6318

U-003-307 .23

RECOVERY OF URANIUM FROM PIT SLUDGES AND COLD METAL OXIDE - (USED AS A REFERENCE IN OU1 RI)

01/ /78

NLCO-1149
NLCO
50
REPORT

6318

NLCO - 1149
Special

RECOVERY OF URANIUM FROM PIT SLUDGES AND COLD METAL OXIDE

Project AP - 178

by

R. C. Kispert
Senior Staff Engineer

Issued: January, 1978

Approved By:

L. M. LEVY, MANAGER
ADVANCE PLANNING DEPT.

Authorized By:

S. F. AUDIA
MANAGER

NATIONAL LEAD COMPANY OF OHIO
Cincinnati, Ohio
Contract No. EY-76-C-05-1156

ABSTRACT

Economic incentives do not currently exist for recovering uranium from either GAT pond sludge or the FMPC pit sludges and cold metal oxide. This conclusion is based on a detailed process engineering and economic analysis for recovering 184 MTU from the low-level radioactive waste materials having a combined value of nearly eight million dollars.

Processing the pond sludge may become desirable at some future time when economic factors could provide the proper incentive for making the venture attractive.

DISTRIBUTION

W. J. Adams
S. F. Audia
J. H. Cavendish
J. W. DeDapper – NLI (2X)
H. D. Fletcher – ORO (5X)
B. Gessiness
W. J. Grannen
R. C. Heatherton
R. C. Kispert
N. R. Leist
L. M. Levy (10X)
A. F. Pennak
C. E. Polson (4X)
C. A. Schwan
Library (3X)

TABLE OF CONTENTS

	Page No.
ABSTRACT	iii
TABLE OF CONTENTS	iv
LIST OF FIGURES	vi
LIST OF TABLES.	vii
1. INTRODUCTION AND STUDY OBJECTIVES	1
2. SUMMARY HIGHLIGHTS AND CONCLUSIONS	2
3. URANIUM CONTENT AND VALUE OF WASTE MATERIALS	3
4. PROCESS FLOWSHEETS	3
5. GAT POND SLUDGE	4
5.1 Operational Aspects of the Process Flowsheet	4
5.2 Manpower Requirements	4
5.3 Incremental Recovery Costs	4
5.4 Capital Requirements and GPP Costs	8
5.5 Materials Management Planning	9
5.6 Economic Incentive.	9
6. SLUDGE FROM FMPC PITS 3 AND 5	9
6.1 Operational Aspects of the Process Flowsheet	9
6.2 Manpower and Direct Materials Requirements	11
6.3 Incremental Recovery Costs	12
6.4 Capital Requirements and GPP Costs	12
6.5 Materials Management Planning	14
6.6 Economic Incentive.	14
7. COLD METAL OXIDE STORED IN FMPC SILO 3	15
7.1 Operational Aspects of the Process Flowsheet	15
7.2 Manpower and Direct Materials Requirement	19
7.3 Incremental Recovery Costs	19
7.4 Capital Requirements and GPP Costs	19
7.5 Materials Management Planning	19
7.6 Economic Incentive.	21

TABLE OF CONTENTS (Continued)

Page No.

8. ECONOMIC ANALYSIS 21

8.1 Incentive for Processing FMPC Wastes 21
8.2 Incentive for Processing GAT Pond Sludge 21

9. SENSITIVITY ANALYSIS FOR RECOVERY OF GAT POND SLUDGE 23

9.1 Sludge Volume Removed 23
9.2 Uranium Yield 23
9.3 Isotopic Assay 23
9.4 Combined Factors of Yield and Isotopic Assay 29
9.5 Benefit Potential and Breakeven Point 29

10. SLUDGE GENERATION AT GAT 29

ACKNOWLEDGEMENT 29

REFERENCES 30

LIST OF FIGURES

Figure No.		Page No.
1	Recovery of Uranium From GAT Pond Sludge	5
2	Conceptual Flowsheet for Recovering Uranium Contained in Sludge From FMPC Pits 3 and 5	6
3	Conceptual Flowsheet for Recovering Uranium From FMPC Cold Metal Oxide Stored in Silo 3	7
4	Distribution of Uranyl Nitrate Between Aqueous Phase and 7.5 Vol % Tributyl Phosphate in n-Paraffin as a Function of Aqueous Nitric Acid and Uranyl Nitrate Concentrations at 23°C	17
5	Crude Uranium Extraction From Low-Grade Feed	18
6	Sensitivity of Economic Incentive to Sludge Volume	24
7	Sensitivity of Economic Incentive to Uranium Yield	25
8	Sensitivity of Economic Incentive to Isotopic Assay	26
9	Sensitivity of Economic Incentive to Combined Factors	27
10	Determination of Benefit Potential and Breakdown Point	28

LIST OF TABLES

Table No.		Page No.
3-1	Content and Value of Low-Level Radioactive Waste Materials	3
5-1	Incremental Operating and Other Costs for Recovery of Uranium From GAT Pond Sludge	8
6-1	Manpower Requirements for Processing Sludge From FMPC Pits 3 and 5	11
6-2	Direct Materials Usage for Processing FMPC Pits 3 and 5 Sludges	12
6-3	Incremental Operating and Other Costs for Recovery of Uranium From FMPC Pit 3 Sludge	13
6-4	Incremental Operating and Other Costs for Recovery of Uranium From FMPC Pit 5 Sludge	13
7-1	Manpower Requirements for Processing Cold Metal Oxide Stored in FMPC Silo 3	19
7-2	Direct Materials Usage for Processing Cold Metal Oxide Stored in FMPC Silo 3	20
7-3	Incremental Operating and Other Costs for Recovery of Uranium From Cold Metal Oxide Stored in FMPC Silo 3.	20
8-1	Summary of Economic Incentives for U Recovery Operations.	22
8-2	Analysis of Economic Incentive for Processing GAT Pond Sludge	22

1. INTRODUCTION AND STUDY OBJECTIVES

The economic feasibility of recovering uranium from low-level radioactive waste materials stored at the four locations listed below has been investigated:

- GAT X-701 B Pond (sludge) - See Section 5
- FMPC Pit 3 (sludge) - See Section 6
- FMPC Pit 5 (sludge) - See Section 6
- FMPC Silo 3 (cold metal oxide) - See Section 7

Interest in the recovery economics was prompted by the increased value of uranium in recent years and the availability of underutilized processing capabilities at the FMPC.

Consideration of recovering uranium from low-level wastes began in 1971, when the AEC requested[1] NLO to investigate the technical and economic feasibility of processing sludge contained in the X-701 B holding pond at Goodyear Atomic (GAT). Although the initial investigations using either hydrochloric or sulfuric acids for leaching uranium from the sludge were unsuccessful, subsequent testing of carbonate leaching provided an efficient method for solubilizing uranium[2]. This work led to the development of a conceptual flowsheet[3,4]. Later discussions with GAT in 1973 led to the conclusion that pond storage of enriched uranium presented no immediate particular problem[5].

Renewed interest was prompted in mid-1975 by increases in the purchase price of uranium and the cost of separative work. Also, the concern with the permanent disposal of low-level radioactive wastes in an environmentally compatible manner contributed to the renewed interest. A sampling program conducted by GAT in 1975 established estimates of the pond contents at 907 KgU at 7.0% U-235[6]. Capital and incremental operating costs were estimated at that time to total $540,000 – excluding GAT purification and UF_6 conversion costs[7].

Although uranium recovery appeared marginally attractive at the prevailing feed and separative work values, projected increases in material value indicated that future recovery may eventually have potential economic benefit. At the same time, the project scope was expanded to include the recovery of uranium contained in the Feed Materials Production Center (FMPC) Pits 3 and 5 sludges, and the cold metal oxide stored in Silo 3[8].

The total value of the uranium contained in these four locations was estimated to exceed five million dollars. At that time, however, ERDA set a higher priority on cleaning up the pits located at the Weldon Spring site[9,10,11].

Early in 1977, interest was again expressed in recovering uranium from low-level wastes presently being stored at the FMPC and GAT[12,13]. In response to this renewed expression of interest, the present study[14] was initiated to:

- Update the previous investigations.
- Perform an operations analysis based on process engineering flowsheets.
- Establish the current and projected economic incentives as a basis for preparing a formal proposal for doing the work.

2. SUMMARY HIGHLIGHTS AND CONCLUSIONS

2.1 Economic incentives do not exist for recovering uranium from FMPC waste materials and only marginally exist on an incremental cost basis for processing GAT pond sludge as shown below:

	GAT Pond Sludge	Pit 3 Sludge	Pit 5 Sludge	Silo 3 Oxide
SS Recovered Value ($)	1,039,175	4,631,891	1,291,774	517,914
Overall Recovery Costs ($)	954,817	15,352,207	6,074,241	2,856,417
Economic Incentive ($)	84,358	(10,720,316)	(4,782,467)	(2,338,503)

Although a benefit is indicated, uranium recovery from GAT pond sludge should be deferred until such time that economic factors or irreducible reasons may provide the proper incentive for undertaking the venture. A sensitivity analysis of the economic incentive to value/costs factors further supports the recommendation to defer processing GAT pond sludge for uranium recovery. The generation of additional uranium in the sludge has no near-term impact upon this conclusion.

2.2 The present assessment of the contents and value of uranium stored at each location is summarized as follows:

	GAT Pond Sludge	Pit 3 Sludge	Pit 5 Sludge	Silo 3 Oxide
SS Weight (KgU)	907	118,281	47,135	18,000
U-235 Assay (%)	7.00	0.785	0.685	0.711
Material Value ($)	1,093,425	4,875,543	1,361,259	575,460
Recovered Value ($)	1,039,175	4,631,891	1,291,774	517,914

The combined value of 184 MTU stored in all four locations amounts to nearly eight million dollars. Recovery of sludge is assumed to be 95 percent efficient; a 90 percent recovery efficiency is assumed for processing cold metal oxide. It was hoped that uranium recovery could be accomplished at a significant monetary benefit to ERDA.

2.3 Overall incremental operating and other costs estimated for uranium recovery operations and subsequent conversion to both oxide and UF_6 are summarized below:

	GAT Pond Sludge	Pit 3 Sludge	Pit 5 Sludge	Silo 3 Oxide
Incremental Operating				
FMPC Costs	722,559	14,776,933	6,063,137	2,763,968
Off-site Costs	18,229	119,112	47,413	17,172
Capital Equipment	212,000	86,500	28,500	20,000
Gen. Plant Projects	2,029	369,662	(198,303)	263
Separative Work Loss	0	0	133,494	55,014
Overall Costs	954,817	15,352,207	6,074,241	2,856,417

Pit storage of process tailings comprises the cost incurred under General Plant Projects (GPP). A credit of $198,303 in GPP costs is realized from processing Pit 5 sludge since the pit would be completely restored to an operating condition.

The economic analysis was based on a carbonate leach flowsheet for processing sludges from GAT and FMPC Pits 3 and 5. Cold metal oxide stored in FMPC Silo 3 would be processed using modified Refinery operations to produce a concentrated crude uranyl nitrate solution. Uranium recovered from GAT pond sludge would be returned to GAT as cascade-feed black oxide. All uranium recovered from FMPC low-level wastes would be converted to UO_3 for conversion to UF_6 at Paducah.

3. URANIUM CONTENT AND VALUE OF WASTE MATERIALS

The present assessment of the contents of the four storage locations considered in this study is presented in Table 3-1. Material values are based on 1977 ERDA-ORO directed values for feed and separative work components of $31.97 and $61.30 per KgU, respectively, at 0.30% tails assay[15]. The combined value of all the uranium stored in each locations amounts to nearly eight million dollars. Assuming complete removal of sludge and yields of 95 and 90 percent for sludge and cold metal oxide processing operations, respectively, results in the recovery of uranium having a combined value of 7.5 million dollars.

TABLE 3-1 Content and Value of Low-Level Radioactive Waste Materials

	GAT Pond Sludge	Pit 3 Sludge	Pit 5 Sludge	Silo 3 CMO
Volume (Million Gal)	0.2618	50	20.5	1.0
Metric Tons Waste	1,008	255,000	83,224	3,525
U Assay (%)	0.090	0.0464	0.057	0.51
U Weight (KgU)	907	118,261	47,135	18,000
Recovered Weight (KgU)	862	112,370	44,729	16,200
U-235 Assay (%)	7.00	0.785	0.685	0.711
Feed Value ($/KgU)	521.17	37.73	29.95	31.97
SW Valve ($/KgU)	684.37	3.49	−1.07	0.00
Material Value ($/KgU)	1,205.54	41.22	28.88	31.97
Total Value ($)	1,093,425	4,875,543	1,361,259	575,460
Recovery Yield (%)	95	95	95	90
Value of Recovered U ($)	1,039,175	4,631,891	1,291,774	517,914

NOTE: (1) Feed value @ $31.97/KgU; SW value @ $61.30/KgU.
(2) Tails assay @ 0.30%.

4. PROCESS FLOWSHEETS

Recovery of uranium from the GAT pond sludge is based on the laboratory work leading to the development of the carbonate leach –ion exchange purification– ADU precipitation flowsheet[4,7]. New safe geometry equipment would be required for the processing steps following leaching and filtration using existing large-scale equipment in Plant 8.

Sludges from FMPC Pits 3 and 5 would be processed in the Plant 8 Hydrometallurgical System using carbonate leaching followed by precipitation of ammonium diuranate (ADU) and filtration in the Refinery Sump. The rotary kiln would then be used to calcine the filter cake slurry to produce Refinery feed.

Refinery equipment would be employed for processing cold metal oxides from Silo 3 by utilizing modified digestion and extraction conditions and extensive evaporation.

Flowsheets for each recovery method are presented in Figures 1 - 3.

5. GAT POND SLUDGE

5.1 Operational Aspects of the Process Flowsheet

Sludge would be removed from the X-701 B holding pond by using a submersible pump mounted to a floating raft. A water addition of five percent is assumed necessary for improving the pumpability of sludge to a new 4000-gallon, hopper-type tank truck. An estimated 69 loadings would be required for the transfer of the total sludge/water volume of 275,000 gallons to the FMPC. Sludge would be placed into interim storage in 5000-gallon hold tanks in Plant 8 by bottom unloading using compressed air. The truck would be flushed with 600 gallons of water before turnaround to GAT.

Processing the sludge for the recovery of enriched uranium is represented by the flow diagram of Figure 1. A carbonate ($Na_2CO_3/NaHCO_3$) leach solution would be used to solubilize uranium from the pond sludge. The bulk of the impurities would remain undissolved in this process and be separated from the leach liquor by filtration in Plant 8. Large equipment could be used up to this point in the process because of small quantities and low concentrations of uranium. Filter cake would be discarded to dry pit storage at the FMPC. Filtrate would advance to new safe geometry equipment for ion exchange purification and ADU precipitation. ADU cake would be calcined in the Pilot Plant oxidation furnace to provide a feed for safe geometry digestion, two-inch column purification and conversion to oxide in the evaporator/calciner. These latter operations may become avoidable if the ion exchange purification step is capable of directly producing a product solution meeting cascade-feed specifications. Following packaging and sampling in Plant 1, the oxide would be shipped to GAT for conversion to UF_6.

5.2 Manpower Requirements

Processing 907 KgU is estimated to require 227 operating days and yield 862 KgU product at an assumed overall recovery of 95%. Manpower requirements are estimated at 4 men per shift, 3 shifts per day or a total of 2720 mandays, giving an average production rate of 4 KgU per day. Full-time supervision is required.

5.3 Incremental Recovery Costs

Incremental operating costs were estimated by updating the previous estimate[7] to 1977 dollars using 7 percent escalation in 1976 and 8 percent for 1977. Cost adjustments for revisions to the pond contents were made on the basis of bulk volume. In the previous study, it was

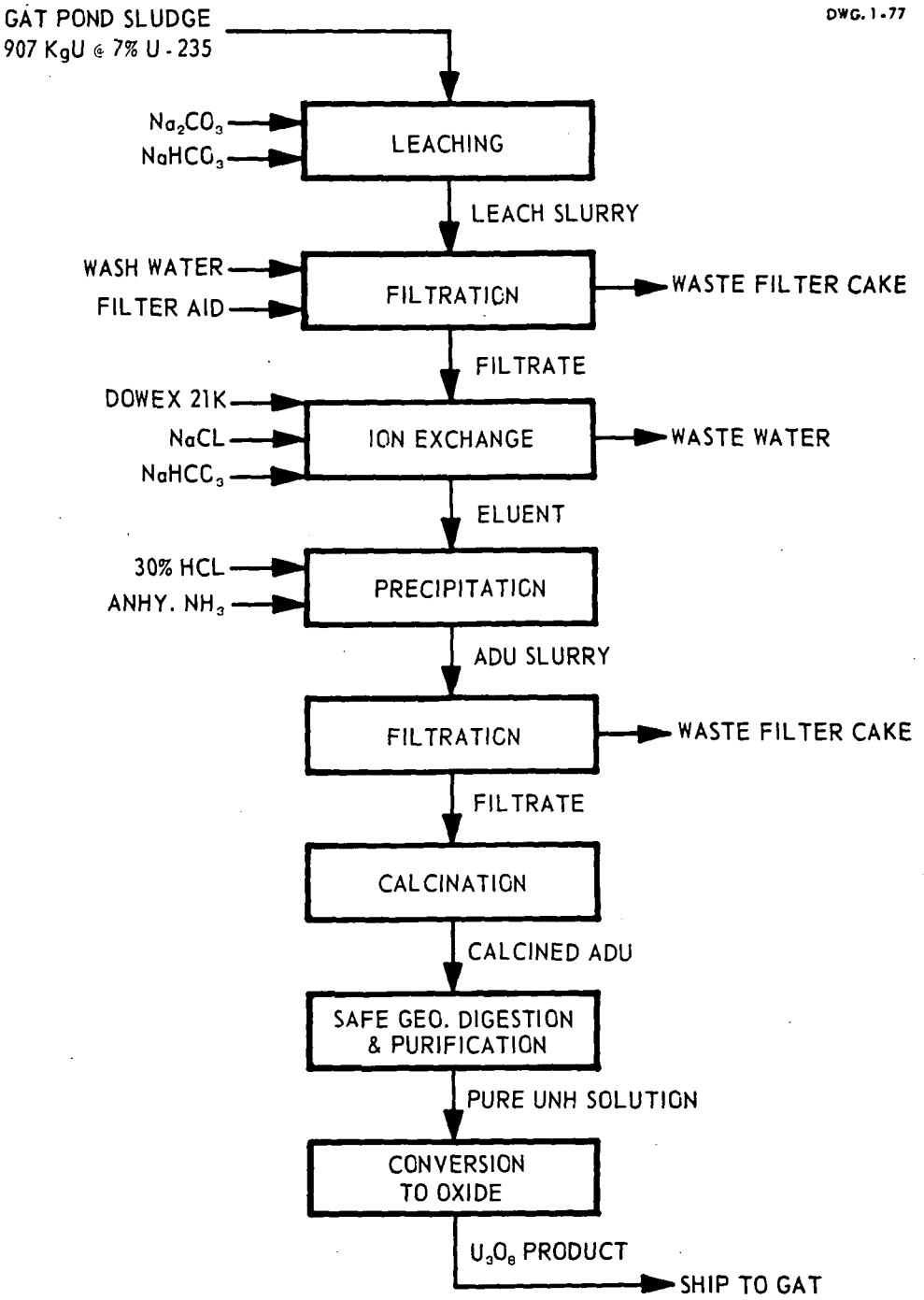


FIGURE 1 Recovery of Uranium From GAT Pond Sludge (Reference 8)

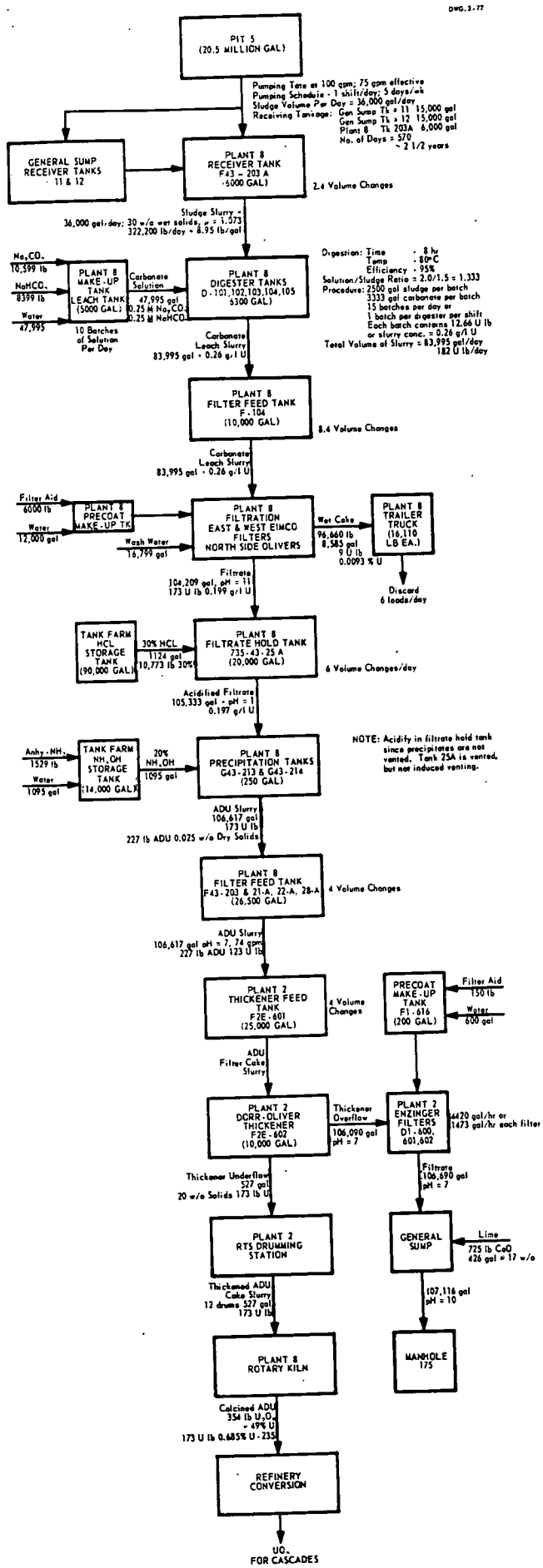


FIGURE 2 Conceptual Flowsheet for Recovering Uranium Contained in Sludges From FMPC Pits 3 and 5

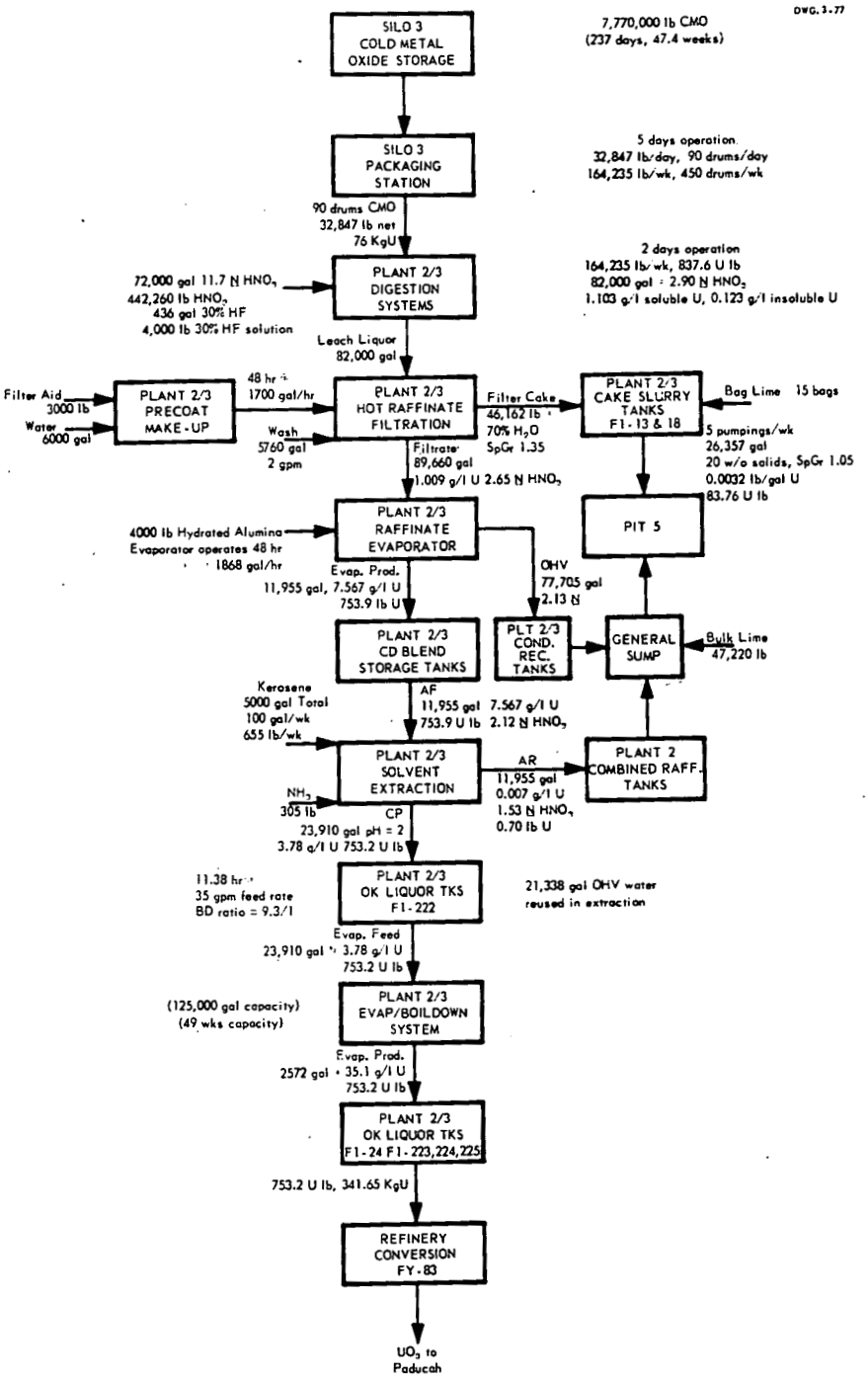


FIGURE 3 Conceptual Flowsheet for Recovering Uranium From Silo 3 Cold Metal Oxide

assumed that calcined ADU would be packaged for shipment to GAT, where further purification would be performed before conversion to UF_6. With the addition of an enriched purification capability at FMPC, the present study includes costs for converting the impure roasted ADU to black oxide via safe geometry digestion, two-inch column purification and evaporator/calciner denitration.

Overall FMPC recovery costs are estimated at $619,122 (See Table 5-1, Item A.2.3). Packaging, sampling and shipment of product U_3O_8 to Goodyear Atomic are included in recovery costs. Estimates for FMPC purification and conversion to oxide and GAT conversion to UF_6 are based on $29.45 and $16.64 per KgU, respectively, and are included in the operating costs (Table 5-1). The avoidance of FMPC costs for purification and conversion to oxide would reduce costs by $26,711. Since this reduction represents only 3 percent of the total expenditure required, this cost is included in the economic analysis of the venture.

TABLE 5-1 Incremental Operating and Other Costs for Recovery of Uranium from GAT Pond Sludge (1977 Dollars)

A.	Operating Costs (Including 20% Contingency)	
	1. GAT	
	1.1 Sludge removal and loading truck	3,885
	1.2 Conversion to UF_6	14,344
	Sub-total	18,229
	2. FMPC	
	2.1 Transportation	74,104
	2.2 Unloading sludge and decontamination	2,622
	2.3 Processing for U recovery	619,122
	2.4 Purification and conversion to oxide	26,711
	Sub-total	722,559
	3. Incremental Operating Costs	740,788
B.	Capital Costs (Including 30% Contingency)	
	1. Sludge Removal Facilities at GAT	11,000
	2. Hopper-Type Tank Truck	16,000
	3. Unloading Facilities at FMPC	4,000
	4. Process Equipment and Modifications at FMPC	181,000
	Sub-total	212,000
C.	General Plant Projects (GPP) Costs	
	1. Pit Storage of Process Tailings	2,029
D.	Separative Work Loss	0
E.	Sum of Costs	$954,817
F.	Unit Costs ($/KgU)	$1,107.68

5.4 Capital Requirements and GPP Costs

Capital requirements are estimated at $212,000 to provide for sludge removal facilities at GAT, hopper-type tank truck, unloading facilities at Plant 8, safe geometry recovery equipment and a 30 percent contingency.

The generation of process tailings is estimated at 65,450 gallons of wet filter cake, which would be discarded to the new dry storage pit at a cost of $2,029 in General Plant Projects (GPP) costs. This was determined from pit construction costs of $100,000 for providing 3,230,000 gallons storage or $0.03 per gallon.

Capital and GPP costs are presented in Table 5-1 together with overall incremental operating costs.

5.5 Materials Management Planning

Since the isotopic assay of recovered uranium would be preserved by providing feed for GAT conversion to UF_6, no separative work loss would be incurred in the potential work program.

5.6 Economic Incentive

An economic benefit of $84,358 would be derived from the recovery of 862 KgU (95% yield) at 7.0% U-235 having a value of $1,039,175 (Table 3-1) at an overall cost of $954,817 (Table 5-1). The attractiveness of this venture is the subject of Section 8.2 of this report.

6. SLUDGE FROM FMPC PITS 3 AND 5

The processing of low-level radioactive wastes presently stored at FMPC would begin with the recovery of uranium contained in Pit 5 sludge because:

- Pumpback facilities exist and the capability has been demonstrated.
- Upon completion of the work, Pit 5 becomes an effective chemical pit suitable for accommodating tailings from the subsequent processing of cold metal oxide stored in Silo 3.
- The much larger volume of Pit 3 sludge can remain undisturbed while the carbonate leach process is demonstrated on a large scale using Pit 5 sludge.

6.1 Operational Aspects of the Process Flowsheet

The carbonate leach flowsheet presented in Figure 2 would be used for recovering near-normal uranium from both pit sludges. Sludge would be pumped from Pit 5 to Plant 8 using a submersible pump mounted to a floating raft as was done in 1975, when several hundred thousand gallons of sludge were transferred. Because of the need to use the 3800-foot underground pipe for water transfers between the General Sump and Pit 5 and between the Clearwell and Manhole-175, sludge pumpback activity would be limited to one shift per day on a five days per week basis. Approximately 36,000 gallons of sludge would be transferred to Plant 8 daily. Tanks 11 and 12 in the General Sump and F43-203A tank in Plant 8 would be used as receiver and surge tanks.

Removal of Pit 3 sludge would be performed similarly, following the installation of piping and valving for tying-in to the 3800-foot underground pipe. A sludge sluicing area would be created by clamshelling a work area having dimensions of 12' radius by 8' depth. Pit 5 water would be used to sluice the sludge to produce a pumpable slurry.

Plant 8 processing of sludge from either location is identical. It is assumed that the sluiced sludge from Pit 3 has the same texture and consistency as Pit 5 sludge. Carbonate solution would be prepared in the leach tank to provide the process requirement of about 48,000 gallons per day. This volume requirement necessitates continual make-up of carbonate solution. All five digester tanks must be utilized in order to process the daily volume of sludge. Each batch consists of 2500 gallons of sludge and 3333 gallons of carbonate solution and requires 8 hours digestion time to achieve the target recovery efficiency of 95 percent. A high on-stream factor must be achieved in order to process the required 15 batches per day.

A volume of nearly 84,000 gallons per day of carbonate leach slurry would be generated and received in F-104 tank. Because the capacity of this tank is 10,000 gallons, it will be necessary to continuously receive and pump slurry to the filters. Four rotary vacuum filters are required to handly the daily generation of carbonate leach slurry. The east and west Eimco filters and both Oliver filters on the north side are designated for use because of their capability for discharging filter cake into a trailer truck.

A combined filtration rate of 3900 gallons/hr must be achieved to handle 84,000 gallons per day at a 90 percent on-stream factor. This seems attainable from past experience filtering Pit 5 sludge. Continual make-up of precoat would be required. Six truckloads of filter cake would be discharged daily to dry pit storage. It is important to note here that primary justification for the proposed work is presumed to be economically rather than environmentally motivated.

Filtrate would be collected in 735-43-25A tank having a capacity of 20,000 gallons. Again, the limited tank capacity compared with the high volume of 105,000 gallons of filtrate (including wash water) requires continuous receiving and pumping operations. Acidification with 30% HCl to destroy the uranyl carbonate soluble complex would also be performed in this tank to take advantage of the tank's ventilation and freeboard space.

ADU would be precipitated continuously from the acidified filtrate in tanks G43-213 and G43-214. The precipitated slurry would be collected in tanks F43-203, 21-A, 22-A, and 28-A having a combined capacity of 26,500 gallons. Conventional precoat filtration of the ADU slurry would require four rotary vacuum filters for the daily volume of 107,000 gallons. Since four of the six Plant 8 filters would already be in service for filtering carbonate leach slurry, the procurement of two new filters would be necessary.

As an alternate, the ADU slurry would be transferred to F2E-601 tank in the Refinery Sump. Tank F1-608 would be isolated, preserved for collecting ordinary sump liquors and operated to produce a magnesium diuranate precipitate on a batch basis for NMC purposes.

Both ADU and MgO precipitates would be pumped to the thickener for sedimentation. Thickener underflow would be drummed for direct calcination in the rotary kiln. The thickener overflow could be expected to contain a relatively high solids content, which would be removed by the Enzinger filters. In this operation, the Enzinger filters would be cleaned by water flushing and air blowback. The cleanout material would be sent to the thickener. The Refinery Sump

has a capacity for handling 125,000 gallons per day and should be able to accommodate the volume of ADU slurry in addition to the usual sump liquor (with no Refinery operation).

6.2 Manpower and Direct Materials Requirements

Time requirements for processing the entire contents of Pits 3 and 5 are 1389 and 570 days, respectively, based on a daily pumpback rate of 36,000 gallons of sludge. Manpower requirements are summarized in Table 6-1 and reflect the one shift/day pumpback operation and three shifts/day production operation. It is estimated that 30 chemical operators would be required to cover plant operations. Because of the high level of activity in Plant 8, extraordinary transportation manpower requirements have been estimated at one motor vehicle operator (MVO) on the 2nd or 3rd shift and one fork truck operator (ITO) on each shift. Three shift supervision is required. Manpower costs were determined on the basis of a wage rate of $8.35 per hour (direct and indirect).

Direct materials requirements and costs are presented in Table 6-2 and were calculated from the usages indicated in Figure 2 and current Stores issue prices.

TABLE 6-1 Manpower Requirements for Processing Sludge From FMPC Pits 3 and 5

	Men/Shift	Shifts/Day	Men
A. Pit 5 and Sump Area			
1. Sludge pumpback	1	1	1
2. Sump area	1	0.5	0.5
Sub-total			1.5
B. Plant 8			
1. Receiving Sludge & Pumping ADU Slurry to Ref. Sump	1	3	3
2. Carbonate Solution Make-up	1	3	3
3. Digester Tanks	1	3	3
4. Filter Feed & Filtrate Tanks	1	3	3
5. Filtration	2	3	6
6. ADU Precipitation	1	3	3
7. Rotary Kiln & Misc.	1	3	3
Sub-total			24
C. Refinery Sump			
1. Receive ADU Slurry, Monitor Thickener, Pump Filtrate	1	3	3
2. Enzinger Filters, Precoat Make-up, Drum Slurry	1	3	3
Sub-total			6
D. Total			
1. Engineering Wage			1.5
2. Production Wage			30

TABLE 6-2 Direct Materials Usage for Processing FMPC Pit 3 and 5 Sludges

Material	Basis	Cost ($/lb)	Usage (lb/day)	Mat'l Cost ($/day)
Sodium Carbonate	100% Na_2CO_3	0.051	10,599	540.55
Sodium Bicarbonate	100% $NaHCO_3$	0.150	8,399	1,259.85
Filter Aid	50 lb bags	0.087	6,150	535.05
Hydrochloric Acid	30% HCL	0.080	10,773	861.84
Ammonia	Anhydrous	0.073	1,529	111.62
Bulk Lime	100% CaO	0.022	725	15.95
			Total	3,324.86

6.3 Incremental Recovery Costs

First approximation incremental recovery costs are summarized in Tables 6-3 and 6-4 for Pits 3 and 5, respectively. Object cost classes are based on a five-year cost history between FY-67 and FY-71, when the west area of Plant 8 was last operated for uranium recovery. The factors developed were applied to direct plus indirect wages to provide the estimate of incremental recovery costs of $14,570,611 and $5,979,300 for Pits 3 and 5, respectively. A 25 percent contingency is included because of inherent uncertainties in the process. Refinery conversion costs are based on the FY-77 normal concentrate experience of about $0.60 per KgU incremental. UF_6 conversion costs at Paducah are based on the present authorization of $1.06 per KgU, excluding depreciation[16].

6.4 Capital Requirements and GPP Costs

Capital costs for the restoration or replacement of major equipment in Plant 8 are estimated at $100,000 (including 30% contingency). These costs have been prorated between Pit 3 ($71,500) and Pit 5 ($28,500) on the basis of uranium content. An additional $15,000 has been added to the capital costs for Pit 3 sludge to provide for valving and piping changes in the pit area.

General Plant Projects (GPP) costs for discarding tailings are based on the construction of new dry storage pits to handle the volume of filter cake generated in each case. A cost of $0.031 per gallon was determined from the construction costs and volume of the new dry pit. A credit of $350,000 is applied to Pit 5 processing costs for completely restoring the wet chemical storage pit. (See Tables 6-3 and 6-4)

TABLE 6-3 Incremental Operating and Other Costs for Recovery of Uranium From FMPC Pit 3 Sludge (1977 Dollars)

A. Operating Costs	
1. FMPC	
1.1 Sludge pumpback	138,900
1.2 Processing for U recovery*	14,570,611
1.3 Purification and conversion to oxide	67,422
Sub-total	14,776,933
2. Paducah	
2.1 Conversion to UF_6	119,112
3. Incremental Operating Costs	14,896,045
B. Capital Costs (Includes 30% Contingency)	
1. Creating pumpback capability	15,000
2. Prorated expenditure for modifications**	71,500
Sub-total	86,500
C. General Plant Project (GPP)	
1. Pit Storage of Process Tailings	369,662
D. Separative Work Loss	0
E. Sum of Costs	15,352,207
F. Unit Cost ($/KgU)	136.62

*Includes 25% Contingency.
**Portion of $100,000 attributable to Pit 5; becomes entire amount if Pit 5 sludge is not processed.

TABLE 6-4 Incremental Operating and Other Costs for Recovery of Uranium From FMPC Pit 5 Sludge (1977 Dollars)

A. Operating Costs	
1. FMPC	
1.1 Sludge pumpback	57,000
1.2 Processing for U recovery*	5,979,300
1.3 Purification and conversion to oxide	26,837
Sub-total	6,063,137
2. Paducah	
2.1 Conversion to UF_6	47,413
3. Incremental Operating Costs	6,110,550
B. Capital Costs (Includes 30% Contingency)	
1. Prorated expenditure for modifications**	28,500
C. General Plant Projects (GPP) Costs	
1. Pit Storage of Process Tailings	151,697
2. Credit for Restoring Pit 5	(350,000)
Sub-total	(198,303)
D. Separative Work Loss	133,494
E. Sum of Costs	6,074,241
F. Unit Cost ($/KgU)	135.80

*Includes 25% contingency.
**Portion of $100,000 attributable to Pit 5; becomes entire amount if Pit 3 sludge is not processed.

6.5 Materials Management Planning

Scheduling emerges as an important consideration in the potential work program. Recovery of Pit 5 sludge would require approximately 2.5 years. In the analysis, it was postulated that the work could be performed either before or after the scheduled FY-80 Refinery enriched campaign for the NPR stream. Current plans call for the production of 177 MTU or 246 MTU as UO_3 in FY-80, depending on the Base or Alternate Case requirements. Since the Refinery campaigns will be conducted early in FY-80, only the uranium recovered from Pit 5 sludge during FY-78 and FY-79 can be assumed available for those campaigns. Any uranium recovered during FY-80 would be held until the FY-83 Refinery campaign.

Combining the estimated recovery of 27,230 KgU at 0.685% U-235 with 187.5 MTU at 0.952% U-235 (averages for the FY-80 0.95% campaign) requires the use of 6 MTU of 2% enriched UO_3 to adjust the combined tonnage of 214,730 KgU to 0.947% U-235. A separative work loss of $217,278 would be incurred using $61.30 per KgU SW valve at 0.30% tails assay. Consequently, introducing uranium recovered from Pit 5 sludge to the FY-80 Refinery 0.95% campaign has several drawbacks:

- A substantial loss in separative work loss would be incurred requiring the use of 2% enriched UO_3 as blending material.
- U recovered from sludge during FY-80 must be stored until FY-83.

It is clearly preferable to begin recovering uranium from Pit 5 sludge during the last half of FY-80 and completing the work in FY-82. All 44,729 KgU (recovery of 95%) would then be available for the FY-83 Refinery campaign, which will produce 164 MTU at 0.99% U-235 (average of Base and Alternate Cases) as UO_3 for cascade feed. The separative work loss incurred from combining the tonnages of 44,729 KgU @ 0.685% U-235 an 164 MTU @ 0.99% U-235 amounts to $133,494 (See Table 6-4). It may be possible to reduce the extent of separative work losses by campaigning the pit source uranium to preserve the FY-83 tonnage at 0.99% U-235.

No particular materials management concerns are associated with recovering uranium from Pit 3 sludge since the work would be conducted after the FY-84 NPR "dump" campaign. The preservation of separative work values is assumed.

6.6 Economic Incentive

Economic incentives for recovering uranium from Pits 3 and 5 sludges do not exist. Overall incremental operating and other costs total $15,352,207 (Table 6-3), which greatly exceeds the value of uranium recoverable from Pit 3 sludge of $4,631,891 (Table 3-1). Similar costs and value for Pit 5 sludge recovery are $6,074,241 (Table 6-4) and $1,291,774 (Table 3-1), respectively.

The apparent lack of economic incentives for recovering uranium from either location should not be entirely unexpected since Plant 8 wet chemical operations are manpower intensive and have a high requirement of direct materials on a unit effective production basis.

7. COLD METAL OXIDE STORED IN FMPC SILO 3

7.1 Operational Aspects of the Process Flowsheet

Cold metal oxide (CMO) would be gulped from Silo 3 using a heavy duty air compressor in conjunction with appropriate vacuum hoses, vacuumax adapters and gulping tools for packaging material into 55-gallon steel drums. Based on experience in similarly packaging concentrate into drums at the Weldon Spring site several years ago, it is estimated that 30 drums can be packaged in an eight-hour shift. At a bulk density of 52 lb/cu ft[17], a daily removal rate of 32,847 lb CMO was estimated for a three shift operation.

Processing low-level radioactive wastes via the carbonate leach route has been previously shown to be uneconomical in this study. In addition, an ion exchange step must be included for processing CMO to avoid reprecipitating a substantial amount of metallic impurities with ammonia. An alternate flowsheet to carbonate leach was considered in order to pursue the evaluation of the economic incentive for uranium recovery. Without an alternate, this study would be terminated at this point in view of the high operating costs of approximately $136 per KgU estimated for Pits 3 and 5 sludges. (See Tables 6-3 and 6-4, Item F)

The alternate flowsheet is presented in Figure 3, and consists of digesting CMO in nitric acid, filtration, evaporation, crude solvent extraction purification, evaporation of OK Liquor and recycling through standard Refinery operations to produce pure UO_3.

Drums of cold metal oxide would be fed to the continuous digestion (CD) system in the Refinery. Digestion conditions of 0.1 M HF in concentrated HNO_3 at 160°F for 8 hours would be employed to achieve 90 percent recovery efficiency. It is estimated that 41,059 lb CMO can be digested in one CD batch to produce 20,500 gallons of leach liquor at 1.226 g/l U and 2.90 N HNO_3 in 12 hours total time. Operation of the digestion system on a 3-shifts per day, 2-days per week basis will match the weekly rate of gulping CMO from Silo 3.

Nitric aicd digest liquors would be pumped to Hot Raffinate for filtration. At a rate of 1700 gal/hr using one Oliver filter, two days are required to filter the weekly generation of 82,000 gallons of liquor. Cake slurry would be sent to Pit 5 and filtrate would be collected in Combined Raffinate area tanks until an evaporator run could be made.

Filtrate and wash water would give a combined weekly volume of 89,660 gallons at 1.009 g/l U and 2.65 N HNO_3. Following the addition of hydrated alumina to give a Al/F weight ratio of 1.2/1, the free acid concentration is further reduced to 2.45 N HNO_3. At an evaporator feed rate of 2000 gal/hr, two operating days are required to handle the weekly generation. A boil-down ratio of 7.5/1 is assumed to produce an evaporator product having solution stability. An appreciable loss of HNO_3 in the overhead vapor will occur from the high degree of boildown. Acid condensate will require neutralization with slaked lime in the General Sump. Almost 12,000 gallons of evaporator product solution will be generated weekly and it will have concentrations of 7.567 g/l U and 4.5 N HNO_3.

Storage of evaporator product would be provided by the SE, SW, and NE tanks in the digestion area. Capacity exists for 5½ weeks of operation, after which, the solution must be processed through solvent extraction.

Because of the low uranium concentration (7.6 g/l) in the evaporator product, an extraction flowsheet was postulated for producing OK Liquor meeting cascade feed specifications in a single pass.

A flowsheet using 7.5 v/o TBP in Kerosene was based on equilibrium data in the literature[18] and achieving 92.5 percent AP saturation. Using an aqueous feed at 7.6 g/l U requires an A/O = 4/1. Under these constraints, a "pinched" condition is seen to exist between the operating line and equilibrium curve of Figure 4. In-specification raffinate can be produced using an A/O = 1/1, using 3-4 theoretical stages from a feed containing 7.6 g/l U. Under these conditions, the AP concentration is estimated at 7.4 g/l U or a saturation of 23 percent. Cascade specifications could not be attained in such an operation.

Consideration was then given to further decreasing the TBP solvent concentration to 4.5 v/o as used in the TBP-25 Process[19]. Pure OK Liquor can be produced from a weak concentration of uranium in aqueous feed; but, it requires nine theoretical stages in primary extraction. Since the Refinery A columns possess 3 to 4 theoretical stages, major changes in equipment utilization would be required to implement the TBP-25 Process. Consequently, it was decided to select flowsheet conditions for performing a crude solvent extraction purification rather than consider major equipment changes. Because cascade specifications will not be achieved, 15 v/o TBP in Kerosene would be used to minimize uranium losses in the aqueous raffinate. Flowsheet conditions are presented in Figure 5.

Extraction would be operated for an average of 16.8 hours per week. Since it is impractical to operate the columns for such a small period, aqueous feed would be collected for five weeks in the CD Blend Tanks.

A reasonable extraction campaign operation of 77 hours could then be conducted. Aqueous raffinate would be sent to the General Sump for neutralization with slaked lime and disposal to Pit 5. Again, it is important to keep in mind that the incentive for the potential work is economically motivated. The generation of upgraded uranyl nitrate solution from the C-columns is 23,910 gallons, having concentrations of 3.78 g/l U and 0.3 N HNO_3.

Operation of the denitration evaporator (E1-200 or E1-201) would coincide with extraction operations. On a weekly basis, either evaporator would be operated for 12 hours at a rate of 35 gpm to reduce the volume of extraction product from 23,190 to 2572 gallons (9.3/1 boil-down ratio) and concentrate the uranium from 3.78 to 35.1 g/l. This degree of boildown was estimated from the capability of the evaporator for vaporizing 1875 gal/hr water in routine service.

A total storage capacity of 125,000 gallons is required to handle 123,000 gallons of concentrated crude extract generated in the entire 48 week campaign. It will be necessary to use the weak

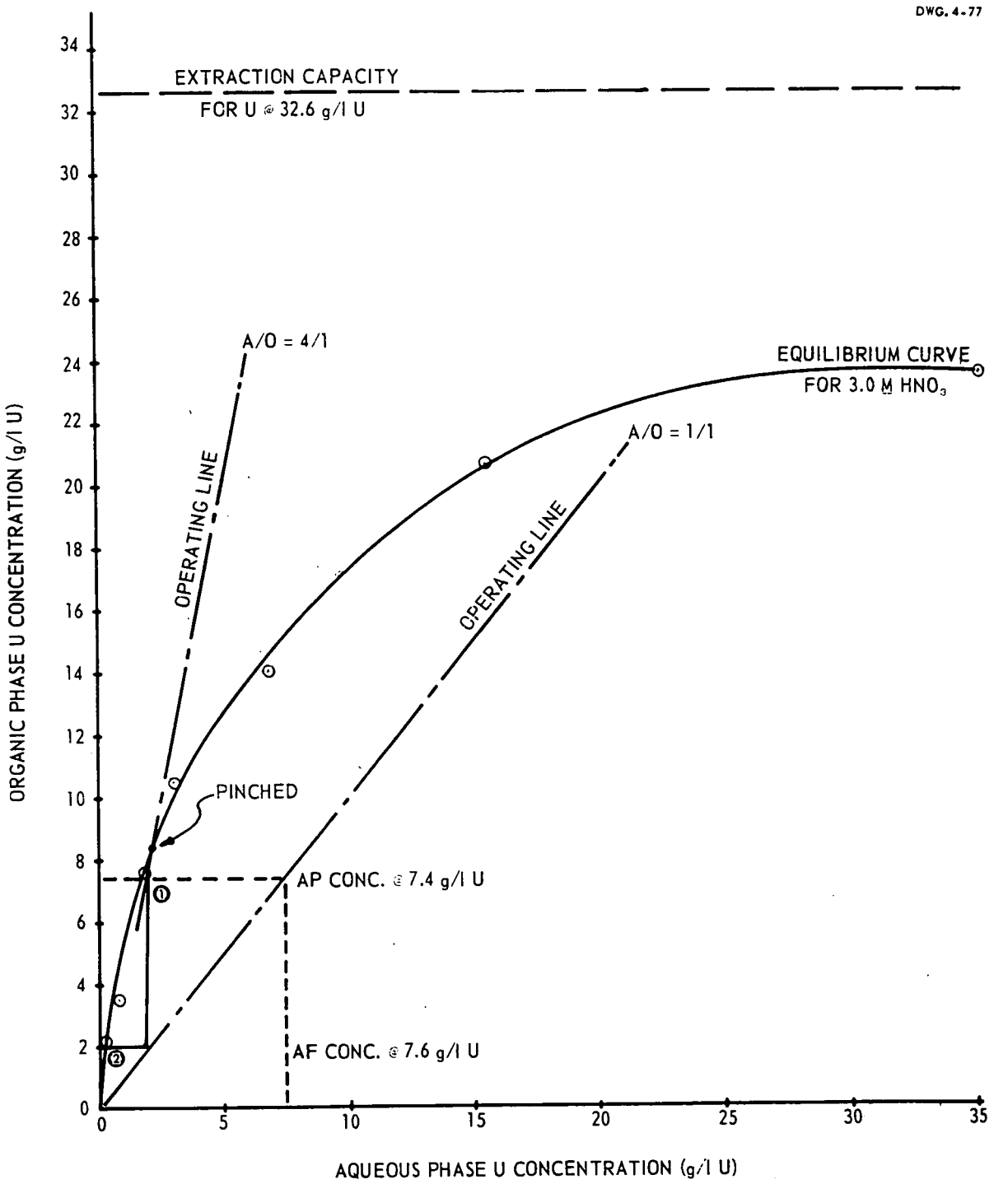
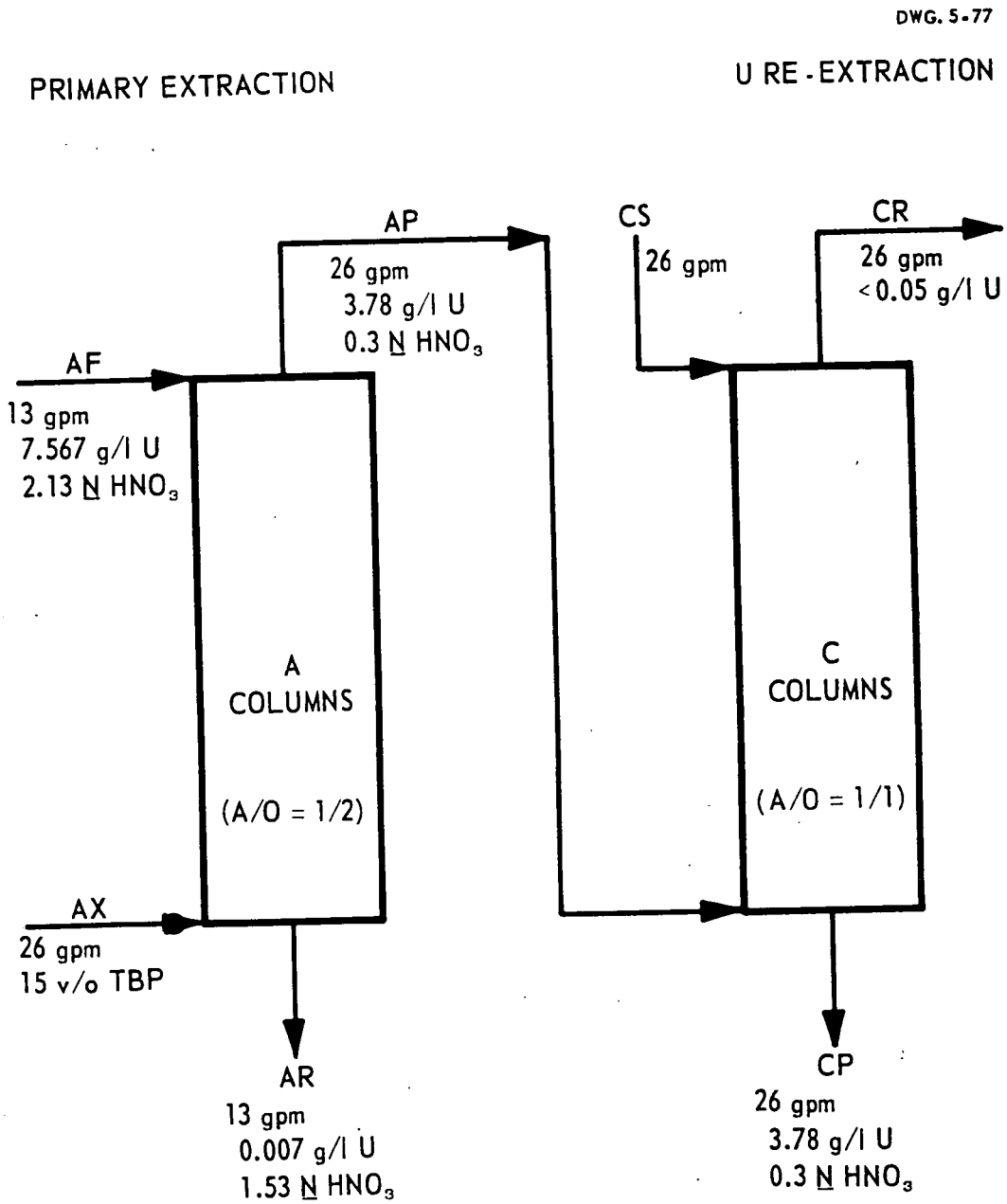


FIGURE 4 Distribution of Uranyl Nitrate Between Aqueous Phase and 7.5 vol % Tributyl Phosphate in n-Paraffin as a Function of Aqueous Nitric Acid and Uranyl Nitrate Concentrations at 23°C (Reference 18)



NOTES: [1]*15 v/o TBP solvent selected to maximize U recovery.*
[2]*AP saturation @ 6%; no scrubbing of extract.*
[3]*CP neutralized to pH = 2 prior to boildown.*

FIGURE 5 Crude Uranium Extraction From Low-Grade Feed

acid storage tank (F1 -24) in addition to OK Liquor tanks F3E - 223, 224, and 225. Tank F3E - 222 would be needed for feeding the evaporator. Condensate from boildown operations would be recycled for use as strip water in extraction.

7.2 Manpower and Direct Materials Requirements

Manpower requirements are summarized in Table 7-1. Two men would be needed for gulping operations in the silo area on a 3-shift per day, 5-days per week basis. Refinery operations would require a roster of nine men to provide an average of 346 manhours weekly. At the prevailing average rate of $8.35 per hour (direct & indirect wages), total manpower costs are estimated at $4,893 per week. Direct materials requirements are presented in Table 7-2 and amount to $28,112 each week of operation.

TABLE 7-1 Manpower Requirements for Processing Cold Metal Oxide Stored in FMPC Silo 3

	Men/Shift	Shifts/Day	Days/Wk	Mandays Per Week
A. Silo 3 Area				
1. Gulping Operations	2	3	5	30
B. Refinery				
1. Digestion	2	3	2	12
2. Filtration	2	3	2	12
3. Evaporation	2	3	2	12
4. Extraction	2	2	1	4
5. Den. Evaporation	2	1.5	1	3
Sub-total				43
C. Total				
15 men required for providing 73 mandays per week.				

7.3 Incremental Recovery Costs

Cost factors for object cost classes were based on the FY-77 Refinery experience processing normal concentrates. Full-time supervision would be necessary at a cost of $1,256 per operating week. Incremental recovery costs are presented in Table 7-3. Costs for the eventual conversion of the concentrated crude extract to UO_3 in ordinary Refinery operations is based on the FY-77 experience of about $0.60 per KgU incremental. UF_6 conversion costs at Paducah are based on the present authorization of $1.06 per KgU, excluding depreciation[16].

7.4 Capital Requirements and GPP Costs

Capital costs of $20,000 are estimated to provide for removal of cold metal oxide from Silo 3. Requirements include piping and flanges, gulping hoses and tools, Vacuumax adapters and dust collection equipment. Minor GPP costs would be required for discarding tailings to Pit 5. (See Table 7-3)

7.5 Materials Management Planning

Because extensive use of storage tanks in the digestion and denitration areas of the Refinery

and the use of 15 v/o TBP solvent are required, it will not be possible to conduct ordinary UO_3 production campaigns while the CMO recovery operation is in progress. It is assumed that the scheduled FY-83 enriched UO_3 campaign will be conducted during the first half of that year. Recovery operations would commence upon completion of the Refinery campaign and extend into the first half of FY-84. The uranium recovered from cold metal oxide would be introduced to the FY-84 "NPR dump" Refinery campaign, which would be conducted during the last half of FY-84. Although gulping operations at Silo 3 could be started in advance of the FY-83 campaign (to shorten the time requirement for the CMO recovery campaign), the lead time cannot be great because of the number of drums that would be required in the stockpiling effort. A separative work loss of $55,014 would be incurred from blending 16,200 KgU at 0.711% U-235 with the NPR dump tonnage of 636 MTU at 0.986% U-235. (See Table 7-3)

TABLE 7-2 Direct Materials Usage for Processing Cold Metal Oxide Stored in FMPC Silo 3

Material	Basis	Cost ($/lb)	Usage (lb/week)	Mat'l Cost ($/week)
Nitric Acid	100% HNO_3	0.0585*	442,260	25,872
Filter Aid	50 lb bags	0.087	3,000	261
Bag Lime	50 lb bags	0.033	750	25
Alumina	$Al_2O_3 \cdot 3H_2O$	0.079	4,000	316
Bulk Lime	100% CaO	0.022	47,220	1,039
Ammonia	Anhydrous	0.073	305	22
Aqueous HF	30% HF	0.1335**	4,000	534
Kerosene	—	0.066	655	43
			Total	28,112

*HNO_3 Cost @ $0.031/lb (53% basis) or $0.0585/lb (100% basis).
**HF Cost @ $0.445/lb (100% basis) or $0.1335/lb (30% basis).

TABLE 7-3 Incremental Operating and Other Costs for Recovery of Uranium From Cold Metal Oxide Stored in FMPC Silo 3

(1977 Dollars)

A. Operating Costs	
1. FMPC	
1.1 Unloading Silo	94,990
1.2 Processing for U recovery*	2,659,258
1.3 Purification and conversion to oxide	9,720
Sub-total	2,763,968
2. Paducah	
2.1 Conversion to UF_6	17,172
3. Incremental Operating Costs	2,781,140
B. Capital Costs	
1. Establish gulping capability	20,000
C. General Plant Projects (GPP) Costs	
1. Pit Storage of Process Tailings	263
D. Separative Work Loss	55,014
E. Sum of Costs	2,856,417
F. Unit Cost ($/KgU)	176.32

*Includes 25% contingency.

7.6 Economic Incentive

An economic incentive for recovering uranium from cold metal oxide stored in Silo 3 does not exist. Overall incremental operating and other costs total $2,856,417 (Table 7-3), which greatly exceeds the value of recovered uranium estimated at $517,914 (Table 3-1).

8. ECONOMIC ANALYSIS

Overall costs for recovering uranium from each location are summarized in Table 8-1 together with estimates of material values.

8.1 Incentive for Processing FMPC Wastes

As previously discussed, an economic incentive does not exist for recovering uranium from FMPC low-level radioactive wastes. For each FMPC source, the incremental operating costs alone are approximately four times greater than the value of the recovered uranium. High operating costs are primarily the result of manpower and direct materials requirements. Hard dollars expenditures for direct materials exceed the material value in each case. A significant technological breakthrough or an order of magnitude increase in either the feed or separative work component values is necessary before recovery of FMPC wastes can be seriously considered on the sole basis of economic incentive.

8.2 Incentive for Processing GAT Pond Sludge

Further consideration must be given to the recovery of uranium from the GAT pond sludge. Although unit incremental operating costs are high, the quantity and isotopic assay of this material warrant economic analysis to establish which one of the approaches listed below offers the optimum economic incentive.

Case (1) : Store U in pond; recover in 1985.
Case (2) : Recover U in 1977; store product to 1985.
Case (3) : Recover U in 1977; use product in 1977.

Economic factors and assumptions used in the analysis are as follows:

(1) Annual interest rate at 10%; escalation of costs at 6%.
(2) Feed component of material value increases from the present authorization of $31.97 per KgU to $68 per KgU in 1985. (This is partly based on recent spot sales of yellowcake at $104 per KgU).
(3) Separative component of material value increases from the present authorization of $61.30 per KgU to $130 per KgU in 1985. (This is based on an average annual increase in separative work value of $9 per KgU).
(4) Continuation of 0.30% tails assay.
(5) Annual storage costs of enriched U_3O_8 at $0.25 per sq. ft. or $265 for the 862 KgU recovered from the pond sludge over the eight year period.
(6) No increase in uranium content of the pond during the next eight years. Although increases will occur, freezing the U content at the present level permits a comparison of the three cases on a common basis and brackets the minimum incentive.

The economic benefits derived from the three recovery/storage cases are presented in Table 8-2.

TABLE 8-1 Summary of Economic Incentives for U Recovery Operations (1977 Dollars)

	GAT Pond Sludge	Pit 3 Sludge	Pit 5 Sludge	Silo 3 CMO
A. Value of Recovered U	1,039,175	4,631,891	1,291,774	517,914
B. Incremental Oper. Costs				
1. FMPC Costs	722,559	14,776,933	6,063,137	2,763,968
2. Off-site Costs	18,229	119,112	47,413	17,172
Sub-total	740,788	14,896,045	6,110,550	2,781,140
C. Non-recurring Costs				
1. Capital Equipment	212,000	86,500	28,500	20,000
2. General Plant Projects*	2,029	369,662	151,697	263
3. Credits	0	0	(350,000)	0
Sub-total	214,029	456,162	(169,803)	20,263
D. Separative Work Loss	0	0	133,494	55,014
E. Sum of Costs	954,817	15,352,207	6,074,241	2,856,417
F. Economic Incentive	84,358	(10,720,316)	(4,782,467)	(2,338,503)

*Pit storage of process tailings.

TABLE 8-2 Analysis of Economic Incentive for Processing GAT Pond Sludge

	Case (1) Store Now; 1985 Recovery	Case (2) Recover Now; Store to 1985	Case (3) Recover Now; Use in 1977
Value in 1977			1,039,175
Value in 1985	2,206,603	2,206,603	
Costs in 1977		(954,817)	(954,817)
Costs in 1985	(1,521,978)		
TV of Money		(1,091,929)	
Storage Costs		(265)	
Total Disbursements	(1,521,978)	(2,047,011)	(954,817)
Benefit	684,625	159,592	84,358
Rate of Return (%)	45	1.5	9
Risk/Gain	2.2	12.8	11.3

If recovery is necessary in 1977 for irreducible reasons, it is preferable to use the material in 1977 (Case 3) rather than to store it until 1985 (Case 2) because of the higher rate of return. Disbursements for Case (2) are more than twice those of Case (3), offsetting the estimated doubling of material value and net cash flow (benefit).

The higher disbursement in Case (2) results primarily from time value of money amounting to $1,091,929. Therefore, Case (2) is discarded from further consideration.

Case (3) is economically unattractive relative to prevailing interest rate assumptions. An investment of $954,817 (1977 cost of work) invested for one year at 10% would yield $95,482 which is greater than the net cash flow from pursuing the activity. Stategically, it would be preferable to invest $954,817 for one year at 10% interest rate with little inherent risk than to invest the same amount in production activity having major uncertainties of:

- Uranium content of pond sludge (907 KgU) and isotopic assay (7% U-235).
- Efficiency of carbonate leach recovery operations (95%).
- Capital equipment expenditures ($212,000).

In the absence of irreducible factors, Case (2) is discarded from further consideration.

The recommended approach is Case (1) with periodic updates to test future feed and separative work component values versus prevailing interest rates and escalation of costs. Furthermore, operating costs have been estimated on an incremental basis. Budgeting the activity on a total cost basis would negate the economic benefit.

Assuming no compelling irreducible reason, the recovery of uranium from GAT pond sludge should be deferred until such time that economic factors provide the proper incentives for undertaking this relatively high risk venture.

9. SENSITIVITY ANALYSIS FOR RECOVERY OF GAT POND SLUDGE

Major uncertainties in pursuing the work deal with sludge removal from the GAT pond, uranium content and isotopic assay. Figures 6-8 were developed to establish breakeven points for each factor and identifying prime areas of sensitivity.

9.1 Sludge Volume Removed

Assuming a constant uranium content of 907 KgU at an isotopic assay of 7.0% U-235, uranium recovery costs are seen to be sensitive to sludge removal as the breakeven point is approached (See Figure 6). If the current estimate of 261,800 gallons of sludge is exceeded by 23 percent, for a total of 322,014 gallons, then operations to recover 907 KgU at 7.0% U-235 would be conducted at a net loss.

9.2 Uranium Yield

For a constant sludge volume of 261,800 gallons and 7.0% U-235 assay, the uranium content of pond becomes sensitive to breakeven at 87 percent of the present estimate or 789 KgU (See Figure 7). This does not include the assumed 5 percent loss in yield from processing operations.

9.3 Isotopic Assay

Assuming 907 KgU contained in 261,800 gallons of sludge, the isotopic assay becomes sensitive to breakeven at 6.22% U-235 (See Figure 8). Recovery of uranium assaying less than the breakeven isotopic would become a losing venture.

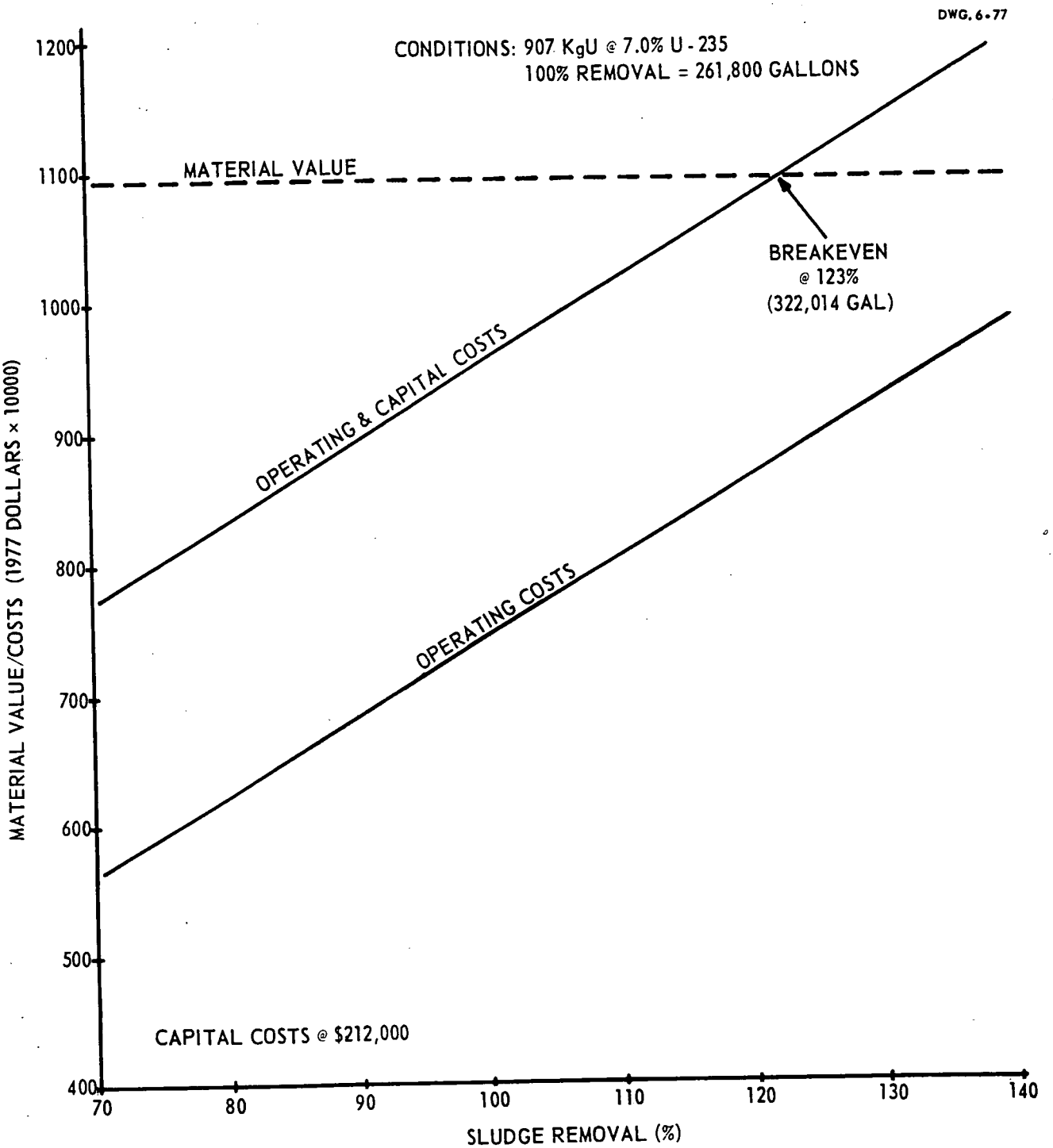


FIGURE 6 Sensitivity of Economic Incentive to Sludge Volume

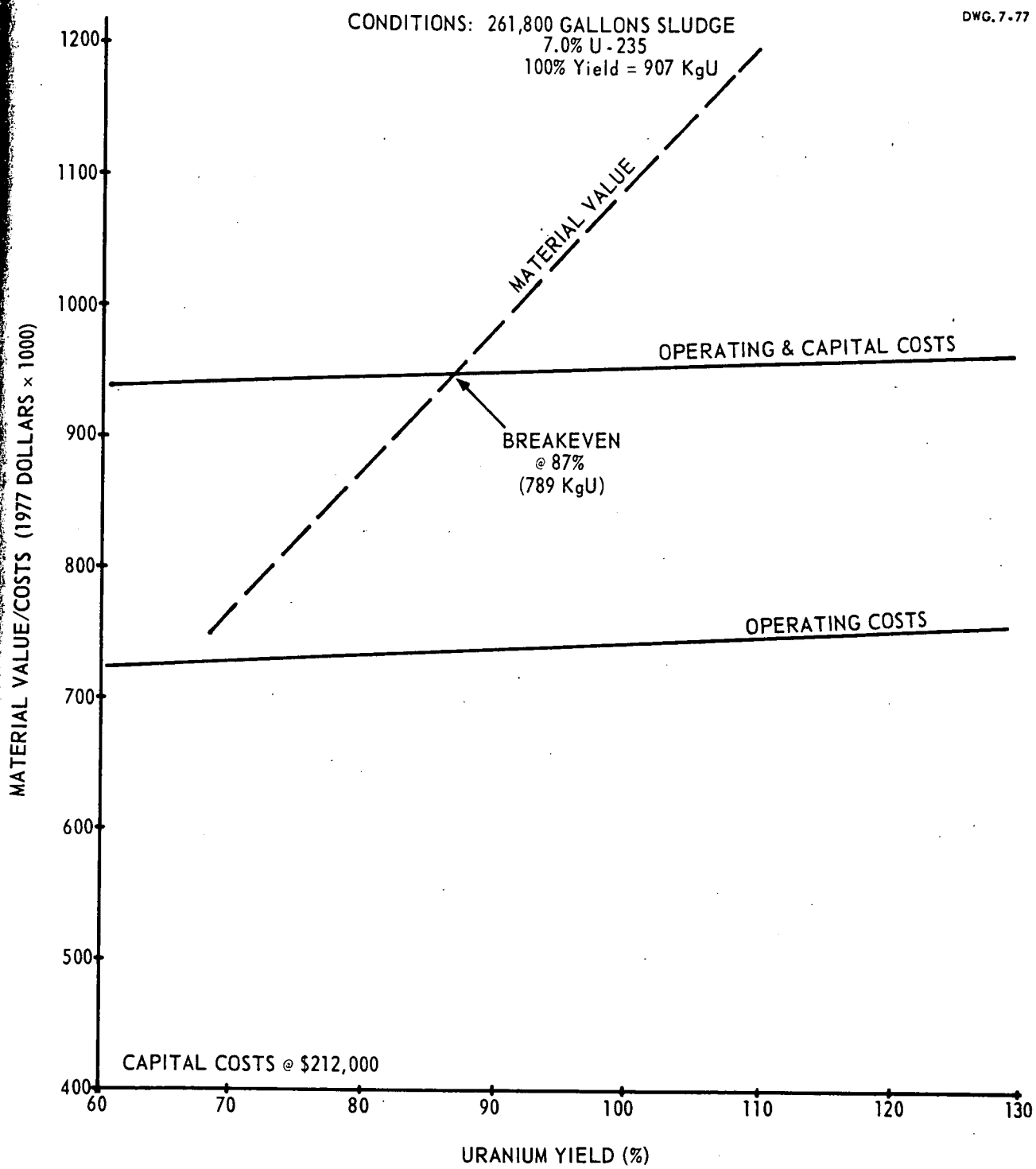


FIGURE 7 Sensitivity of Economic Incentive to Uranium Yield

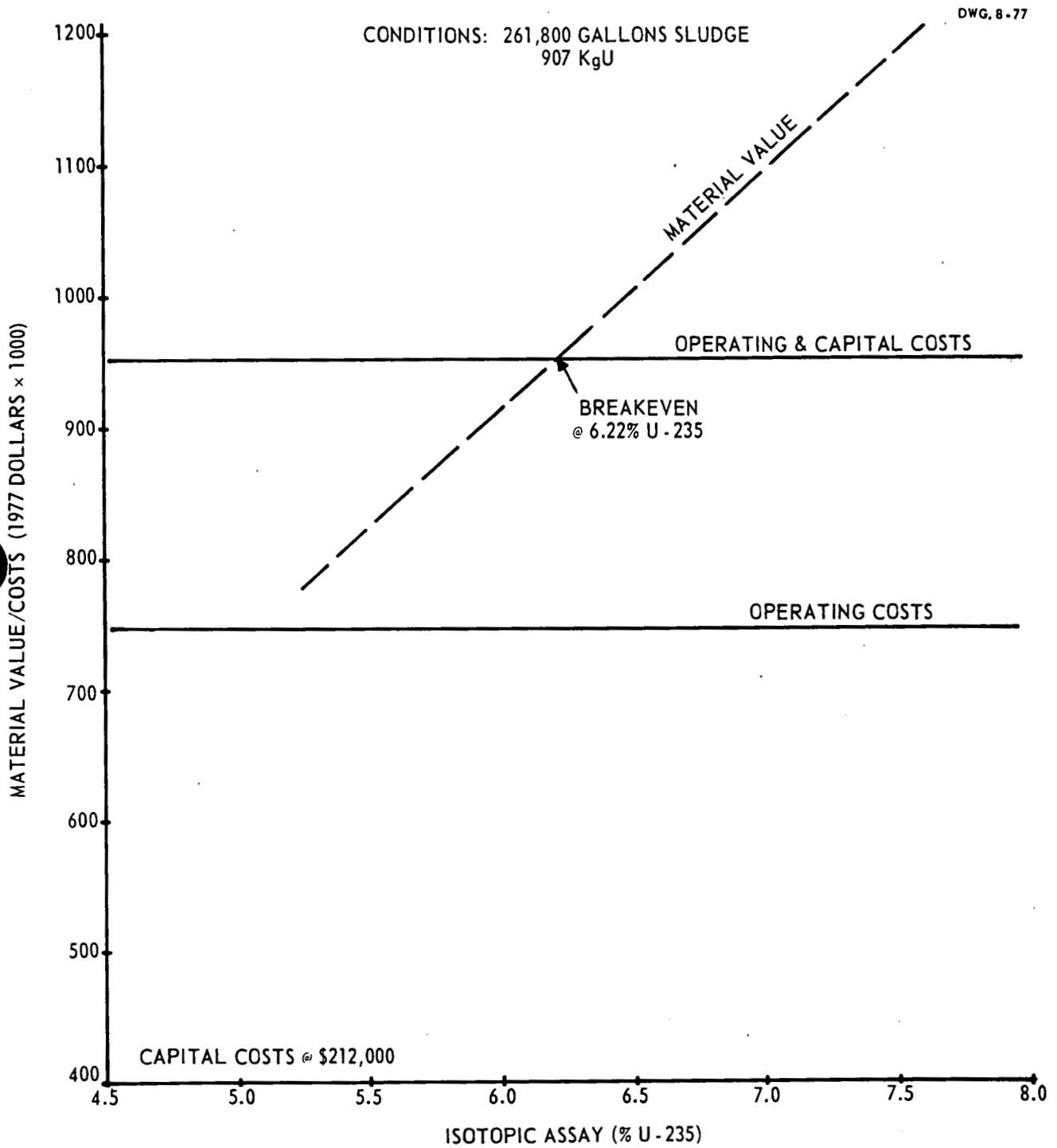


FIGURE 8 Sensitivity of Economic Incentive to Isotopic Assay

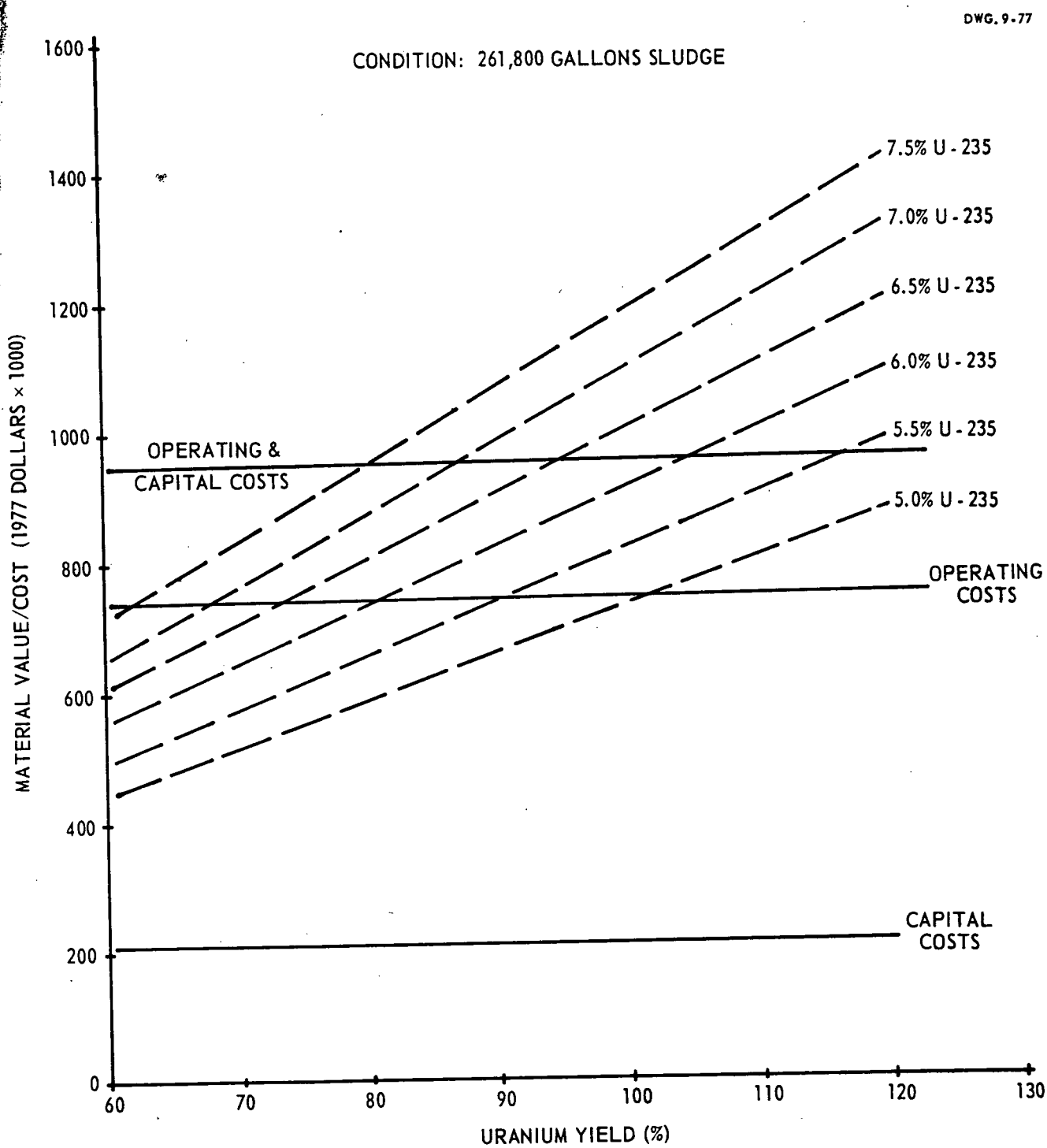


FIGURE 9 Sensitivity of Economic Incentive to Combined Factors

6318

DWG. 10-77

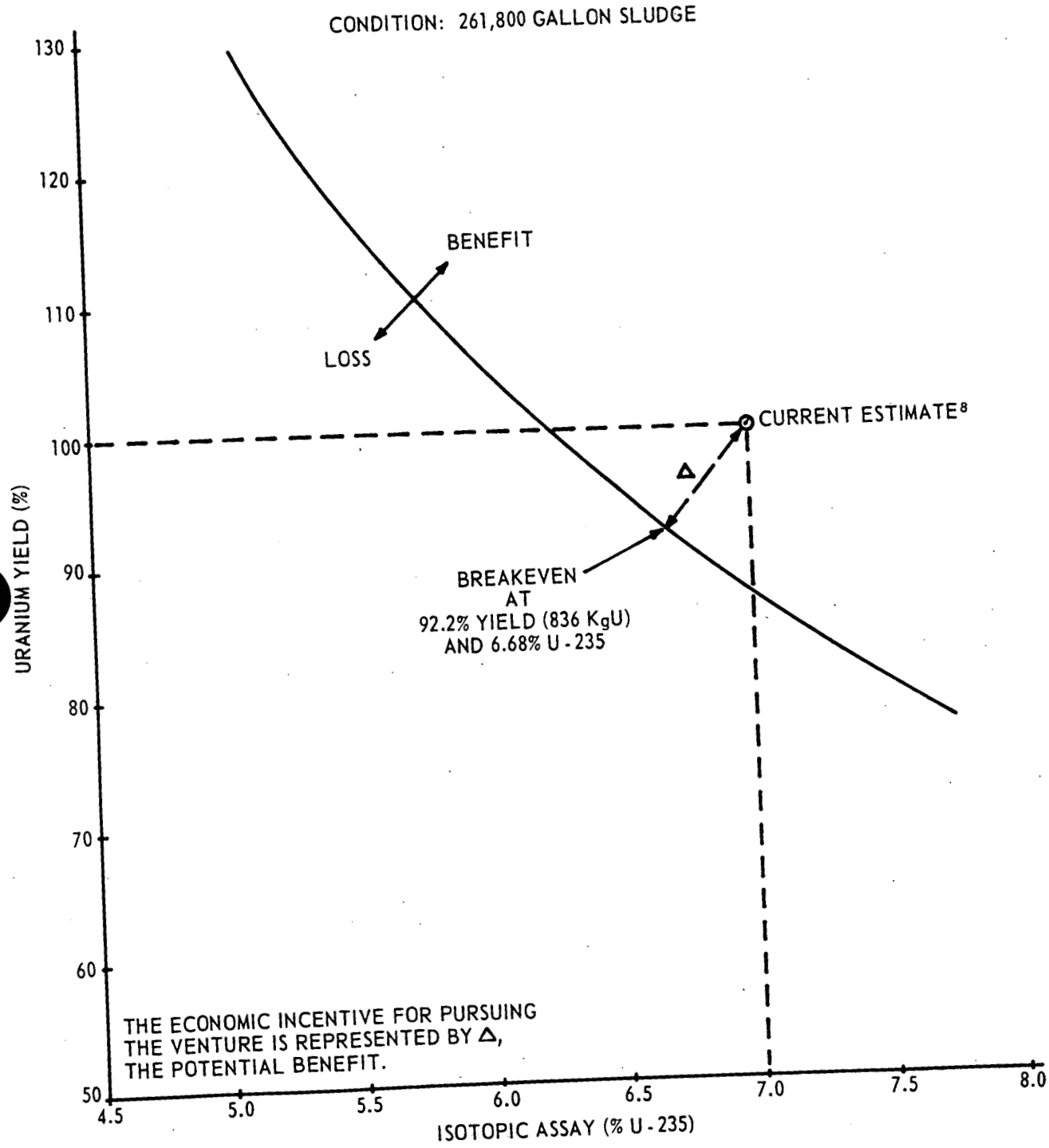


FIGURE 10 Determination of Benefit Potential and Breakeven Point

9.4 Combined Factors of Yield and Isotopic Assay

Since the sensitivity to value/costs breakeven is more heavily dependent on material value factors (U content and U-235 assay) than processing cost factors (sludge volume), Figure 9 was developed to bracket the sensitivity of the combined factors to breakeven at constant sludge volume.

The intersections of the U-235 parametric lines with the combined operating and capital costs curve establishes the breakeven curve plotted in Figure 10.

9.5 Benefit Potential and Breakeven Point

Although the current estimates of 907 KgU at 7.0% U-235 would be economically favorable for recovery, breakeven is estimated to require the processing of at least 836 KgU at 6.68% U-235 (See Figure 10). Compared with the estimated recovery of 862 KgU at 95 percent processing yield and 7.0% U-235 assay, the benefit potential based on current estimates is very small and unattractive given the uncertainties. Because of the sensitivity of the economic incentive to U content and U-235 assay, the economic analysis of the preceding section leading to the recommendation of "store now-recover later" is further supported.

10. SLUDGE GENERATION AT GAT

GAT has estimated the annual discharge of enriched uranium to X-701 B holding pond at 400 KgU[20]. Neither the isotopic assay of this generation nor the volume of sludge containing the quantity of uranium is specified. The venture could become attractive if this quantity would be contained in essentially the same volume of 261,800 gallons (already containing 907 KgU) used in the estimate. If the sludge volume increases proportionately with uranium content, the venture would continue as a low rate of return venture. The generation of additional uranium in the pond sludge has no near term impact on the recommendation of continuing the present storage until recovery becomes more attractive at some future time.

ACKNOWLEDGEMENT

The author expresses his appreciation to the persons listed below for consultation related to the formulation of conceptual flowsheets, process planning and cost analysis:

J. E. Beckelheimer
J. H. Cavendish
J. D. Kennedy
A. B. Kreuzmann
N. R. Leist
L. M. Levy
M. G. Mendel
A. F. Pennak
C. F. Peters

REFERENCES

[1] Advance Planning Department Project AP-120.

[2] M. G. Mendel and N. R. Leist. "Processing Portsmouth Pond Sludge - Enriched Uranium", Production Technology Monthly Report, March, 1971.

[3] L. M. Levy. Meeting Notes, "Portsmouth Pond Sludge", September 16, 1971.

[4] M. G. Mendel to N. R. Leist. "Laboratory Investigation of the Recovery of Uranium From Portsmouth Pond Sludge", February 25, 1977 (Work performed in 1971).

[5] N. R. Leist, W. E. Shaw and J. F. Werdmann to C. E. Polson and L. M. Levy. "Trip Report to Goodyear Atomic Corporation, Portsmouth, Ohio, on May 23, 1973", June 5, 1973.

[6] J. H. Cavendish to C. E. Polson. "Report on a Trip to Goodyear Atomic Corporation (GAT), Piketon, Ohio, August 19, 1975", August 25, 1975.

[7] C. F. Peters to L. M. Levy. ">2% Enriched GAT Pond Sludge", October 29, 1975.

[8] C. R. Chapman to H. D. Fletcher. "Recovery of Uranium From Waste Sludges and Metal Oxides", November 18, 1975 (Unpublished).

[9] C. R. Chapman to H. D. Fletcher. "Processing Weldon Spring Pit Sludge at NLO", January 29, 1976.

[10] Dewey Large to A. F. Pennak. "Removal of Sludges From Weldon Spring by Cotter Corporation", ERDA Contact Report, October 12, 1976.

[11] J. H. Cavendish to D. Large. "Removal of Sludges From Weldon Spring by Cottor Corporation", November 16, 1976.

[12] R. Cross to L. M. Levy. "Recovery of Uranium From Pit Sludges", ERDA Contact Report, January 28, 1977.

[13] R. Cross to R. M. Spenceley. "Proposal to Mine and Process U in NLO Pits", ERDA Contact Report, January 31, 1977.

[14] Advance Planning Department Project AP-178.

[15] H. D. Fletcher to S. F. Audia. "Materials Management Valuation Data", August 16, 1976.

[16] H. Stanton Oster, Jr. to C. A. Schwan. "Values for UO_3, Fiscal Year 1977", August 24, 1976.

[17] M. S. Nelson to C. A. Keller. "U Content of Silos", September 21, 1972.

[18] M. C. Thompson, B. E. Murphree, et al. "Equilibrium Distribution of Uranyl Nitrate Between Nitric Acid and 7.5 v/o TBP", USERDA Report DP-1384. October 1975.

[19] Reactor Handbook, Volume II, Fuel Reprocessing, Page 194. New York:Interscience, 1961.

[20] Energy Research & Development Administration. "Final Environmental Impact Statement Portsmouth Gaseous Diffusion Plant Site", USERDA Report ERDA-1555. May 1977.