	4321	6.96	47508	6.46
ENGINEERING SERVICES	56L	1692	2.58	893	1.13	103	.10	11493	1.19
DEPARTMENTAL - ADMIN., CLERICAL & OTHER	65L	8600	12.56	8488	12.85	8340	12.40	101135	12.74
DEPARTMENTAL - SCIENTIFIC & TECHNICAL	66L								
LOANEE - IN - SCIENTIFIC & TECHNICAL	67L								
FRINGE BENEFITS	69L	1789	2.64	2073	2.86	1459	1.55	20446	2.48
OTHER LABOR	70L							12	
TOTAL LABOR		16662	25.12	16233	24.75	14223	21.01	180594	22.87
SHOPS, MAINT., INSTRUMENTATION & INSP. ENGR.	54M	7638		6265		3829		57833	
ENGINEERING SERVICES	56M	98						98	
SUBCONTRACTS	61M								
TRAVEL	62M								
MAJOR DEPARTMENT PROCUREMENT	64M								
MINOR DEPARTMENT SUPPLIES	65M	1863		1400		854		16796	
FRINGE BENEFITS	69M								
OTHER MATERIALS	70M								
COMPUTER (ORNL)	72M	2		1				9	
EDP - CENTRAL DATA PROCESSING	73M								
MISCELLANEOUS CASH INCOME	80M								
TOTAL MATERIAL		9601		7666		4683		74736	
TOTAL BASIC OPERATING COST		26263		23899		18906		255330	
GEN. & ADMN. EXPENSE ALLOCATION		14448		12222		11573		143747	
SHOPS, MAINT., INSTRUMENTATION & INSP. ENGR. BURDEN									
ENGINEERING BURDEN									
DIVISION ADMINISTRATION									
UTILITIES		1811		1746		1612		20764	
TECHNICAL SERVICES		8485		8064		8712		77363	
OTHER WORKED MATERIAL		142		203		171		2130	
OTHER CHARGES									
TOTAL GROSS COST		51149	25.12	46134	24.75	40974	21.01	499334	22.87
DISTRIBUTION (OUT)		51149		46134		40974		499334	
INVENTORY CHANGE									
NET OPERATING COST									
TECHNICAL SERVICES: ANALYTICAL CHEMISTRY		7421		7149		7851		68037	
TECHNICAL SERVICES: HEALTH PHYSICS		1064		915		1061		11326	
TECHNICAL SERVICES: ORR AND REACTOR TECHNICAL									
TECHNICAL SERVICES: LITR									
TECHNICAL SERVICES: HOT CELLS									
TECHNICAL SERVICES: TANK FARM									
TECHNICAL SERVICES: METALS & CERAMICS LABS.									

MEMO: Scientific & Technical Fringe Benefits (included in 69L)

UCN-1410 (1-65)

No. P. OVERTIME .05

BUDGET _____ % EXP. .01

Table 8. Operating Cost Report for Solid Waste Disposal.

NO. 3057

OPERATING COST REPORT

GFRJOHNSON

ACCOUNT TITLE BURIAL GROUNDS 010 CIV 21

AEC ACTIVITY NO. 13 21 05 00 0 FISCAL YEAR 65 ACCT. NUMBER 3032-0000

		APR		MAY		JUN		FY TO DATE	
		$	MM	$	MM	$	MM	$	MY
SHOPS, MAINT., INSTRUMENTATION & INSP. ENGR.	54L	2888	5.91	3531	7.42	4387	8.74	46662	8.04
ENGINEERING SERVICES	56L	432	.55	270	.36	326	.44	5206	.59
DEPARTMENTAL ADMIN., CLERICAL & OTHER	65L	720	1.11	712	1.13	773	1.19	7669	.92
DEPARTMENTAL - SCIENTIFIC & TECHNICAL	66L								
LOANEE IN - SCIENTIFIC & TECHNICAL	67L								
FRINGE BENEFITS	69L	1167	1.43	1082	.90	571	.47	7311	.65
OTHER LABOR	70L							992	.08
TOTAL LABOR		5207	9.00	5595	9.81	6057	10.84	67840	10.28
SHOPS, MAINT., INSTRUMENTATION & INSP. ENGR.	54M	809		782		1054		8986	
ENGINEERING SERVICES	56M								
SUBCONTRACTS	61M								
TRAVEL	62M								
MAJOR DEPARTMENT PROCUREMENT	64M								
MINOR DEPARTMENT SUPPLIES	65M	422		856		264		4996	
FRINGE BENEFITS	69M								
OTHER MATERIALS	70M								
COMPUTER (ORNL)	72M								
EDP – CENTRAL DATA PROCESSING	73M	252		166		164		1739	
MISCELLANEOUS CASH INCOME	80M	257-		1151-		1961-		21982-	
TOTAL MATERIAL		1226		653		479-		6261-	
TOTAL BASIC OPERATING COST		6433		6248		5578		61579	
GEN. & ADMN. EXPENSE ALLOCATION									
SHOPS, MAINT., INSTRUMENTATION & INSP. ENGR. BURDEN									
ENGINEERING BURDEN									
DIVISION ADMINISTRATION									
UTILITIES									
TECHNICAL SERVICES									
OTHER WORKED MATERIAL									
OTHER CHARGES									
TOTAL GROSS COST		6433	9.00	6248	9.81	5578	10.84	61579	10.28
DISTRIBUTION (OUT)									
INVENTORY CHANGE									
NET OPERATING COST		6433		6248		5578		61579	
TECHNICAL SERVICES: ANALYTICAL CHEMISTRY									
HEALTH PHYSICS									
ORR AND REACTOR TECHNICAL									
LITR									
HOT CELLS									
TANK FARM									
METALS & CERAMICS LABS.									
MEMO: Scientific & Technical Fringe Benefits (included in 69L)				74				419	.03

N. P. OVERTIME

BUDGET _____ % EXP. _____

UCN-1810 (8 1-65)

The first seven items (54L - 70L) indicate the labor charges in terms of cost ($), and time (man-months and man-years). Fringe benefits (69L) account for non-productive time devoted to vacations, holidays, sick and personal leave.

The next 11 items (54M - 80M) report the costs of materials consumed.

The entry labeled "Gen. & Admin. Expense Allocation" is Laboratory overhead. This charge is assessed on the basis of the "total labor" cost (sum of items 54L - 70L) and in FY-1965 it amounted to about 80% of the labor cost. It includes the following items:

Budget and Program Planning

Employee Insurance, Savings, and Retirement Plans

Laboratory Director's Department

Finance and Materials (including telephone, postage)

Medical Department

Security Department

Operations (Custodial, Grounds, Laundry, Sewage Disposal)

Personnel Department

Public Information Department

Technical Information

Administrative and Support Costs for

- Plant and Equipment Division
- Instrument and Controls Division
- Inspection Engineering Division
- General Engineering and Construction Division

"Utilities" is the cost of electric power, steam, and water. It is assessed on the same basis as are overhead charges; i.e., on the basis of the labor cost. At ORNL, the unit costs for utilities are approximately $0.004/kwh for electricity, $2.10/ton for steam, and $0.034/$m^3$ for water.

"Technical Services" includes the costs of analytical chemistry and health physics and are further detailed at the bottom of Tables 6,7, and 8.

In Table 8, the item entitled "Miscellaneous Cash Income" represents charges credited to the burial ground account from disposal of "off-site" solid wastes. It should be pointed out that this account does not include overhead charges. Furthermore, part of the personnel charged against it are involved in the disposal of non-contaminated solid wastes.

Using the operating costs from Tables 7 and 8 and the estimated distribution of personnel from Table 5, incremental operating costs are estimated for the three waste streams as shown in Table 9.

3.2 Capital Costs

Capital cost records are kept by the Budget and Accounting Division, and are depreciated annually according to AEC Service Life Guides. The service lives of several items relevant to the waste management system are as follows:

Dam or weir	100 years
Masonry building with concrete and steel frame	50 years
Masonry building with wooden frame	40 years
Ponds	50 years
Tank farm	30 years
Tanks	40 years
Water pumps	25 years
Low-Level Waste Treatment Plant	25 years
Chemical piping system	25 years
Water piping system	40 years
Evaporators	20 years
Radiation monitors	10 years
Trucks, earth-moving equipment	10 years

Table 9. Estimated Incremental Operating Costs of ORNL Waste Management for FY-1965

	Intermediate Level Liquid Waste	Low-Level Liquid Waste	Solid Waste
Labor			
General Direction & Support	$ 13,600	$ 13,600	$ 12,000
Collection & Sampling	8,800	8,000	8,000
Transport	4,000	4,000	13,200
Treatment	8,000	8,000	-
Monitoring	4,000	4,000	2,000
Analytical	23,100	23,100	-
Disposal	-	800	19,800
Environmental Monitoring			
On-Site	4,000	4,000	800
Off-Site	11,400	11,400	5,700
Maintenance	24,700	24,700	3,800
Total Labor	$101,600	$101,600	$ 65,300
Overhead	$ 50,300	$ 50,300	$ 32,500
Materials			
General Direction & Support	750	750	1,740
Treatment	1,950	9,800	-
Disposal	-	-	5,000
Utilities	7,300	7,300	-
Maintenance	20,200	20,200	9,000
Total Materials	$ 30,200	$ 38,050	$ 15,740
Total Operating Cost	$182,100	$189,950	$113,540

The capital costs of the waste management facilities are given in Table 10, together with the depreciation during FY-1965, the total accumulated depreciation, and the net book cost.

3.3 Research and Development Costs

Research and development costs incurred in previous years which are appropriate to the present waste management system are as follows:

Soil Disposal Studies (1958 - 64):	$430,000
Clinch River Studies (1960 - 65):	$720,000
Low-Level Waste Treatment Plant Studies (1959 - 61):	$ 99,000

These costs may be allocated to waste management on an annual basis as follows:

	Cost, $/year		
	Intermediate Level Liquid Waste	Low-Level Liquid Waste	Solid Wastes
Soil and Clinch River Studies	9200	9200	4600
Waste Treatment Plant Studies	-	4000	-

Soil Disposal Studies and Clinch River Studies is depreciated over 50 years and proportioned among intermediate-level liquid waste, low-level liquid waste, and solid waste in the ratio of 2:2:1. Low-Level Waste Treatment Plant Studies is depreciated over 25 years.

No additional research and development work is underway on the present system.

3.4 Total ORNL Management Costs

Total costs of waste management at ORNL for FY-1965 are compiled in Table 11. These costs reflect actual operating experience, but they are not exact in that the division of operating expenses among the different waste types was made on the basis of "best judgment" rather than from detailed records compiled for this purpose.

Table 10. Oak Ridge National Laboratory
Completed Plant and Equipment Radioactive Waste Management Facilities
At June 30, 1965
(Dollars in Thousands)

Facilities	Gross Cost	Depreciation During FY-1965	Accumulated Depreciation	Net Book Cost
A. Intermediate-Level Liquid Wastes				
Underground Hot Waste System	$ 1,475	$ 50	$ 823	$ 652
Radioactive Liquid Waste Collection System	950	41	174	776
Waste Monitoring Control Center	6	1	1	5
Settling Basin	1	0	1	0
Capital Equipment	149	1	32	117
Subtotal	$ 2,581	$ 93	$1,031	$ 1,550
B. Low-Level Liquid Wastes				
Radioactive Liquid Waste Collection System	$ 950	$ 41	$ 174	$ 776
Process Waste Water Treatment Plant	300	12	46	254
Waste Monitoring Control Center	6	1	1	5
Capital Equipment	347	28	109	238
Subtotal	$ 1,603	$ 82	$ 330	$ 1,273
C. Solid Wastes				
Burial Grounds	$ 12	$ 0	$ 2	$ 10
Capital Equipment	120	8	76	44
Subtotal	$ 132	$ 8	$ 78	$ 54
Total	$ 4,316	$183	$1,439	$ 2,877

Table 11. Total Costs Estimated for Waste Management at ORNL for FY-1965

	Intermediate Level Liquid Waste	Low-Level Liquid Waste	Solid Waste
Operating Cost (Table 9)			
Labor	$ 101,600	$ 101,600	$ 65,300
Overhead	50,300	50,300	32,500
Materials	30,200	38,100	15,700
Total Operating	$ 182,100	$ 190,000	$113,500
Capital Depreciation (Table 10)	93,000	82,000	8,000
Research & Development (See 3.3)	9,200	13,200	4,600
Total Cost	$ 284,300	$ 285,200	$126,100
Total Unit Cost*	$16.53/$m^3$	$0.34/$m^3$	$31.32/$m^3$
	($62.56/$10^3$ gal)	($1.29/$10^3$ gal)	($0.89/$ft^3$)

*Based on annual volumes of 1.72×10^4 m^3 of intermediate-level liquid waste, 8.36×10^5 m^3 low-level liquid waste, and 4026 m^3 of solid waste.

4. INFORMATION ABOUT THE ENVIRONMENT

4.1 Brief Description[1,8,9,10]

ORNL is isolated by distance (20 kilometers to the nearest community) and by patrols that keep the public from potentially hazardous areas. The average population density in the immediate vicinity is about 56 persons/km.^{2} The land area over which waste disposal operations are carried out is about 2.6 square kilometers (Fig. 2), and it has an average annual rainfall of about 1.4 m/year. Surface water is drained from this area by White Oak Creek which has a variable flow averaging about 0.3 m^3/sec. Approximately 1 km from the edge of the waste disposal area, this creek flows into the Clinch River (average flow ~140 m^3/sec.) the Clinch, in turn, flows into the Tennessee River (average flow ~900 m^3/sec.) at a point about 33 km from the outfall of White Oak Creek.

The surface of the area is covered by an average of about 1 m of clay which is underlain by a shale formation. Laboratory measurements of the weathered shale have shown it to have an ion-exchange capacity of from 6 - 30 meq/100 g.

The ground water depth varies from about 10 m below the surface at points of high elevation to near the surface along White Oak Creek.

4.2 Wastes are Discharged as Described in 2.1 - 2.3

4.3 Regulations for Discharge

Discharges from ORNL are governed by the standards specified in AEC Manual, Chap. 0524, "Standards for Radiation Protection," which are consistent with the recommendations of the National Committee on Radiation Protection and Measurements (NCRP) and the International Commission on Radiological Protection (ICRP).[12,13] Both on-site and off-site monitoring is performed to determine the fate of radionuclides that are released and to ensure that such operations are conducted safely.

4.4 Environmental Monitoring Program

Environmental monitoring of the creek and rivers is described in 2.1 - 2.3. Manpower and costs are given in Tables 5 and 9, respectively.

4.5 Studies of Environmental Capacity for Radioactive Material

Such studies have been in progress since 1944. Meteorology, hydrology, mineralogy, geology, and ecology of this area have all been studied. The principal programs related to liquid and solid waste management concerned are summarized in references 8, 9, and 10. The estimated manpower and costs are given in 2.7 and 3.3, respectively.

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