3.0 Recycled Uranium

3.1 Uranium Recycle Description

This chapter is designed to quantitatively define the recycled uranium flows to and from Hanford. The transactions into and out of Hanford will focus on the 300 Area Fuel Fabrication complex of facilities and the UO_3 Plant (224-U Building).

3.1.1 Hanford Key Interfaces for Recycled Uranium

For the Uranium Recycle Project, the Hanford Site is designated as a "Source Site". A source site is viewed as one at which uranium fuel is irradiated, chemically separated, and shipped to offsite locations. These offsite locations are referred to as "Tier 1" sites. Tier 1 sites are those which received recycled uranium directly from the Hanford Site. From the Hanford perspective, uranium transactions offsite are divided into "Major Tier 1" sites and "Minor Tier 1" sites. The distinction is made primarily as it relates to the quantities of recycled uranium shipped and/or received. The Major Tier 1 and Minor Tier 1 sites (from Hanford's perspective) are identified below:

Major Tier 1 Sites:

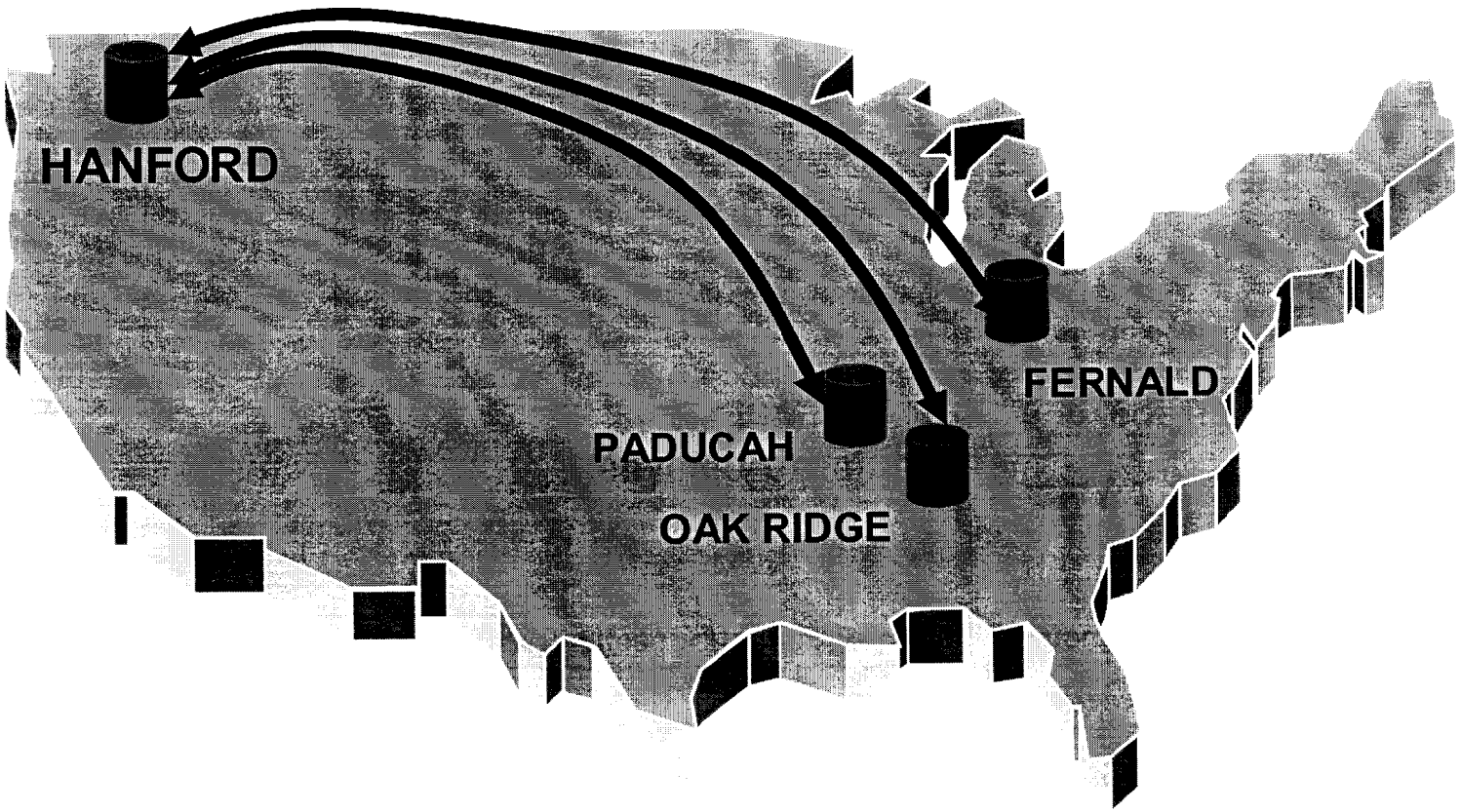
- Paducah Gaseous Diffusion Plant (GDP), Kentucky
- Fernald, Ohio (FMPC), previously National Lead of Ohio (NLO)
- K-25 Gaseous Diffusion Pant & Y-12 Plant, Oak Ridge, Tennessee

Minor Tier 1 Sites:

- All others (see Appendix B tables for these sites)

Major Tier 1 site locations are shown in Figure 3-1. Figure 3-2 shows the locations of many of both the Major and some of the Minor Tier 1 site locations. Figures 3-3A through Figure 3-3D show the flow of material through the complex for various time periods [DOE/EM-0319 1997]. There have been no reviewed records which indicate transfers of recycled uranium directly to the Portsmouth GDP.

Figure 3-1 Major "Tier 1" Sites for Hanford Recycled Uranium Transactions



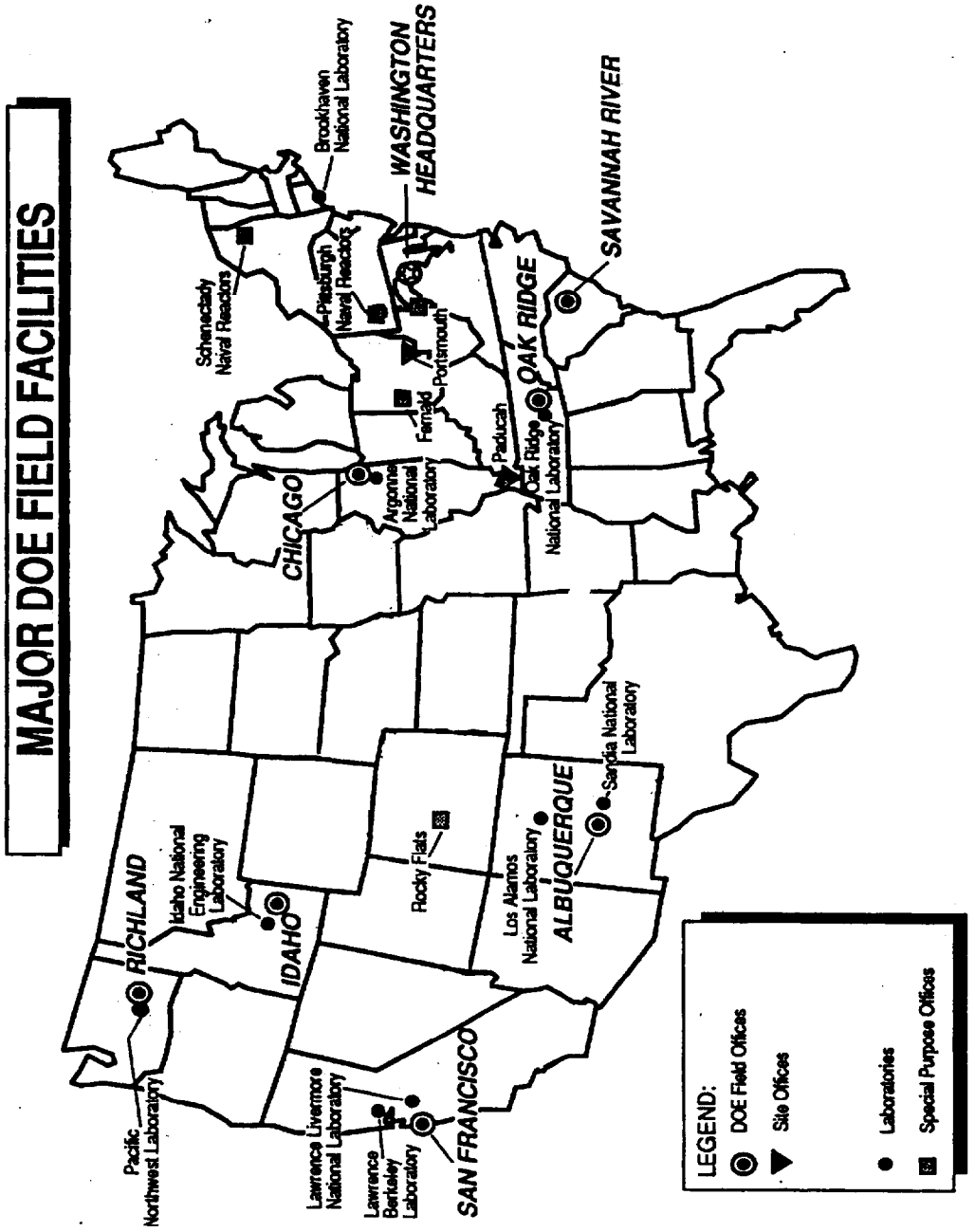


Figure 3-2 Major DOE Field Facilities

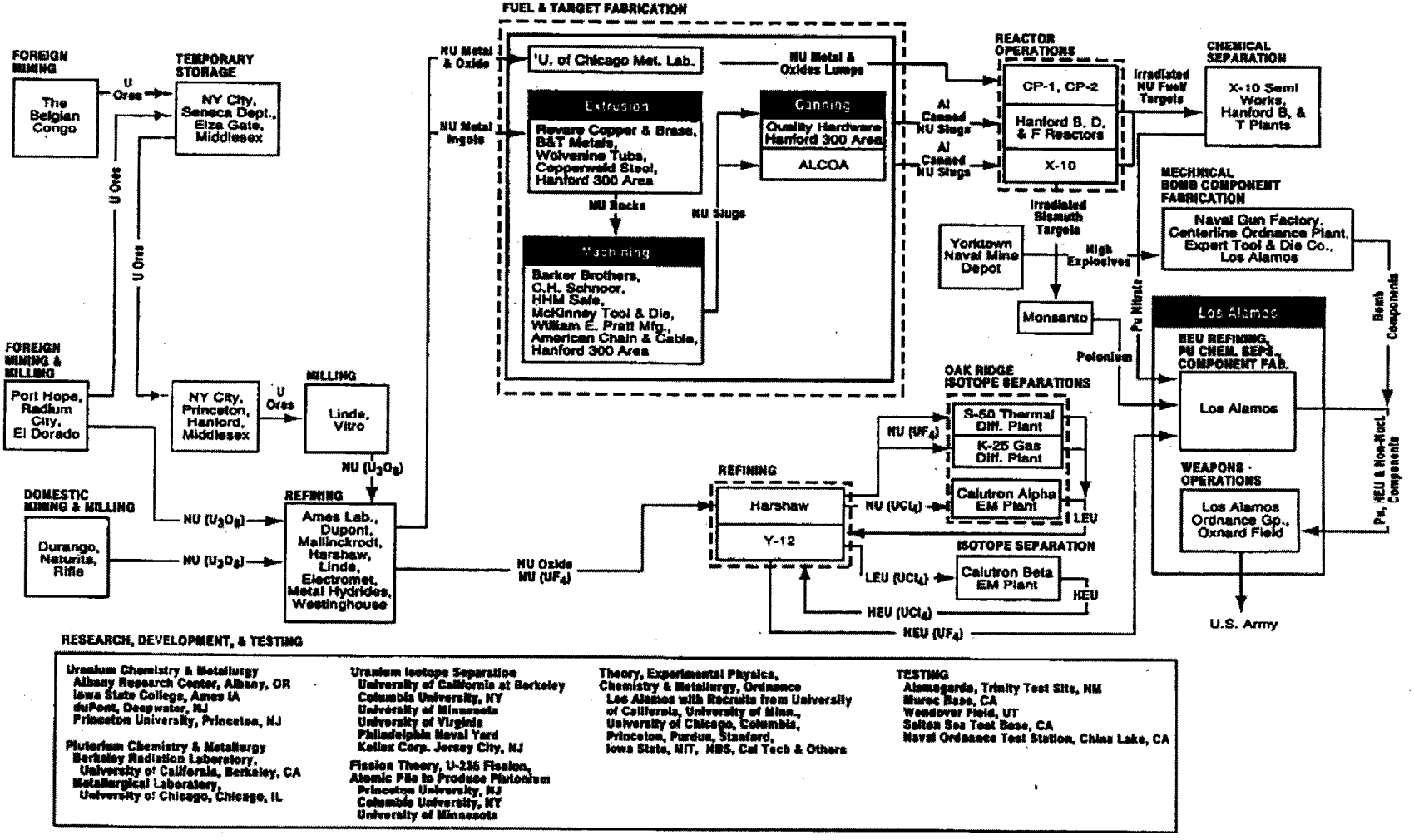


Figure 3-3A Material Flow – Manhattan Engineer District: 1942 – 1946 [DOE/EM-0319 1997]

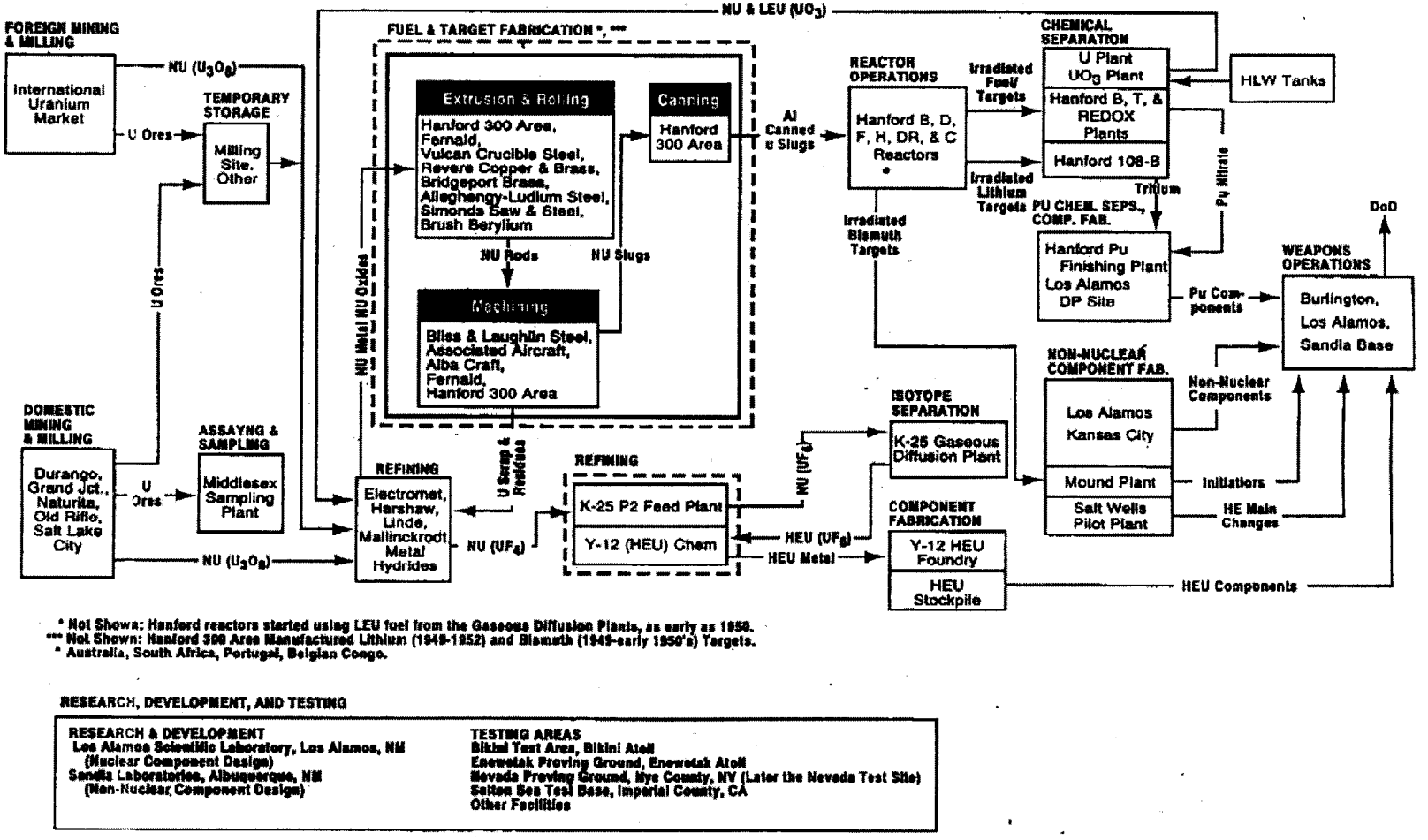


Figure 3-3B Material Flow – Atomic Energy Commission: 1946 – mid 1950s [DOE/EM-0319 1997]

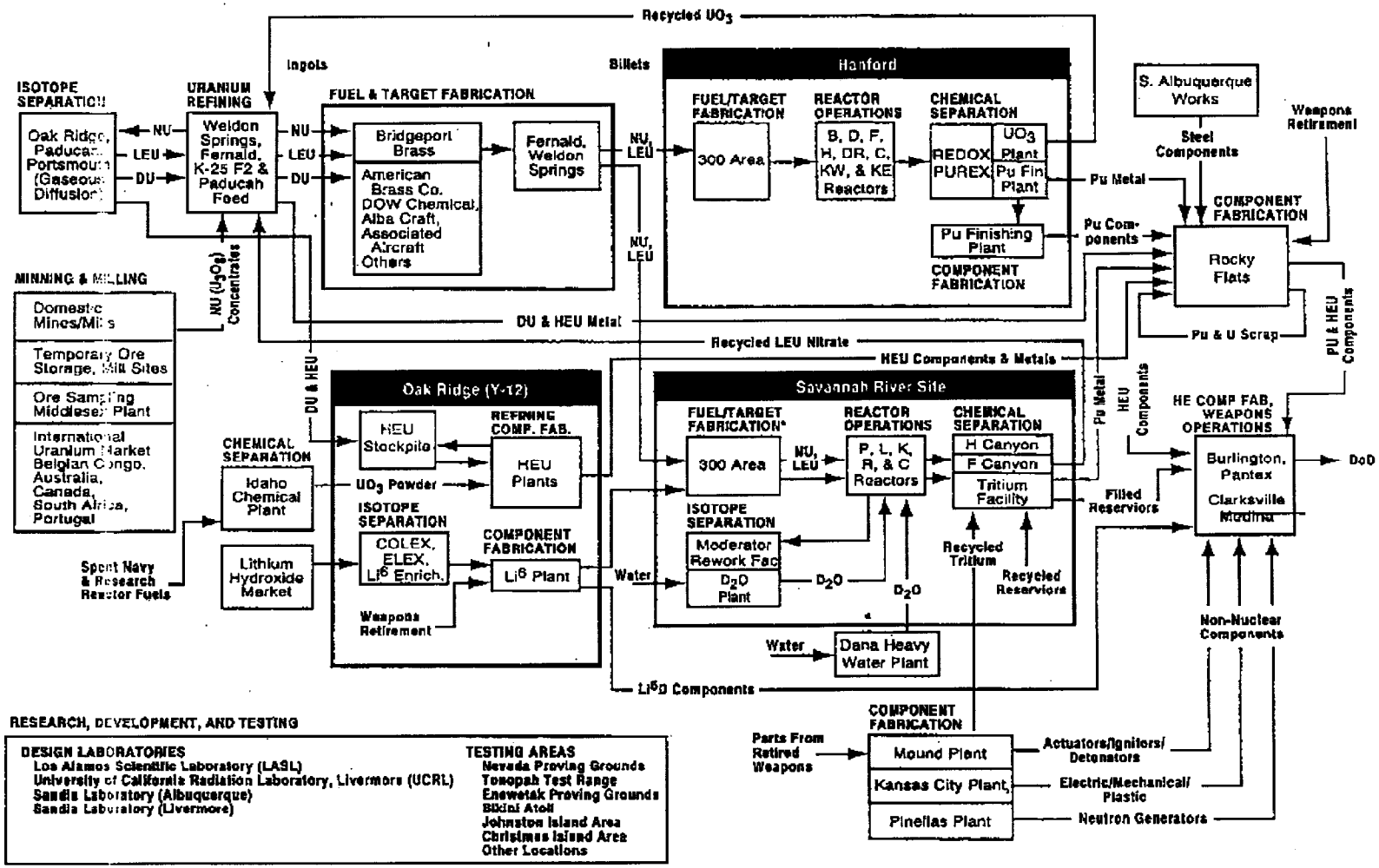


Figure 3-3C Material Flow – Atomic Energy Commission: mid 1950s – mid 1960s [DOE/EM-0319 1997]

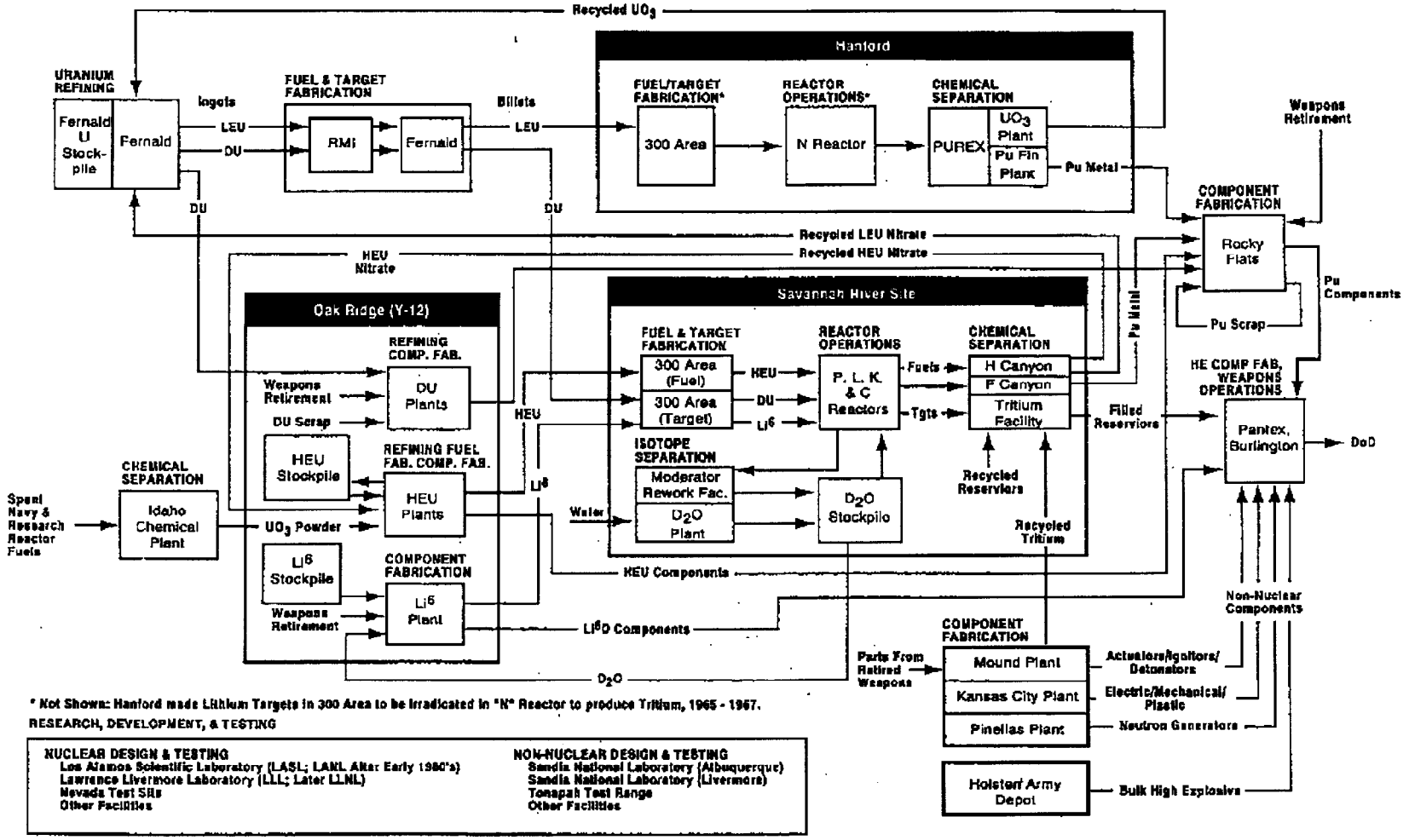


Figure 3-3D Material Flow – Atomic Energy Commission/Energy Research and Development Agency/Department of Energy: mid 1960s – late 1980s [DOE/EM-0319 1997]

3.1.2 Beginning of Hanford In-Scope Recycled Uranium Transactions

3.1.2.1 Key Hanford Historical Dates for Recycled Uranium

Beginning of Recycled Uranium Shipments **OUT** of Hanford:

Depleted Uranium:	Mar 1952	UO_3 product to Oak Ridge K-25
Normal Uranium:	July 1952	Metal scrap returns to offsite fuel reprocessors
Enriched Uranium:	July 1952	Research & development quantities
Enriched Uranium:	Mar 1959	UO_3 LEU product to Oak Ridge K-25 (Production Channel)

Beginning of Recycled Uranium Receipts **INTO** Hanford:

Depleted Uranium:	July 1952	Hanford UO_3 heels in returned drums from Oak Ridge K-25
Normal Uranium:	July 1952	Metal billets from offsite fuel fabricators
Enriched Uranium:	July 1952	Research and development quantities
Enriched Uranium:	July 1960	Metal LEU billets from Fernald (Production Channel), at parts per trillion Pu (from cascades)
Enriched Uranium:	Oct 1963	Metal LEU billets from Fernald (Production Channel) (at parts per billion Pu)

3.1.2.2 Production Channel Material Transactions

3.1.2.2.1 Shipments

For UO_3 finished product from the Hanford production channel, the first lot of UO_3 was rail shipped to K-25 on January 25, 1952 and consisted of 8 drums of Lot 001 [Richards 1952b]. The second shipment (Lot 002, 7 drums) was shipped to K-25 on February 11, 1952 [Richards 1952]. Both of these lots were produced from natural uranium and contained no fission products. They were "cold" test runs to validate the UO_3 conversion process. This material was shipped to K-25 to make sure the physical (particle size) and metallic impurities were within Oak Ridge acceptance criteria. As the "cold" UO_3 was examined and found acceptable, Hanford began spiking the feed stream with UNH from irradiated fuel.

Production records indicate shipment of recycled uranium trioxide product to the Oak Ridge K-25 GDP first occurred on March 10, 1952. Examples of the historical transfer documents, with attendant analytical data, are shown in Figures 3-4, 3-5, and 3-6. This March 1952 UO_3 shipment is consistent with Hanford production history indicating UO_3 test runs in January 1952 and full operation in February 1952.

[redacted]

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RW-2375

March 11, 1952

This Document consists of
2 Pages No. 1 of
19 Copies, Series [redacted]

Dr. Frank Hurd
Carbide and Carbon Chemicals Corporation
K-25 Plant
Oak Ridge, Tennessee

Dear Dr. Hurd:

Hanford
43666

UO3 TRIAL PRODUCTION LOTS 007, 008, and 009

We are shipping by truck (United Motor Freight, GBL AT26971) Lots 007, 008, and 009 of UO_3 prepared from material processed through the Redox plant. This shipment, consisting of 24 drums, left on March 10 and should arrive about March 17, directed to K-25 Plant, Oak Ridge, Tennessee, att'n F. H. Anderson - J. W. Arendt./ The average irradiation history of this uranium is considerably below the nominal 600 MWD/t for full level material due to blending with cold uranium dissolver heels, etc. This is confirmed by the isotopic analyses reported in the table below. Results of other analyses on a composite sample of each lot are also given.

Classification cancelled (Change to
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Section 2.7.3.1
by CARBaughPNL
Verified By WHC CO
11/14/94

Very truly yours,

R.B. Richards

R. B. Richards, Manager
Separations Technology Unit

[redacted]

1-2 Dr. Frank Hurd, K-25
3 AF Huber, K-25
4 WB Harnes, K-25
5 Sylvan Cromer, K-25
6-7 Hanford Operations Office - Atomic Energy Commission - Attn: DG Sturges
8 AE Greninger - CH Greager
9 JE Haider - TW Hauff
10 RS Bell - VR Chapman
11 VD Donihoe
12 JS
13 FW
14 RF
15 FW Albaugh - AH Bushey
16 300 File
17 700 File
18 Pink
19 Keller

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RIALS

[redacted]

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Figure 3-4A First Hanford Shipment of UO_3 Containing Transuranics & Analytical Data
[Richard 1952a]

HAN-43666

Dr. Frank Hurd - 2 - March 11, 1952

Component or Property	Reported as	Lot 007	Lot 008	Lot 009
UO_3	%	97.9	97.7	97.4
H_2O	"	0.21	0.23	0.26
HO_3	$\%HNO_3$	0.06	0.61	0.55
U_3O_8	%	0.12	0.1	0.11
Na	ppm	3000	3000	2500
PO_4	"	1500	1500	1500
Fe	"	700	950	550
Ni	"	20	20	20
Mo	"	50	50	< 50
Cr	"	2	2	5
W	"	< 100	< 100	< 100
Si	"	10	10	50
B	"	< 0.2	< 0.2	< 0.2
S	"	27	6	< 1
Al	"	5000	5000	5000
Particle Size	% thru 80 Mesh	98.2	99.0	97.7
Bulk Density	g./cc.	1.99	2.07	1.75
Surface Area	sq. m./g.	1.3	1.035	1.2
Pu	ppb	< 5	< 5	< 5
f.p. activity, β	*	< 5%	< 5%	< 10%
f.p. activity, δ	*	< 70%	< 100%	< 56%
U_{235}	% of U	0.68	0.68	0.67

* %, relative to (beta or gamma) activity of an equal weight of natural uranium

Figure 3-4A (Continued) First Hanford Shipment Containing Transuranics and Analytical Data [Richards 1952a]

[redacted]

DECLASSIFIED

HW-23346

T.W.
Box 130263
1849

March 19, 1952

This Document Consists of
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Copies, Series

Hanford
43786

Dr. Frank Hurd
Carbide and Carbon Chemicals Corporation
K-25 Plant
Oak Ridge, Tennessee

Dear Dr. Hurd:

UO_3 TRIAL PRODUCTION LOTS 010, 011, 012, and 013

We are shipping by rail (car Milwaukee 1014, GRL AT-26979) lots 010, 011, 012, and 013 of UO_3 prepared from nominal 600 MWD/t material processed through the Redox Plant. This shipment, consisting of 32 drums and 4 boxes, left on March 19 and should arrive on March 24, directed to K-25 Plant, Oak Ridge, att'n F. H. Anderson - J. W. Arendt. Results of analyses of a composite sample of each lot are given below.

Classification cancelled (Change to
UNCLASSIFIED)
By Authority of RLO-CG-5
Section 1.4.3
IFS8-94 PNL
By C A Bauman
Verified By J Briggs WHC-CO 11/14/94

Yours very truly,

R. B. Richards, Manager
Separations Technology Unit
Technical Section, Engineering Dept.

By J. B. Work
J. B. Work

RBR:JBW:blp

bcc: 1-2 Dr. Frank Hurd, K-25
3 AP Huber, K-25
4 MB Hunes, K-25
5 Sylvan Cromar, K-25
6-7 Hanford Operations Office - Atomic Energy Commission - Att'n: DC Stranges
8 AB Greninger - ON Greager
9 JB Neider - TW Kauff
10 RS Bell - VR Chapman
11 VD Doubleo
12 JB Work - RB Richards
13 FW Woodfield
14 [illegible]
15
16
17
18 Pink
19 Yellow

[redacted] DECLASSIFIED

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MATERIALS

Figure 3-4B Second Hanford Shipment Containing Transuranics and Analytical Data [Work 1952]

[redacted] HW-23846

Dr. Frank Hurd - 2 - March 19, 1952

Component or Property	Reported as	Lot 010	Lot 011	Lot 012	Lot 013
UO_3	%	97.3	97.6	98.0	98.1
H_2O	"	0.27	0.24	0.24	0.23
NO_3	$\%HNO_3$	0.65	0.55	0.62	0.54
U_3O_8	%	0.24	0.46	0.35	0.45
Na	ppm	2500	2500	5000	2000
PO_4	"	< 15	<15	< 15	150
Fe	"	174	177	133	116
Ni	"	< 10	< 10	< 10	< 10
Mo	"	< 50	< 50	< 50	< 2
Cr	"	1	10	1	< 1
W	"	< 10	< 10	< 10	< 10
Si	"	10	20	50	25
B	"	< 0.2	< 0.2	< 0.2	< 0.2
S	"	7	< 1	< 1	< 1
Al	"	2500	2000	2000	1500
Particle Size	% thru 80 Mesh	95.5	96.4	99.1	80.7
Bulk Density	g./cc.	2.2.	1.69	1.75	2.10
Surface Area	sq. m./g.	1.1	1.15	1.0	1.0
Pu	ppb	< 5	< 1	< 5	< 1
f.p. activity, β	*	< 5%	29%	18%	18%
f.p. activity, δ	*	83%	105%	82%	77%
U_{235}	% of U	0.67	0.66	0.66	0.66

* %, relative to (beta or gamma) activity of an equal weight of natural uranium

[redacted]

Figure 3-4B (continued)
Second Hanford Shipment of UO_3 – Analytical Results
[Work 1952]

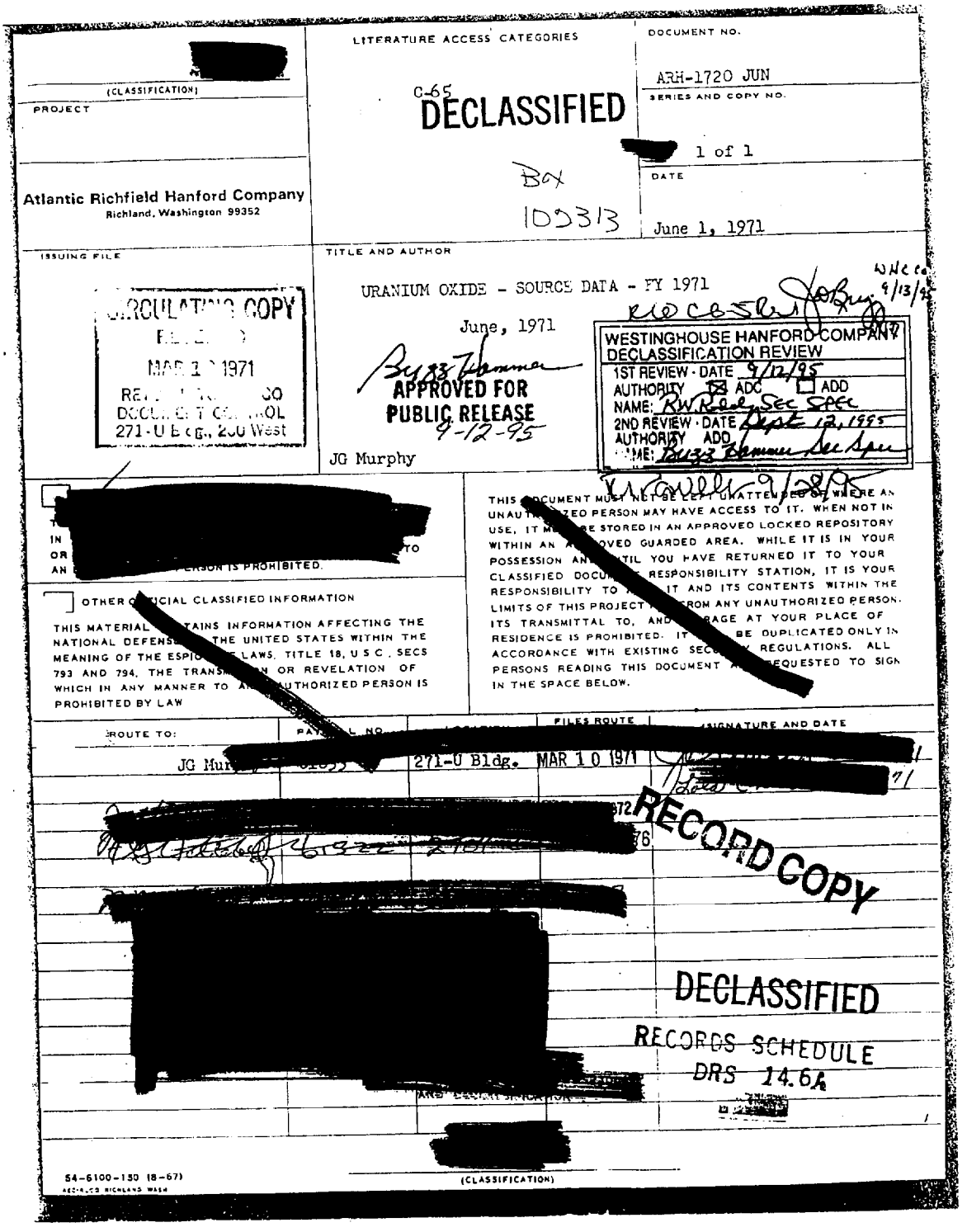

Figure 3-5 Example of Historical Transfer Forms-Cover Page

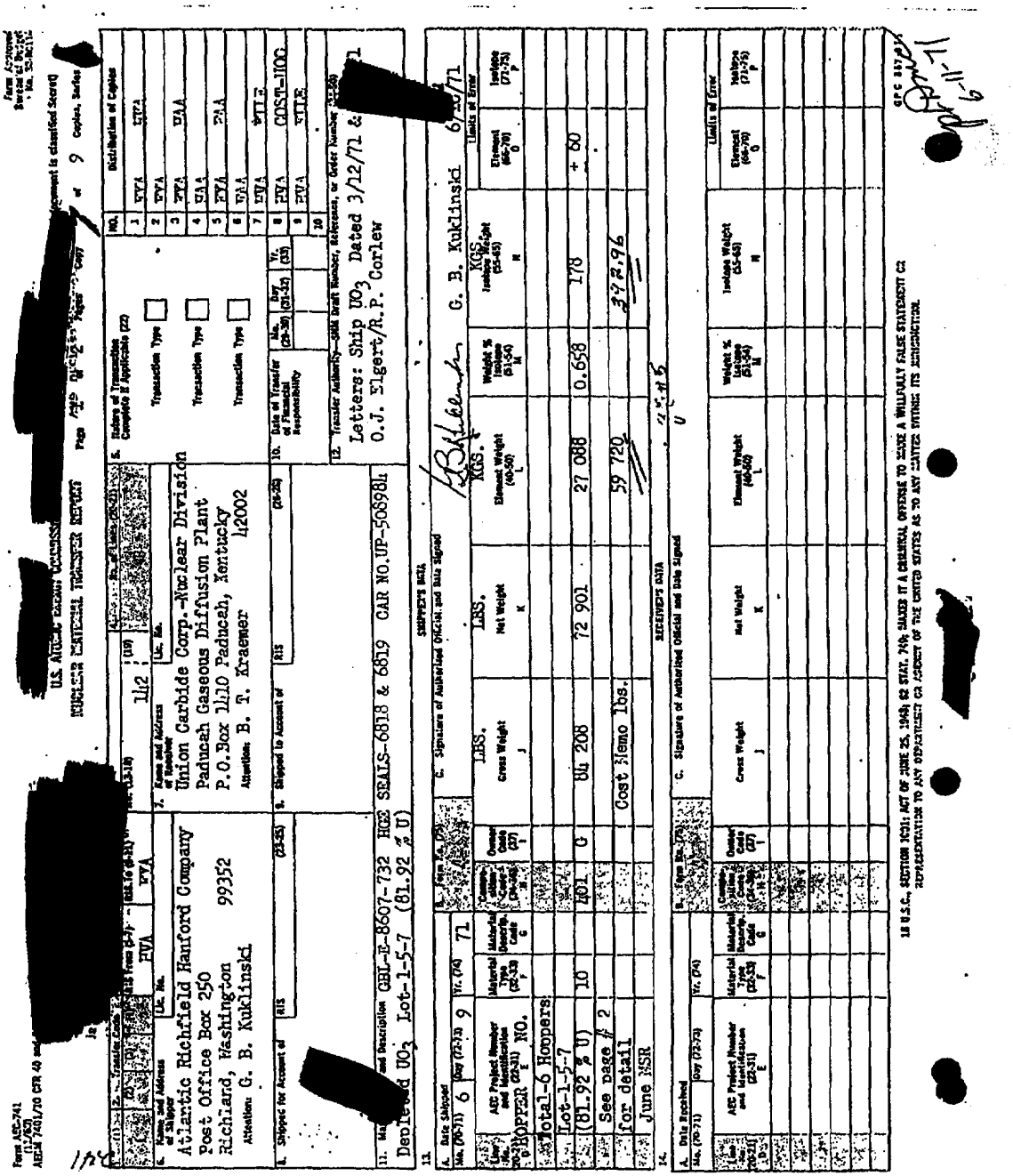

Figure 3-5 (Continued) Example of Historical Transfer Form for Shipment from Hanford to Paducah (circa 1971)

[redacted] 208 [redacted]

[redacted]
(CLASSIFICATION)

UO_3 — PRODUCT ACCEPTANCE

LOT NUMBER	1-5-2 & 1-5-3		
TRANSFER SERIES	HVA-FYA-133	GROSS WEIGHT	Lot-1-5-2 28 210 Lot-1-5-3 56 234 Lbs.
SHIPPED TO	Union Carbide Corporation	TARE WEIGHT	3 820 7 570 Lbs.
GBL NUMBER	E-8607-725	NET WEIGHT	24 390 48 664 Lbs.
MATERIAL	Depleted UO_3	DATE SHIPPED	6-1-71
NO. OF CONTAINERS	Lot-1-5-2 2 cont. Lot-1-5-3 4 cont.	NET SAMPLE WEIGHT	Lot-1-5-2 3 Kgs. Shipped 5-28-71
CAR NUMBER	UP-508825	AVERAGE PERCENT U	82.04 81.90
SEAL NUMBERS	HGE-6803 & 6804	AVERAGE PERCENT U-235	0.658 Est.

SUBMITTED BY: G.B. Kuklinski — ATLANTIC RICHFIELD HANFORD COMPANY — DATE: 6-2-71

ACCEPTED BY: A. N. Singleton — U.S. ATOMIC ENERGY COMMISSION — DATE: 6/7/71

Shipment Pending on Lot-1-5-3

[redacted]

[redacted] SIFICATION

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1 PAGES, NO. 1 OF
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HANFORD CATEGORY C-65

Figure 3-6 Example of Historical Product Acceptance Form Hanford Depleted UO_3 to Paducah (circa 1971)

In March 1959, General Electric was authorized by the AEC to begin routine shipments of low-enriched (0.94% ^{235}U before irradiation) UO_3 to the K-25 facilities in Oak Ridge [Gifford 1959]. Hanford LEU UO_3 shipments began soon thereafter. From this March approval-to-ship to the end of June 1959, Hanford produced and shipped approximately 288 MTU of the low-enriched (0.85%) UO_3 to Oak Ridge. Although the K-25 facility was the first recipient of Hanford recycled uranium, the vast majority of the UO_3 product was shipped to the Paducah site beginning in FY 1954 through FY 1972.

The third major recipient of Hanford recycled UO_3 was the Fernald site, which began receiving research quantities of depleted UO_3 in FY 1953. Although Fernald received small quantities of Hanford depleted UO_3, they were the major recipient of Hanford low-enriched recycled UO_3 beginning in the early 1960s through March 1989. These shipments originated from the Hanford chemical processing contractors (GE, Isochem, ARHO, RHO, WHC). Some small quantities of Hanford UO_3 which did not meet K-25 acceptance criteria for non-radioactive chemical purity were sent to Harshaw for purification. The majority of Hanford UO_3 shipped from Hanford to the K-25 plant was later shipped from K-25 to Paducah.

3.1.2.2.2 Receipts

Beginning in the late 1940s, Hanford received uranium product to support fuel fabrication activities. Metal feedstock was received from Mallinckrodt (St Louis and Weldon Spring, Missouri), and Simonds. Fuel samples were exchanged with many sites as this new technology was rapidly growing. With the Fernald Plant coming on line in March 1953, an increasing quantity of uranium was received and shipped between Hanford and Fernald. Hanford receipt of recycled uranium is assumed to begin in July 1952 (FY 1953) as material shipped from Hanford offsite between March through June 1952 could not have reasonably been received, reprocessed, and returned as feedstock from offsite until that time. In discussions with Fernald staff, normal (recycled) uranium metal feedstock initially received at Hanford could be expected to have contained only parts-per-trillion quantities of plutonium. Further discussions concerning the Hanford receipts are detailed in Section 3.2. Figure 3-7 (based on a 1949 document) shows the flow of uranium received into Hanford's 300 Area Fuel Fabrication facilities.

3.1.3 Out-of-Scope Uranium Transactions

3.1.3.1 Hanford Production Channel

Prior to March 1952, uranium shipments were confined to natural uranium scrap from Hanford's 300 Area Fuel Fabrication activities or metallurgical and process research involving UNH solutions. Natural uranium metal rods were received, principally from the New York Operations Office contractors, and processed at the 300 Area. The unirradiated scrap generated, in various forms, was sent offsite for reclamation. The finished fuel, termed "slugs" were "canned" and sent to the Hanford reactors for subsequent irradiation. Significant effort was made at Hanford in the early 1950s to reclaim and reuse as much of the generated uranium scrap due to the shortage of

feedstock within the production complex. The fuel fabrication process had no input points at which transuranics could be introduced into the unirradiated fuel manufacturing process. There has been no evidence of any transuranic contaminants being introduced into the fuel within the Hanford manufacturing process.

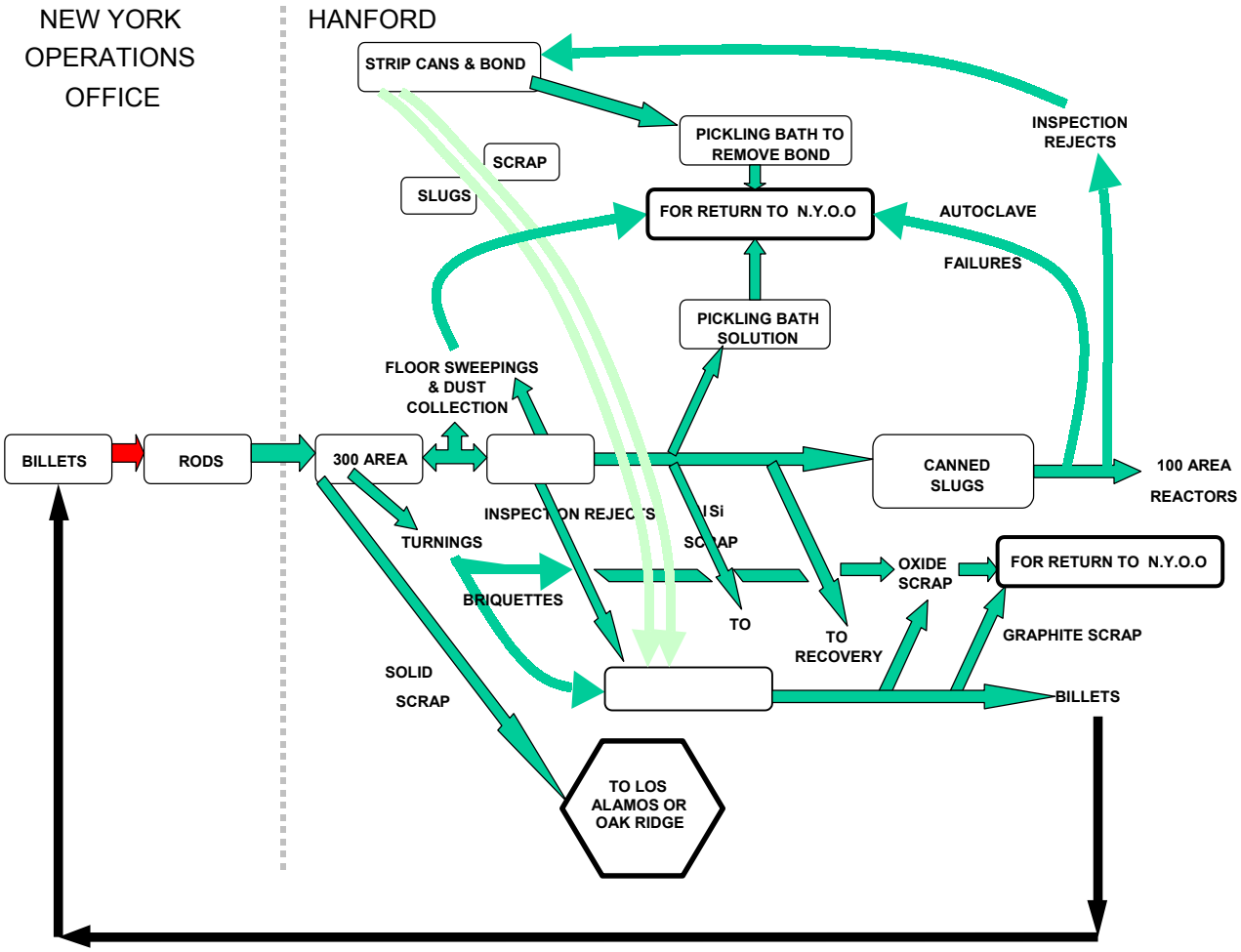

Figure 3-7 1949 Schematic Diagram Showing Uranium Flow in 300 Area (based on HAN-25257, dated May 25, 1949)

3.1.3.2 Out-of-Scope Research and Development Programs

As the development for increased uranium fuel productivity and chemical integrity continued during the late 1940s and early 1950s, small amounts of uranium were diverted from the production channels for research and development. The three areas of R&D were 1) Exponential Pile Program; 2) Fuel Development Metallurgy; and 3) Separations Technology. One such research program, referred to as the Pile Enrichment program, involved transfers of unirradiated slugs between the Y-12 Plant

and Hanford. Hanford received the bare slugs from the Y-12 Plant, canned them, and returned slugs, scrap metal, and reject slugs to Y-12. There is no indication that these slugs contained recycled uranium, and are therefore considered out-of-scope transactions.

A subsequent part of the R&D program sent irradiated slugs to the Idaho Chemical Processing Plant (ICPP) . These J-1 slugs were also irradiated at H reactor and the J-2 slugs at C reactor. The "C" slugs were irradiated at C and H reactor. As the ICPP came on line, shipments of these "J" irradiated slugs began in late calendar year 1951 and were reported in a 1952 Material Balance Report, FTS-953 [Donihee 1952]. As spent fuel, the irradiated slugs sent to Idaho are considered out-of-scope for this project.

Another mid-1960 AEC research program, termed the Plutonium Credit Activity, involved shipment of Hanford irradiated fuel to Nuclear Fuel Services (NFS) in West Valley, New York [DOE 1999]. Uranium contained in this spent fuel is also considered out-of-scope for this study.

3.1.3.3 Recycled Uranium Timeframe Summary

Summaries of recycled uranium transfers at Hanford have been separated into two distinct timeframes. The period from January 1952 through June 1970 (FY 1970) represents the initiation of Hanford processing of recycled uranium from one or more separation plants. (In 1967, REDOX (S-Plant) shut down.) The second period from July 1970 through the present (March 1999) represents a period in which the PUREX plant (when operating) was the sole separation plant for Hanford's Defense missions. This later period is also one in which Hanford supported multiple non-defense missions, such as the Fast Flux Test Facility, under multiple Hanford contractors.

Quantities of uranium shipped and received are presented in Sections 3.2 and 3.3 and further detailed in Appendix B.

3.1.4 Data Presentation – Isolation of Specific Timeframes

This narrative section is prepared to explain the Hanford Recycled Uranium Project team's approach to quantitatively define recycled uranium materials that were shipped into and out of the Hanford Site since its inception in 1943 until March 30, 1999. To simplify reporting, Hanford shipments and receipts include the aggregate of the fuel fabrication/reactor operations contractors (Douglas United, UNI) and the chemical processing contractors (Isochem, ARHO, Rockwell, Westinghouse, Fluor) after contractor turnover from General Electric (GE, 1965-66 turnover). The Pacific Northwest National Laboratory (PNNL) and its predecessors offsite shipments and receipts are addressed separately.

In an effort to simplify the data investigation, the team chose to separate the Hanford Site uranium transactions to correspond to the following four timeframes:

- Late 1940s – December 31, 1951: Hanford Site external shipments and receipts from December 1947-December 31, 1951 encompasses the General Electric Company (GE), which solely operated the fuel fabrication, reactors, and chemical separations plants. This first timeframe was isolated to define a demarcation between In-Scope and Out-of-Scope uranium transactions. All transactions within this timeframe have been evaluated as Out-of-Scope to this project. These transactions, detailed in Section 3.2 and 3.3, were almost exclusively natural uranium product and scrap transfers between the New York Operations Office (NYOO) and its contractors and Hanford's Fuel Fabrication facilities.

- January 1, 1952 – June 30, 1965: This timeframe represents the beginnings of Hanford transactions involving recycled uranium under a single GE Company contractor. This period also represents a high production timeframe. As the research for safer and more efficient plutonium production continued, more offsite facilities become recipients and suppliers for recycled uranium into and out of Hanford. In the early 1950s, the major NYOO contractors were replaced primarily by the Fernald and Weldon Spring (Mallinckrodt) facilities as the major suppliers of Hanford metal feedstock and recyclers of Hanford scrap.

- July 1, 1965 – June 30, 1970: This timeframe represents a transitional period of Hanford contractor turnover from the GE Company to multiple contractors and the beginnings of implementation of a DOE-wide Nuclear Materials Management and Safeguards System (NMMSS). PNL, assumed the management of Hanford Laboratories in 1965 as an independent research entity from Hanford Operations.

- July 1, 1970 – March 30, 1999: This timeframe includes the period when the PUREX Plant became the sole producer of UNH for Hanford. The NMMSS MC&A system became operational (complex-wide). Recycled uranium transactions between Hanford and Paducah and Oak Ridge were minimal, and the vast majority of transactions for Hanford were with Fernald (NLO, FMPC, FEMP) and Reactive Metals Incorporated (RMI, Ashtabula Extrusion Plant).

3.1.5 Hanford Historical Timeline References

In tracing the historical transfers, the key activities and timeframes listed below were identified as potentially significant for the purposes of this study. (A more complete Hanford historical timeline of events is provided in Appendix H.)

- Events Related to Hanford:

1950:	Paducah Gaseous Diffusion Plant sited
1951:	Savannah River Plant sited
1951:	Fernald Feed Materials Production Plant (Ohio) sited
1952:	Fernald production begins
1953:	Paducah GDP becomes operational

- Hanford Contractor timeline:

December 21, 1942: Du Pont signed to construct/operate atomic plants

September 1, 1946: General Electric Company (GE) assumes control as overall Site Contractor

1965 to 1966:	GE replaced by multiple contractors
September 1965 - 1973	**Fuel Fabrication & Reactor Operation:** Douglas United Nuclear (DUN-joint venture subsidiary of Douglas Aircraft Co. and United Nuclear Corp.)
1973-1979	United Nuclear Industries
1979-1987	United Nuclear Corporation (UNC)
1987-1996	Westinghouse Hanford Operations (WHC)
October 1996 - Current	Fluor Hanford Incorporated (FHI)
	Chemical Separations, Processing & Production
January 1966 - September 1967	Isochem (joint venture subsidiary of U.S. Rubber Co. and Martin Marietta Corp.)
September 1967 - October 1967	Atlantic Richfield Hanford Company, chemical processing operations
October 1977- July 1987	Rockwell Hanford Company, chemical processing operations
July 1977 - October 1996	Westinghouse Hanford Operations, reactor operations and chemical processing
October 1996 - Current	Fluor Hanford Incorporated (FHI)
	Research & Environmental Monitoring
January 1965 - 1977	Battelle Memorial Institute (BNWL) (became PNL)
1977 – Current	Pacific Northwest Laboratory (PNL)(became PNNL)

- Government Agencies Having Control of Hanford Site:

1943 - 1946	U. S. Army, Manhattan Engineer District
1947 – 1974	Atomic Energy Commission (AEC)
1/1/75 – 9/30/77	Energy Research and Development Administration (ERDA)
10/1/77 – Current	U. S. Department of Energy (DOE)

3.1.6 Key Dates/Assumptions for Uranium Transactions

May 5, 1950:	First shipment of unirradiated EU "J" slugs to Y-12
January 1952:	First recorded shipments of irradiated EU slugs to Idaho ICPP
January 1952:	Depleted UO_3 product was shipped (no fission products)
March 10, 1952:	First recorded shipment of UO_3 product to K-25 GDP with fission products
July 1952:	First assumed return of recycled uranium into Hanford
July 1958	Scheduled start of enriched UNH input into UO_3 Plant [Gustafson 1957]
March-June, 1959:	First production and shipment of enriched UO_3 to K-25

3.1.6.1 Beginning Shipment of Recycled Depleted Uranium Trioxide (UO_3)

As previously noted, the first shipment of recycled UO_3 produced at Hanford was shipped to Oak Ridge, Tennessee on March 10, 1952. Trial Production Lots 007, 008, and 009 were prepared from nominal 600 MWD/t material processed through the REDOX Plant. This initial truck shipment consisted of 24 drums and was sent to the K-25 Plant. The analytical results of composite samples for each lot were also provided [Richards 1952] and are shown in Figure 3-4. Further discussion of Hanford analytical data and product quality is detailed in Section 4.0.

3.1.6.2 Initial Shipments of Recycled Low-Enriched Uranium Trioxide (UO_3)

The first shipments of low-enriched (0.8 -0.9% ^{235}U) UO_3 to Oak Ridge were approved by the AEC on March 3, 1959. Shipments were initially to be made to the K-25 Facility [Gifford 1959].

3.2 Recycle Uranium Receipts

3.2.1 Uranium Forms Received from Offsite

The principal uranium form received at Hanford since its inception until the end of fiscal year 1988 was metal as either rods or billets to support fuel fabrication for Hanford Defense reactors. Figure 3-8 shows a typical box of inbound metal billets.

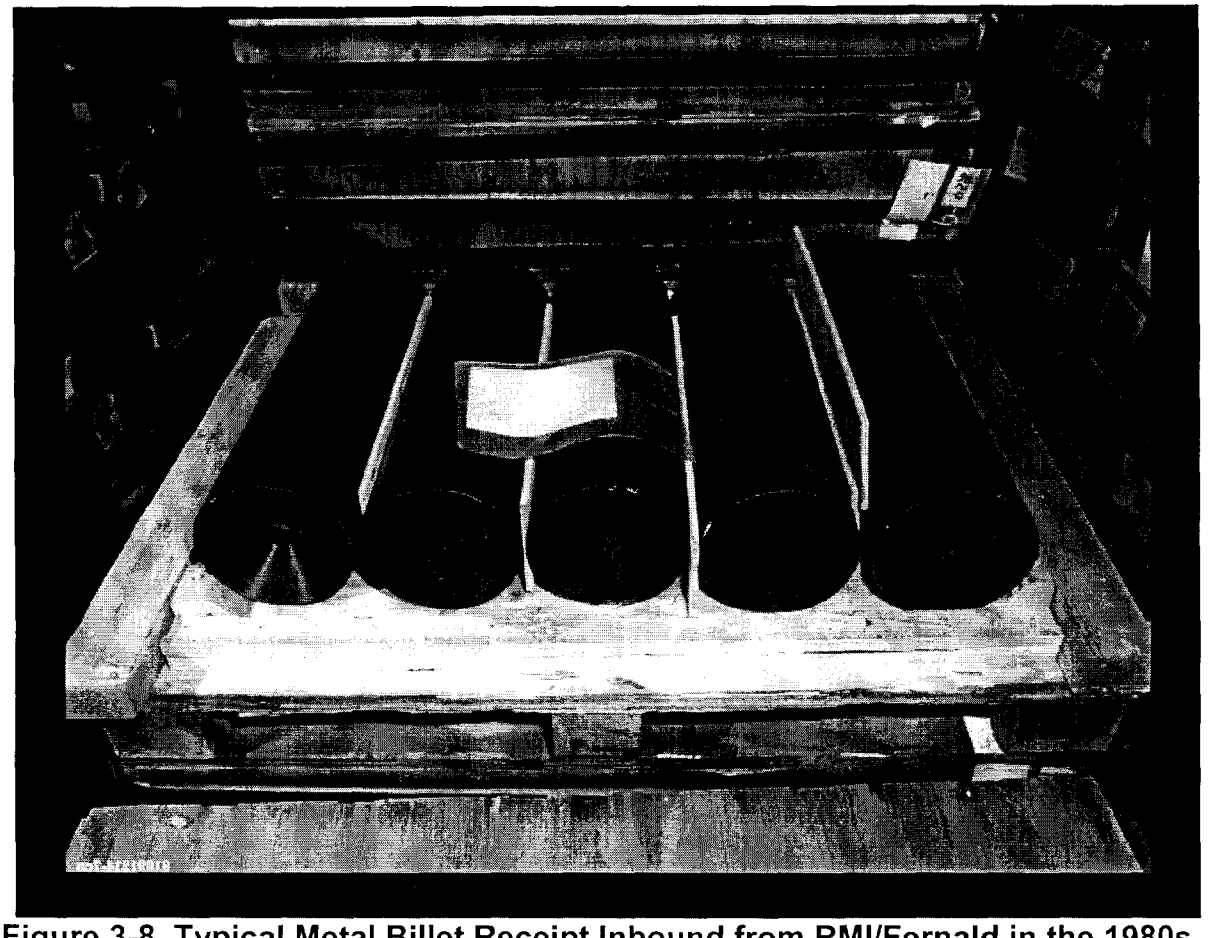

Figure 3-8 Typical Metal Billet Receipt Inbound from RMI/Fernald in the 1980s

To add some perspective, billets were typically 6-18 inches in diameter and ranged from 110 to as much as 190 Kg each. On a much smaller scale, as the UO_3 shipping containers were cycled back to Hanford from the Major Tier 1 sites, relatively small amounts of UO_3 were received as heels remaining in the returned shipping containers.

3.2.2 Initial Recycled Uranium Receipts into Hanford

- Depleted Uranium: July 1952 Hanford UO_3 heels in returned drums from Oak Ridge K-25
- Normal Uranium: July 1952 metal billets from offsite fuel fabricators

- Enriched Uranium: July 1952 research and development quantities
- Enriched Uranium: July 1960 metal LEU billets from Fernald from production channel (Pu in parts per trillion U) (from cascades)
- Enriched Uranium: October 1963 metal LEU billets from Fernald (Pu in parts per billion U)

3.2.3 Receipts Prior to July 1952 (Out-of-Scope)

In the late 1940s, Hanford receipts were natural uranium billets and rods from various metal fabricators under the management of the New York Operations Office (NYOO). Many of these same contractors were the recipients of Hanford shipments of scrap generated during the fuel fabrication activities and are detailed in Section 3.3. In the late 1940s and early 1950s, a majority of the Hanford billets were supplied by Mallinckrodt Chemical Works (MCW) and originated from three types of MCW cast ingots which included 1) ingots cast from natural uranium derbies; and 2) ingots recast from ingot croppings; and 3) ingots recast from reject slugs, rod ends, and rolling mill scrap [Greninger 1953]. Any uranium received at Hanford before July 1952 would not have contained reactor-produced fission products or radionuclides. There would have been no ^{236}U in these uranium receipts but would have contained the same distribution of uranium isotopes as present in natural or enriched uranium from a GDP cascade.

3.2.4 Beginning Receipts of Recycled Uranium at Hanford

The beginning receipts of metal feed stock with trace transuranics into the 300 Area is assumed to begin in July 1952 (FY 1953). This assumption is based on the logic that transuranics in the March 1952 UO_3 shipped offsite, could not have reasonably been processed and re-introduced into the returning metal billets until July 1952. Throughout the 1950s, Hanford continued to receive substantial metal feedstock from the NYOO contractors (Mallinckrodt Chemical Works, Simonds Saw & Steel, etc.). The largest shipper of metal feedstock during the mid-1950s and until the 1980s was the National Lead of Ohio Company (NLO) plant in Fernald, Ohio. NLO was renamed the Feed Materials Production Center (FMPC) in the 1950s. FMPC is now managed by the Westinghouse Materials Company of Ohio. FMPC is a Major Tier 1 site, being both the recipient of Hanford fuel fabrication scrap and UO_3 product and the supplier of metal billet feedstock. FMPC produced, via plants 6 and 9, normal and low-enriched ingots that were finished into billets at Reactive Metals Inc. (RMI) and shipped to Hanford's 300 Area. Informal discussions with Fernald staff, indicate that there were no input points at RMI that could introduce transuranic contaminants into the billets shipped to Hanford. RMI was essentially a heat treating and extruding facility.

3.2.5 Quantities of Recycled Uranium Received from July 1952-March 30, 1999

The summary of in-scope recycled uranium received at the Hanford contractor(s) starting in July 1952 until March 31, 1999 totaled approximately 109,200 metric tons. Of

this total, approximately 85% was received from the three Major Tier 1 sites (~92,800 MTU). Yearly summaries for these three Major Tier 1 sites are detailed in Tables 3-1, 3-2, and 3-3. Summary fiscal year tables for all receipts by Hanford contractors are provided in Appendix B, Tables 3.2.1 through 3.2.8. These Appendix tables are divided into distinct timeframes to simplify transactions associated with the Hanford contractor turnover which occurred continually from 1965 onward. Summarized in Table 3-1below is the total recycled uranium received from offsite sources at Hanford.

Table 3-1 Total Recycled Uranium Received from Offsite Sources

Timeframe:	MTUs Received: All Offsite Sources:	MTUs Rec'd Major Tier 1:	MTUs Rec'd Minor Tier 1:
FY 1953-FY 1965	77,603.7	72,869.5	4,734.2
FY 1966-FY 1970	19,119.5	19,109.6	9.9
FY 1971-3/31/99	12,420.4	788.0	11,632.4*
	109,143.6	92,767.1	16,376.5

*The majority of post FY 1971 receipts were from RMI Extrusion Plant (FTA) which supplied the Hanford fuel fabricator (United Nuclear, HXA).

3.2.6 Hanford Receipts of Recycled Uranium from Paducah

Hanford received residual UO_3 in returned containers from FY 1954 through FY 1964. The receipts from Paducah are detailed in Table 3-2.

3.2.7 Hanford Receipts of Recycled Uranium from Fernald and RMI (Ashtabula)

Hanford received metal billets from Fernald and Reactive Metals Incorporated (RMI), Ashtabula. Hanford also received residual UO_3 in returned shipping containers from Fernald. In 1983, incoming materials into the 300 Area were primarily 0.95% and 1.25% ^{235}U billets from RMI in Ashtabula, Ohio. The receiving rate was nominally 4 ½ loads per month at 18 metric tons uranium per load [Heaberlin 1983]. The receipts from Fernald are summarized in Table 3-3.

3.2.8 Hanford Receipts of Recycled Uranium from Oak Ridge

Hanford received relatively small quantities of UO_3 as heels in returned shipping containers and uranium metal for research programs. These receipts are summarized in Table 3-4.

3.3 Recycle Uranium Shipments

3.3.1 Recycled Uranium Streams Shipped Offsite:

Two major recycle uranium streams were shipped offsite from Hanford's beginnings until March 1999. The first of the two major streams was byproduct from the fuel

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Recycled Uranium

Table 3-2 Hanford Receipts From Paducah

(IN MTU)	Union Carbide of Kentucky Management by Oak Ridge Operations CKY, FYA									
FY	Date From	Date To	Into RIS	Hanford Contractor	Box #	Doc #	DU	NU	EU	MTU Total
1953	01-Jul-52	30-Jun-53	HGE	General Electric	38213	FTS 1085	0	0	0	0
1954	01-Jul-53	30-Jun-54	HGE	General Electric	38213	FTS 1311	0	0	0	0
1955	01-Jul-54	30-Jun-55	HGE	General Electric	38213	FTS 1481	0	0	0	0
1956	01-Jul-55	30-Jun-56	HGE	General Electric	38213	FTS 1644	0	0.002	0	0
1957	01-Jul-56	30-Jun-57	HGE	General Electric	38213	FTS 1980	2.2	0	0.7	2.9
1958	01-Jul-57	30-Jun-58	HGE	General Electric	38213	FTS CLVI 463-1A	2.2	0.049	0	2.2
1959	01-Jul-58	30-Jun-59	HGE	General Electric	38213	HAN 72720	2.9	0	1	3.9
1960	01-Jul-59	30-Jun-60	HGE	General Electric	38213	HAN 75996	1.9	0	0.1	2
1961	01-Jul-60	30-Jun-61	HGE	General Electric	38213	HAN 79125	2.9	0	0	2.9
1962	01-Jul-61	30-Jun-62	HGE	General Electric	38213	HAN 82406	3.4	0	0.6	4.1
1963	01-Jul-62	30-Jun-63	HGE	General Electric	38213	HAN 85615	4.1	0	0	4.1
1964	01-Jul-63	30-Jun-64	HGE	General Electric	38213	HAN 88957	2.4	0	0	2.4
1965	01-Jul-64	30-Jun-65	HZA	General Electric	38213	HAN 92119	0	0	0	0
						FY 1952 - FY 1965 Subtotal	***22***	***0.1***	***2.4***	***24.5***
1966	1-Jul-65	30-Jun-66	HZA	General Electric	38213	HAN 95170				
1966	1-Jul-65	30-Jun-66	HWA	Isochem Inc.	38213	HAN 95136				
				Hanford Chem Processing Contractor subtotals						
1966	1-Jul-65	30-Jun-66	HXA	Douglas United Nuc	38214	HAN 95171				
						Hanford FY 66 Aggregate subtotal	***0***	***0***	***0***	***0***
1967	1-Jul-66	31-Dec-66	HZA	General Electric	39213	HAN 96413				
1967	01-Jan-67	30-Jun-67	HZA	General Electric	39213	HAN 98198				
1967	01-Jul-66	31-Dec-67	HWA	Isochem Inc.	38213	HAN 96400				
1967	01-Jan-67	30-Jun-67	HWA	Isochem Inc.	38213	HAN 98196				
				Hanford Chem Processing Contractor subtotals						
1967	01-Jul-66	31-Dec-66	HXA	Douglas United Nuc	38214	DUN 1916				
1967	01-Jan-67	30-Jun-67	HXA	Douglas United Nuc	38214	HAN 98194				
						Hanford FY 67 Aggregate subtotal	***0***	***0***	***0***	***0***
1968	01-Jul-67	31-Dec-67	HVA	Atlantic Richfield Han	46425	HAN 99439				
1968	01-Jan-68	30-Jun-68	HVA	Atlantic Richfield Han	46425	ARH 699				
				Hanford Chem Processing Contractor subtotals						
1968	01-Jul-67	31-Dec-67	HXA	Douglas United Nuc	38214	DUN 3624				
1968	01-Jan-68	30-Jun-68	HXA	Douglas United Nuc	38214	DUN 4436				
						Hanford FY 68 Aggregate subtotal	***0***	***0***	***0***	***0***
1969	1-Jul-68	31-Dec-68	HVA	Atlantic Richfield Han	46425	ARH 1036				
1969	1-Jan-69	30-Jun-69	HVA	Atlantic Richfield Han	46425	ARH 1099-6				
				Hanford Chem Processing Contractor subtotals						
1969	1-Jul-68	31-Dec-68	HXA	Douglas United Nuc	38214	DUN 5250				
1969	1-Jan-69	30-Jun-69	HXA	Douglas United Nuc	38214	DUN 5942				
						Hanford FY 69 Aggregate subtotal		***0***	***0***	***0***
1970	1-Jul-69	31-Dec-69	HVA	Atlantic Richfield Han	46425	ARH 1099-12				
1970	1-Jan-70	30-Jun-70	HVA	Atlantic Richfield Han	46425	ARH 1540-6				
				Hanford Chem Processing Contractor subtotals				*0*	*0*	
1970	1-Jul-69	31-Dec-69	HXA	Douglas United Nuc	38214	DUN 6557				
1970	1-Jan-70	30-Jun-70	HXA	Douglas United Nuc	38214	DUN 7049				
						Hanford FY 70 Aggregate subtotal	***0***	***0***	***0***	***0***
						FY 1966 - FY 1970 Subtotal	***0***	***0***	***0***	***0***
						1952-June 30, 1970 MTU Subtotal	***22***	***0.1***	***2.4***	***24.5***
						July 1, 1970 - 3/31/99 Hanford MTU Subtotal	***0***	***0***	***0***	***0***
						Hanford In-Scope MTU Grand Total	***22***	***0.1***	***2.4***	***24.5***

Table 3-3 Hanford Receipts From Fernald

TOTAL URANIUM RECEIVED (IN MTUs)					NLO, FMPC, FEMP Fernald Ohio Managed by Oak Ridge Operations FVA, FVB, FVC					
FY	Date From	Date To	Into RIS	Hanford Contractor	Box #	Doc #	MTU DU	MTU NU	MTU EU	Hanford MTU Total
1952	01-Jan-52	30-Jun-52	HGE	General Electric	38213	FTS 953	0	0	0	0
1953	01-Jul-52	30-Jun-53	HGE	General Electric	38213	FTS 1085	0	0	0.8	0.8
1954	01-Jul-53	30-Jun-54	HGE	General Electric	38213	FTS 1311	0.1	2,735	0	2,735.1
1955	01-Jul-54	30-Jun-55	HGE	General Electric	38213	FTS 1481	0	4,550	0	4,550.4
1956	01-Jul-55	30-Jun-56	HGE	General Electric	38213	FTS 1644	55.6	4,564	12.3	4,631.7
1957	01-Jul-56	30-Jun-57	HGE	General Electric	38213	FTS 1980	46.5	5,785	62.3	5,893.4
1958	01-Jul-57	30-Jun-58	HGE	General Electric	38213	FTS CLVI 463-1A	9.9	6,841	405	7,255.9
1959	01-Jul-58	30-Jun-59	HGE	General Electric	38213	HAN 72720	0.4	4,699	614.9	5,314.4
1960	01-Jul-59	30-Jun-60	HGE	General Electric	38213	HAN 75996	0	6,352	794.2	7,146.6
1961	01-Jul-60	30-Jun-61	HGE	General Electric	38213	HAN 79125	1.3	5,306	1,308.4	6,615.2
1962	01-Jul-61	30-Jun-62	HGE	General Electric	38213	HAN 82406	0.4	4,956	1,405.6	6,361.7
1963	01-Jul-62	30-Jun-63	HGE	General Electric	38213	HAN 85615	0	5,743	1,760.6	7,504
1964	01-Jul-63	30-Jun-64	HGE	General Electric	38213	HAN 88957	29.4	4,775	1,923.2	6,727.7
1965	01-Jul-64	30-Jun-65	HZA	General Electric	38213	HAN 92119	0	5,580	2,523	8,103.5
						FY 1953 - FY 1965 Subtotal	***143.7***	***61,886.8***	***10,810.2***	***72,840.7***
1966	1-Jul-65	30-Jun-66	HZA	General Electric	38213	HAN 95170	0	1,126.5	1,202.2	2,328.7
1966	1-Jul-65	30-Jun-66	HWA	Isochem Inc.	38213	HAN 95136	0	0	0.3	0.3
						Hanford Chem Processing Contractor subtotals	*0*	*1,126.5*	*1,202.6*	2,329.1
1966	1-Jul-65	30-Jun-66	HXA	Douglas United Nuc	38214	HAN 95171	0	1,992.8	1,282.8	3,275.6
						Hanford FY 66 Aggregate subtotal	***0***	***3,119.3***	***2,485.4***	***5,604.7***
1967	1-Jul-66	31-Dec-66	HZA	General Electric	39213	HAN 96413	0	2.1	303.9	305.9
1967	1-Jan-67	30-Jun-67	HZA	General Electric	39213	HAN 98198	0	0.5	186.1	186.5
1967	1-Jul-66	31-Dec-67	HWA	Isochem Inc.	38213	HAN 96400	0	0	0.2	0.2
1967	1-Jan-67	30-Jun-67	HWA	Isochem Inc.	38213	HAN 98196	0	0	0.3	0.3
						Hanford Chem Processing Contractor subtotals	*0*	*2.5*	*490.5*	493
1967	1-Jul-66	31-Dec-66	HXA	Douglas United Nuc	38214	DUN 1916	89.6	1,502.7	321.7	1,914
1967	1-Jan-67	30-Jun-67	HXA	Douglas United Nuc	38214	HAN 98194	4.7	1,694.9	950.7	2,650.3
						Hanford FY 67 Aggregate subtotal	***94.3***	***3,200.1***	***1,762.9***	***5,057.3***
1968	1-Jul-67	31-Dec-67	HVA	Atlantic Richfield Han	46425	HAN 99439	0	0.2	0.2	0.4
1968	1-Jan-68	30-Jun-68	HVA	Atlantic Richfield Han	46425	ARH 699	0	0	0.4	0.4
						Hanford Chem Processing Contractor subtotals	*0*	*0.2*	*0.6*	0.8
1968	1-Jul-67	31-Dec-67	HXA	Douglas United Nuc	38214	DUN 3624	0	956.7	934.7	1,891.4
1968	1-Jan-68	30-Jun-68	HXA	Douglas United Nuc	38214	DUN 4436	0	296	1,233.5	1,529.6
						Hanford FY 68 Aggregate subtotal	***0***	***1,253***	***2,168.8***	***3,421.8***
1969	1-Jul-68	31-Dec-68	HVA	Atlantic Richfield Han	46425	ARH 1036	0	0	0.1	0.1
1969	1-Jan-69	30-Jun-69	HVA	Atlantic Richfield Han	46425	ARH 1099-6	0	0	0.2	0.2
						Hanford Chem Processing Contractor subtotals	*0*	*0*	*0.4*	0.4
1969	1-Jul-68	31-Dec-68	HXA	Douglas United Nuc	38214	DUN 5250	0	75.3	1,320.4	1,395.8
1969	1-Jan-69	30-Jun-69	HXA	Douglas United Nuc	38214	DUN 5942	0	63.3	1,122.5	1,185.8
						Hanford FY 69 Aggregate subtotal	***0***	***138.6***	***2,443.3***	***2,581.9***
1970	1-Jul-69	31-Dec-69	HVA	Atlantic Richfield Han	46425	ARH 1099-12	0.1	0.2	0.3	0.5
1970	1-Jan-70	30-Jun-70	HVA	Atlantic Richfield Han	46425	ARH 1540-6	0	0	0.1	0.1
						Hanford Chem Processing Contractor subtotals	*0*	*0*	*0*	0
1970	1-Jul-69	31-Dec-69	HXA	Douglas United Nuc	38214	DUN 6557	0	1,074.3	345.4	1,419.8
1970	1-Jan-70	30-Jun-70	HXA	Douglas United Nuc	38214	DUN 7049	0	707.8	316.3	1,024.1
						Hanford FY 70 Aggregate subtotal	***0***	***1,782.1***	***661.8***	***2,443.9***
						FY 1966 - FY 1970 Subtotal	***94***	***9,493***	***9,522***	***19,110***
						FY 1971-3/1999 Receipts into Atlantic Richfield (HVA)	2.33	0	0.04	2.4
						10/77-7/87 Receipts into Rockwell (HRA)	0	0.03	6.65	6.7
						FY 1971-3/1999 Receipts into United Nuclear (HXA)	0.1	398.6	360.3	759
						8/87-3/1999 Receipts into Westinghouse (HUD) & Fluor (HTA)	0	0.44	0.61	1.1
						1/1/65-3/1999 Receipts into PNNL (HYA)	4.21	0.04	0.37	4.6
						FY 71 thru March 31, 1999 Subtotal	***6.6***	***399.1***	***368***	***773.7***
						Grand MTU Total FY 52 thru March 1999	***244.6***	***71,778.***	***20,700.3***	***92,723.9***
						Grand MTU In-Scope Total FY 52-3/31/99	***244.6***	***71,778.***	***20,700.3***	***92,723.9***

Table 3-4 Hanford Receipts From Oak Ridge (K-25 & Y-12)

TOTAL URANIUM (IN MTUs)				K-25 GDP & Y-12 Oak Ridge, Tenn Managed by Oak Ridge Operations CCC, CYT,FZE,FZA,FZB,FZF						
FY	Date From	Date To	Into RIS	Hanford Contractor	Box #	Doc #	DU	NU	EU	Hanford MTU Total
1951	1-Jan-48	31-Dec-49	HGE	General Electric	38213	FTS 845	0.2	0	0	0.2
1952	31-Dec-49	30-Jun-52	HGE	General Electric	38213	FTS 953	0.02	0.004	0.40	0.42
1953	01-Jul-52	30-Jun-53	HGE	General Electric	38213	FTS 1085	0	0	0.6	0.6
1954	01-Jul-53	30-Jun-54	HGE	General Electric	38213	FTS 1311	0	0	2.1	2.1
1955	01-Jul-54	30-Jun-55	HGE	General Electric	38213	FTS 1481	0	0	0.4	0.4
1956	01-Jul-55	30-Jun-56	HGE	General Electric	38213	FTS 1644	0	0	0	0
1957	01-Jul-56	30-Jun-57	HGE	General Electric	38213	FTS 1980	0	0	0	0
1958	01-Jul-57	30-Jun-58	HGE	General Electric	38213	FTS CLVI 463-1A	0	0	0	0
1959	01-Jul-58	30-Jun-59	HGE	General Electric	38213	HAN 72720	0.1	0	0.1	0.1
1960	01-Jul-59	30-Jun-60	HGE	General Electric	38213	HAN 75996	0	0	0.4	0.4
1961	01-Jul-60	30-Jun-61	HGE	General Electric	38213	HAN 79125	0	0	0.4	0.5
1962	01-Jul-61	30-Jun-62	HGE	General Electric	38213	HAN 82406	0	0	0	0.1
1963	01-Jul-62	30-Jun-63	HGE	General Electric	38213	HAN 85615	0.1	0	0	0.1
1964	01-Jul-63	30-Jun-64	HGE	General Electric	38213	HAN 88957	0	0	0	0
1965	01-Jul-64	30-Jun-65	HZA	General Electric	38213	HAN 92119	0	0	0	0
						FY 1953 - FY 1965 Subtotal	***0.4***	***0.1***	***4.4***	***4.9***
1966	1-Jul-65	30-Jun-66	HZA	General Electric	38213	HAN 95170				0
1966	1-Jul-65	30-Jun-66	HWA	Isochem Inc.	38213	HAN 95136				0
				Hanford Chem Processing Contractor subtotals						0
1966	1-Jul-65	30-Jun-66	HXA	Douglas United Nuc	38214	HAN 95171				0
						Hanford FY 66 Aggregate subtotal	***0***	***0***	***0***	***0***
1967	1-Jul-66	31-Dec-66	HZA	General Electric	39213	HAN 96413				0
1967	1-Jan-67	30-Jun-67	HZA	General Electric	39213	HAN 98198				0
1967	1-Jul-66	31-Dec-67	HWA	Isochem Inc.	38213	HAN 96400				0
1967	1-Jan-67	30-Jun-67	HWA	Isochem Inc.	38213	HAN 98196				0
				Hanford Chem Processing Contractor subtotals						0
1967	1-Jul-66	31-Dec-66	HXA	Douglas United Nuc	38214	DUN 1916				0
1967	1-Jan-67	30-Jun-67	HXA	Douglas United Nuc	38214	HAN 98194		0.034		0
						Hanford FY 67 Aggregate subtotal	***0***	***0.034***	***0***	***0***
1968	1-Jul-67	31-Dec-67	HVA	Atlantic Richfield Han	46425	HAN 99439				0
1968	1-Jan-68	30-Jun-68	HVA	Atlantic Richfield Han	46425	ARH 699				0
				Hanford Chem Processing Contractor subtotals						0
1968	1-Jul-67	31-Dec-67	HXA	Douglas United Nuc	38214	DUN 3624			0	0
1968	1-Jan-68	30-Jun-68	HXA	Douglas United Nuc	38214	DUN 4436				0
						Hanford FY 68 Aggregate subtotal	***0***	***0***	***0***	***0***
1969	1-Jul-68	31-Dec-68	HVA	Atlantic Richfield Han	46425	ARH 1036				0
1969	1-Jan-69	30-Jun-69	HVA	Atlantic Richfield Han	46425	ARH 1099-6				0
				Hanford Chem Processing Contractor subtotals						0
1969	1-Jul-68	31-Dec-68	HXA	Douglas United Nuc	38214	DUN 5250		0.05		0.1
1969	1-Jan-69	30-Jun-69	HXA	Douglas United Nuc	38214	DUN 5942				0
							0	***0.05***	***0***	***0.1***
1970	1-Jul-69	31-Dec-69	HVA	Atlantic Richfield Han	46425	ARH 1099-12				0
1970	1-Jan-70	30-Jun-70	HVA	Atlantic Richfield Han	46425	ARH 1540-6				0
				Hanford Chem Processing Contractor subtotals						0
1970	1-Jul-69	31-Dec-69	HXA	Douglas United Nuc	38214	DUN 6557				0
1970	1-Jan-70	30-Jun-70	HXA	Douglas United Nuc	38214	DUN 7049				0
						Hanford FY 70 Aggregate subtotal	***0***	***0***	***0***	***0***
						FY 1966 - FY 1970 Subtotal	***0***	***0.084***	***0***	***0.084***
				FY 1971 -3/1999 Receipts into Atlantic Richfield (HVA)			0	0	0	0
				10/77-7/87 Receipts into Rockwell (HRA)			0	0	0	0
				FY 1971 -3/1999 Receipts into United Nuclear (HXA)			0.9	0	0	0.9
				8/87-3/1999 Receipts into Westinghouse (HUD) & Fluor (HTA)			0	0	0	0
				1/1/65-3/1999 Receipts into PNNL (HYA)			12.6	0.2	0.8	13.4
						FY 71 thru March 31, 1999 Subtotal	***13.6***	***0***	***0.8***	***14.3***
						Grand MTU Total 1947 thru March 1999	***14***	***0.2***	***5.2***	***19.4***
						MTU In-Scope Total FY 1953 thru March 1999	***13.8***	***0.2***	***4.8***	***18.7***

fabrication activities in the 300 Areas. The other major stream was the UO_3 product produced at the UO_3 Plant in the 200 West Area.

Hanford UO_3 shipped after March 10, 1952 contained recycled uranium. The Major Tier 1 sites of Paducah, Fernald, and Oak Ridge received the vast majority of Hanford recycled uranium. Paducah received the majority for these three sites with approximately 74,500 MTU shipped out of Hanford from FY 1952 through FY 1973. After FY 1973, the majority of recycled uranium was sent to Fernald. Table 3-5 provides a brief summary of recycled uranium shipments from Hanford. Tables 3-6, 3-7, and 3-8 show these shipments to the Major Tier 1 sites in detail. Appendix B Tables 3.3.1 through 3.3.8 show the details of Hanford shipments to all off-site locations.

Table 3-5 Summary of Recycled Uranium Shipments from Hanford

Timeframe:	MTUs Shipped All Offsite Sites	MTUs Shipped Major Tier 1	MTUs Shipped Minor Tier 1
March 1952-FY65	67,740.4	64,593.0	3,147.4
FY 1966-FY 1970	28,292.4	28,289.6	2.8
FY 1971-3/31/99	13,759.6	11,263.6	2,496.0
Recycle Total	**109,792.4**	**104,146.2**	**5,646.2**

3.3.2 Uranium Shipments from 300 Area Fuel Fabrication Activities

Specific uranium forms being removed from the fuel fabrication shops included reject metal rods, uranium oxide, "eggs", "slugs", metallic chips and fines, and floor sweepings. As much uranium was recovered as was possible in the early years due to shortages in uranium feedstock supply. "Eggs" were a term for metal samples cut off from the ends of newly arrived billets and tested for impurities before the billets were fabricated into fuel elements. "Slugs" were an early term for uranium fuel elements in the form of short cylinders clad or encased in corrosion-resistant metals. The 1949 schematic in Figure 3-4 shows the various flows of the generated scrap from the fuel fabrication activities. The four major NYOO sites receiving Hanford scrap were Mallinckrodt Chemical Works (Simonds Saw & Steel (Lockport, New York), Vitro Manufacturing (Cannonburg, Pennsylvania), and Harshaw Chemical (Cleveland, Ohio)). Simonds performed metal rolling of the uranium billets, Mallinckrodt reprocessed sweepings, metal solids, "eggs", and rejected slugs. Vitro reprocessed Hersey Bag Filters (from UO_3 plant) and miscellaneous scrap oxides. Uranium billets and metal turnings were also shipped to National Lead of Ohio (NLO).

Beginning in 1952, Aluminum-Silicon (Al-Si) alloy scrap (from the fuel Fabrication process) was also shipped to the U.S. Bureau of Mines (Albany, Oregon) because that facility had developed a method for recovering the tin. The tin crystals contained uranium.

Table 3-6 Hanford Uranium Shipments To Paducah

BY FISCAL YEARS (BY MTUs)						Union Carbide of Kentucky To Paducah Managed by Oak Ridge Operations CKY, FYA				
FY	Date From	Date To	From RIS		Box #	Doc #	MTU DU	MTU NU	MTU EU	Hanford MTU Total
1952	01-Jul-51	30-Jun-52	HGE	General Electric	38213	FTS 953	0	0	0	0
1953	01-Jul-52	30-Jun-53	HGE	General Electric	38213	FTS 1085	0	0	0	0
1954	01-Jul-53	30-Jun-54	HGE	General Electric	38213	FTS 1311	2,233	0	0	2,233
1955	01-Jul-54	30-Jun-55	HGE	General Electric	38213	FTS 1481	2,586.2	0	0.5	2,586.7
1956	01-Jul-55	30-Jun-56	HGE	General Electric	38213	FTS 1644	4,105	0	0	4,105
1957	01-Jul-56	30-Jun-57	HGE	General Electric	38213	FTS 1980	5,385.9	0	0	5,385.9
1958	01-Jul-57	30-Jun-58	HGE	General Electric	38213	FTS CLVI 463-1A	6,056.4	0	0	6,056.4
1959	01-Jul-58	30-Jun-59	HGE	General Electric	38213	HAN 72720	5,202.4	0	0	5,202.4
1960	01-Jul-59	30-Jun-60	HGE	General Electric	38213	HAN 75996	5,148.1	0	0	5,148.1
1961	01-Jul-60	30-Jun-61	HGE	General Electric	38213	HAN 79125	6,093.8	0	0	6,093.8
1962	01-Jul-61	30-Jun-62	HGE	General Electric	38213	HAN 82406	4,576.4	0	915.5	5,491.9
1963	01-Jul-62	30-Jun-63	HGE	General Electric	38213	HAN 85615	5,771.9	0	0	5,771.9
1964	01-Jul-63	30-Jun-64	HGE	General Electric	38213	HAN 88957	4,087.4	0	0	4,087.4
1965	01-Jul-64	30-Jun-65	HZA	General Electric	38213	HAN 92119	0	0	0	0
						FY 1952 - FY 1965 Subtotal	***51,246.5***	***0***	***916***	***52,162.5***
1966	1-Jul-65	30-Jun-66	HZA	General Electric	38213	HAN 95170	0			
1966	1-Jul-65	30-Jun-66	HWA	Isochem Inc.	38213	HAN 95136	0			
						Hanford Chem Processing Contractor subtotals	*0*			
1966	1-Jul-65	30-Jun-66	HXA	Douglas United Nuc	38214	HAN 95171	0			
						Hanford FY 66 Aggregate subtotal	***0***	***0***	***0***	***0***
1967	1-Jul-66	31-Dec-66	HZA	General Electric	39213	HAN 96413	0			
1967	01-Jan-67	30-Jun-67	HZA	General Electric	39213	HAN 98198	0			
1967	01-Jul-66	31-Dec-67	HWA	Isochem Inc.	38213	HAN 96400	0			
1967	01-Jan-67	30-Jun-67	HWA	Isochem Inc.	38213	HAN 98196	14,432.9			
						Hanford Chem Processing Contractor subtotals	*14,432.9*			
1967	01-Jul-66	31-Dec-66	HXA	Douglas United Nuc	38214	DUN 1916	0			
1967	01-Jan-67	30-Jun-67	HXA	Douglas United Nuc	38214	HAN 98194	0			
						Hanford FY 67 Aggregate subtotal	***14,432.9***	***0***	***0***	***14,433***
1968	01-Jul-67	31-Dec-67	HVA	Atlantic Richfield Han	46425	HAN 99439	0			
1968	01-Jan-68	30-Jun-68	HVA	Atlantic Richfield Han	46425	ARH 699	0			
						Hanford Chem Processing Contractor subtotals	*0*			
1968	01-Jul-67	31-Dec-67	HXA	Douglas United Nuc	38214	DUN 3624	0			
1968	01-Jan-68	30-Jun-68	HXA	Douglas United Nuc	38214	DUN 4436	0			
						Hanford FY 68 Aggregate subtotal	***0***	***0***	***0***	***0***
1969	1-Jul-68	31-Dec-68	HVA	Atlantic Richfield Han	46425	ARH 1036	0			
1969	1-Jan-69	30-Jun-69	HVA	Atlantic Richfield Han	46425	ARH 1099-6	3,537.1			
						Hanford Chem Processing Contractor subtotals	*3,537.1*			
1969	1-Jul-68	31-Dec-68	HXA	Douglas United Nuc	38214	DUN 5250	0			
1969	1-Jan-69	30-Jun-69	HXA	Douglas United Nuc	38214	DUN 5942	0			
						Hanford FY 69 Aggregate subtotal	***3,537.1***	***0***	***0***	***3,537***
1970	1-Jul-69	31-Dec-69	HVA	Atlantic Richfield Han	46425	ARH 1099-12	0			
1970	1-Jan-70	30-Jun-70	HVA	Atlantic Richfield Han	46425	ARH 1540-6	0			
						Hanford Chem Processing Contractor subtotals	*0*	*0*	*0*	
1970	1-Jul-69	31-Dec-69	HXA	Douglas United Nuc	38214	DUN 6557	0			
1970	1-Jan-70	30-Jun-70	HXA	Douglas United Nuc	38214	DUN 7049	0			
						Hanford FY 70 Aggregate subtotal	***0***	***0***	***0***	***0***
						FY 1966 - FY 1970 Subtotal	***17,970***	***0***	***0***	***17,970***
						1952-June 30, 70 MTU Subtotal	***69,216.5***	***0***	***916***	***70,132.5***
1971	1-Jan-70	30-Jun-71	HVA	Atlantic Richfield Hanford			624.9	0	96.7	*721.6*
1972	1-Jan-70	30-Jun-72	HVA	Atlantic Richfield Hanford			1,292	0	1,786.4	*3,078.4*
1973	1-Jan-70	30-Jun-72	HVA	Atlantic Richfield Hanford			208.1	0	350	*558.1*
						July 1, 1970 - Present MTU Subtotal	***2,125***	***0***	***2,233.1***	***4,358.1***
						Hanford MTU Grand Total-All U Types	***71,341.5***	***0***	***3,149.1***	***74,490.6***
						Hanford MTU In-Scope Grand Total-All U Types	***71,341.5***	***0***	***3,149.1***	***74,490.6***

Table 3-7 Hanford Summary Shipments To Fernald In Mtu

BY FISCAL YEARS (BY MTUs)						National Lead of Ohio (NLO) Fernald (FVA, FVB, FVC) FEMP				
FY	Date From	Date To	From RIS	Hanford Contractor	Box #	Doc #	MTU DU	MTU NU	MTU EU	MTU All U Total
1952	01-Jul-51	30-Jun-52	HGE	General Electric	38213	FTS 953	0	0	0	0
1953	01-Jul-52	30-Jun-53	HGE	General Electric	38213	FTS 1085	0.1	0	0	0.1
1954	01-Jul-53	30-Jun-54	HGE	General Electric	38213	FTS 1311	0	0	0	0
1955	01-Jul-54	30-Jun-55	HGE	General Electric	38213	FTS 1481	0	266.2	0	266.2
1956	01-Jul-55	30-Jun-56	HGE	General Electric	38213	FTS 1644	0	411.5	0	411.5
1957	01-Jul-56	30-Jun-57	HGE	General Electric	38213	FTS 1980	0	348.4	0.5	348.9
1958	01-Jul-57	30-Jun-58	HGE	General Electric	38213	FTS CLVI 463-1A	0	359.7	5.5	365.2
1959	01-Jul-58	30-Jun-59	HGE	General Electric	38213	HAN 72720	1.4	489.9	17.7	509
1960	01-Jul-59	30-Jun-60	HGE	General Electric	38213	HAN 75996	0.018	362.1	20.5	382.6
1961	01-Jul-60	30-Jun-61	HGE	General Electric	38213	HAN 79125	0	283.9	49.9	333.8
1962	01-Jul-61	30-Jun-62	HGE	General Electric	38213	HAN 82406	0	144.4	285	429.4
1963	01-Jul-62	30-Jun-63	HGE	General Electric	38213	HAN 85615	0	227.8	1,216	1,443.8
1964	01-Jul-63	30-Jun-64	HGE	General Electric	38213	HAN 88957	0	241.9	1,269.1	1,511
1965	01-Jul-64	30-Jun-65	HZA	General Electric	38213	HAN 92119	0	89.3	1,946.8	2,036.1
						FY 52 thru FY 65 Subtotal	***1.5***	***3,225.1***	***4,811***	***8,037.6***
1966	1-Jul-65	30-Jun-66	HZA	General Electric	38213	HAN 95170	0	122.2	895.6	1,018
1966	01-Jul-65	30-Jun-66	HWA	Isochem Inc.	38213	HAN 95136	0	0	1,128.1	1,128
						Hanford Chem Processing Contractor subtotals	0	122.2	2,023.7	2,146
1966	01-Jul-65	30-Jun-66	HXA	Douglas United Nuc	38214	HAN 95171	0	82.4	14	96
						Hanford FY Aggregate subtotal	***0***	***204.6***	***2,037.7***	***2,242***
1967	01-Jul-66	31-Dec-66	HZA	General Electric	39213	HAN 96413	0	2.5	56.7	59
1967	01-Jan-67	30-Jun-67	HZA	General Electric	39213	HAN 98198	0	1.4	117.6	119
1967	01-Jul-66	31-Dec-67	HWA	Isochem Inc.	38213	HAN 96400	0	0	550	550
1967	01-Jan-67	30-Jun-67	HWA	Isochem Inc.	38213	HAN 98196	0	0	735.2	735
						Hanford Chem Processing Contractor subtotals	0	3.9	1,459.5	1,463
1967	01-Jul-66	31-Dec-66	HXA	Douglas United Nuc	38214	DUN 1916	0	32.2	10.8	43
1967	01-Jan-67	30-Jun-67	HXA	Douglas United Nuc	38214	HAN 98194	0	40.4	14.4	55
						Hanford FY Aggregate subtotal	***0***	***76.5***	***1,484.7***	***1,561***
1968	01-Jul-67	31-Dec-67	HVA	Atlantic Richfield Han	46425	HAN 99439	0	0	552.2	552
1968	01-Jan-68	30-Jun-68	HVA	Atlantic Richfield Han	46425	ARH 699	0	0	1,001.7	1,002
						Hanford Chem Processing Contractor subtotals	0	0	1,553.9	1,554
1968	01-Jul-67	31-Dec-67	HXA	Douglas United Nuc	38214	DUN 3624	0	58.2	88.4	147
1968	01-Jan-68	30-Jun-68	HXA	Douglas United Nuc	38214	DUN 4436	0	26.4	173.6	200
						Hanford FY Aggregate subtotal	***0***	***84.6***	***1,815.9***	***1,901***
1969	01-Jul-68	31-Dec-68	HVA	Atlantic Richfield Han	46425	ARH 1036	0	0	835	835
1969	01-Jan-69	30-Jun-69	HVA	Atlantic Richfield Han	46425	ARH 1099-6	0	0	1,035	1,035
						Hanford Chem Processing Contractor subtotals	0	0	1,870	1,870
1969	01-Jul-68	31-Dec-68	HXA	Douglas United Nuc	38214	DUN 5250	0	46.4	112.2	159
1969	01-Jan-69	30-Jun-69	HXA	Douglas United Nuc	38214	DUN 5942	0	27.2	83	110
						Hanford FY Aggregate subtotal	***0***	***73.6***	***2,065.2***	***2,139***
1970	1-Jul-69	31-Dec-69	HVA	Atlantic Richfield Han	46425	ARH 1099-12	0	0	1,149.1	1,149
1970	1-Jan-70	30-Jun-70	HVA	Atlantic Richfield Han	46425	ARH 1540-6	467.9	0	619.9	1,088
						Hanford Chem Processing Contractor subtotals	467.9	0	1,769	2,237
1970	1-Jul-69	31-Dec-69	HXA	Douglas United Nuc	38214	DUN 6557	8.7	36.7	130.5	176
1970	1-Jan-70	30-Jun-70	HXA	Douglas United Nuc	38214	DUN 7049	0	14.5	49.4	64
						Hanford FY Aggregate subtotal	***476.6***	***51.2***	***1,948.9***	***2,477***
						FY 1966 - FY 1970 Subtotal	***476.6***	***490.5***	***9,352.4***	***10,319.5***
						FY 1971-3/1999 Shipments from Atlantic Richfield (HVA)	***0***	***0.2***	***0.1***	***0.3***
						4/84-4/87 Shipments from Rockwell (HRA)	***0***	***0***	***3,088.29***	***3,088.3***
						FY 1971-3/1999 Shipments from United Nuclear (HXA)	***5.4***	***1,431.3***	***2,186.34***	***3,623***
						9/88-4/89 Shipments Westinghouse Han (HUD)	***0***	***0***	***123.64***	***123.6***
						FY 1971-3/1999 Shipments from PNNL (HYA)	***14.2***	***20.2***	***24.1***	***58.5***
						FY 71 thru March 31, 1999 Subtotal	***19.6***	***1,451.7***	***5,422.5***	***6,893.8***
						Grand MTU Total FY 52 thru March 1999	***497.7***	***5,167.3***	***19,585.9***	***25,250.9***
						Grand MTU In-Scope Total FY 52 thru March 1999	***497.7***	***5,167.3***	***19,585.9***	***25,250.9***

Table 3-8 Hanford Summary Shipments To Oak Ridge (K-25 & Y-12)

BY FISCAL YEARS (IN MTUs)							Oak Ridge K-25 & Y-12 CCC, CYT, FZE, FZA, FZB, FZF			
FY	Date From	Date To	From RIS	Hanford Contractor	Box #	Doc #	MTU DU	MTU NU	MTU EU	MTU All U Total
1952	01-Jul-51	30-Jun-52	HGE	General Electric	38213	FTS 953	154.4			170.6
1953	01-Jul-52	30-Jun-53	HGE	General Electric	38213	FTS 1085	557.2	46.4	0.02	603.6
1954	01-Jul-53	30-Jun-54	HGE	General Electric	38213	FTS 1311	1,147	28.5	0	1,176.1
1955	01-Jul-54	30-Jun-55	HGE	General Electric	38213	FTS 1481	498.9	0	0.5	499.4
1956	01-Jul-55	30-Jun-56	HGE	General Electric	38213	FTS 1644	289.1	0	0.1	289.2
1957	01-Jul-56	30-Jun-57	HGE	General Electric	38213	FTS 1980	98.1	0	0.7	98.8
1958	01-Jul-57	30-Jun-58	HGE	General Electric	38213	FTS CLVI 463-1A	8.6	0.	0.5	9.1
1959	01-Jul-58	30-Jun-59	HGE	General Electric	38213	HAN 72720	0.1	0	288.2	288.3
1960	01-Jul-59	30-Jun-60	HGE	General Electric	38213	HAN 75996	0	0	610.6	610.6
1961	01-Jul-60	30-Jun-61	HGE	General Electric	38213	HAN 79125	0	0	614.9	614.9
1962	01-Jul-61	30-Jun-62	HGE	General Electric	38213	HAN 82406	0	0	46.8	46.8
1963	01-Jul-62	30-Jun-63	HGE	General Electric	38213	HAN 85615	0	0	1.6	1.6
1964	01-Jul-63	30-Jun-64	HGE	General Electric	38213	HAN 88957	0	0	0.01	0.01
1965	01-Jul-64	30-Jun-65	HZA	General Electric	38213	HAN 92119	0	0	0	0
						FY 52 thru FY 65 Subtotal	***2,753.7***	***91.1***	***1,564.2***	***4,409***
1966	1-Jul-65	30-Jun-66	HZA	General Electric	38213	HAN 95170	0	0	0.	0
1966	01-Jul-65	30-Jun-66	HWA	Isochem Inc.	38213	HAN 95136	0	0	0	0
						Hanford Chem Processing Contractor subtotals	0	0	0	0
1966	01-Jul-65	30-Jun-66	HXA	Douglas United Nuc	38214	HAN 95171	0	0.1	0	0
						Hanford FY Aggregate subtotal	***0***	***0.1***	***0***	***0.1***
1967	01-Jul-66	31-Dec-66	HZA	General Electric	39213	HAN 96413	0	0	0	0
1967	01-Jan-67	30-Jun-67	HZA	General Electric	39213	HAN 98198	0	0	0	0
1967	01-Jul-66	31-Dec-67	HWA	Isochem Inc.	38213	HAN 96400	0	0	0	0
1967	01-Jan-67	30-Jun-67	HWA	Isochem Inc.	38213	HAN 98196	0	0	0	0
						Hanford Chem Processing Contractor subtotals	0	0	0	0
1967	01-Jul-66	31-Dec-66	HXA	Douglas United Nuc	38214	DUN 1916	0	0	0	0
1967	01-Jan-67	30-Jun-67	HXA	Douglas United Nuc	38214	HAN 98194	0	0	0	0
						Hanford FY Aggregate subtotal	***0***	***0***	***0***	0
1968	01-Jul-67	31-Dec-67	HVA	Atlantic Richfield Han	46425	HAN 99439	0	0	0	0
1968	01-Jan-68	30-Jun-68	HVA	Atlantic Richfield Han	46425	ARH 699	0	0	0	0
						Hanford Chem Processing Contractor subtotals	0	0	0	0
1968	01-Jul-67	31-Dec-67	HXA	Douglas United Nuc	38214	DUN 3624	0	0	0	0
1968	01-Jan-68	30-Jun-68	HXA	Douglas United Nuc	38214	DUN 4436	0	0	0	0
						Hanford FY Aggregate subtotal	***0***	***0***	***0***	0
1969	01-Jul-68	31-Dec-68	HVA	Atlantic Richfield Han	46425	ARH 1036	0	0	0	0
1969	01-Jan-69	30-Jun-69	HVA	Atlantic Richfield Han	46425	ARH 1099-6	0	0	0	0
						Hanford Chem Processing Contractor subtotals	0	0	0	0
1969	01-Jul-68	31-Dec-68	HXA	Douglas United Nuc	38214	DUN 5250	0	0	0	0
1969	01-Jan-69	30-Jun-69	HXA	Douglas United Nuc	38214	DUN 5942	0	0	0	0
						Hanford FY Aggregate subtotal	***0***	***0***	***0***	***0***
1970	1-Jul-69	31-Dec-69	HVA	Atlantic Richfield Han	46425	ARH 1099-12	0.	0.	0	0
1970	1-Jan-70	30-Jun-70	HVA	Atlantic Richfield Han	46425	ARH 1540-6	0	0	0	0
						Hanford Chem Processing Contractor subtotals	0	0	0	0
1970	1-Jul-69	31-Dec-69	HXA	Douglas United Nuc	38214	DUN 6557	0	0	0	0
1970	1-Jan-70	30-Jun-70	HXA	Douglas United Nuc	38214	DUN 7049	0	0	0	0
						Hanford FY Aggregate subtotal	***0***	***0***	***0***	***0***
						FY 1966 - FY 1970 Subtotal	***0***	***0.1***	***0***	***0.1***
						FY 1971 -3/1999 Shipments from Atlantic Richfield (HVA)	0	0	0	***0***
						4/84-4/87 Shipments from Rockwell (HRA)	0	0	0	***0***
						FY 1971 -3/1999 Shipments from United Nuclear (HXA)	0	0	0	***0***
						9/88 -3/99 Shipments Westinghouse (HUD) & Fluor (HTA)	2.94	0	0.01	***2.95***
						FY 1965 -3/1999 Shipments from PNNL (HYA)	6.58	0	2.09	***8.67***
						FY 71 thru March 31, 1999 Subtotal	***9.5***	***0***	***2.1***	***11.6***
						Grand MTU Total FY 52 thru March 1999	***2,763.2***	***91.2***	***1,566.3***	***4,420.8***
						Grand MTU In-Scope Total FY 52 thru March 1999	***2,763.2***	***75***	***1,566.3***	***4,404.6***

In the late 1940s, as part of Uranium Sample Exchange Programs, Hanford shipped metal billets to Mallinckrodt Chemical Works (St. Louis) for metallic impurity comparisons [Rebol 1949].

Until the end of June 1952, all Hanford outbound shipments were of unirradiated natural uranium scrap or research materials generated at the 300 Area Fuel Fabrication or Hanford research laboratories. The primary recipients for the reprocessing of this scrap were Mallinckrodt Chemical Works, Simonds Saw & Steel Company, Vulcan Crucible Steel, Joslyn Manufacturing, and Vitro Manufacturing. The majority of the receipt sites were under the management of AEC's New York Operations Office (NYOO). As the metallurgical and chemical refinements to the Hanford fuel cycle continued, small quantities of unirradiated natural uranium were also sent to various laboratories for research. Shipments to the New York contractors was phased out in the early 1950s as the Oak Ridge-managed plants at Oak Ridge, Tennessee and Fernald, Ohio became the primary recipients of the fuel fabrication scrap. All production channel shipments of natural uranium from the late 1940s through June 1952 are therefore assumed to be out-of-scope for this report.

For the purposes of this project, it was assumed that offsite scrap shipments of recycled uranium from fuel fabrication activities began in July 1952 (FY 1953). This is based on the assumption that transuranics from UO_3, or within irradiated slugs shipped offsite, could not have been processed and re-introduced into the returning metal billets until July 1952.

In the 1980's, all the Fuel Fabrication scrap was sent to National Lead of Ohio (NLO). Scrap forms included sludges, fines, and burned oxide (began in 1984). Approximately 181 MTU of 0.95% and 26 MTU of 1.25% as scrap was forecasted to be generated per year. A scrap generation rate of 21% of input was forecasted [Heaberlin 1983].

3.3.3 Hanford Shipments of Recycled Uranium in Trioxide Product

3.3.3.1 UO_3 Finished Product

For UO_3 finished product, the first shipment of UO_3 was rail shipped to K-25 on January 25, 1952 and consisted of 8 drums of Lot 001 [Richards 1952b]. The second shipment (Lot 002, 7 drums) to K-25 was shipped on February 11, 1952 [Richards 1952]. Both of these lots were produced from natural uranium and contained no fission products. They were "cold" test runs to validate the UO_3 conversion process. This material was shipped to K-25 to make sure the physical (particle size) and metallic impurities were within Oak Ridge acceptance criteria. As the "cold" UO_3 was examined and found acceptable, Hanford began spiking the feed stream with UNH derived from irradiated fuel.

3.3.3.2 Introduction of Fission Products

The introduction of fission products into the UO_3 product is indicated in production records that show a March 10, 1952 beginning for truck shipments, in drums, of

recycled uranium trioxide product to the Oak Ridge K-25 Gaseous Diffusion Plant (GDP). (Copies of these historical transfer documents, with attendant analytical data, were previously shown in this report as Figures 3-4 and 3-5.) This March 1952 UO_3 shipment is consistent with Hanford production history indicating UO_3 test runs in January 1952 and full operation in February 1952. The primary recipient of early 1950s Hanford UO_3 was to be the Harshaw Plant [Sturges 1952], but shipments were diverted to Oak Ridge facilities as their feedstocks became depleted. In March 1959, General Electric was authorized by the AEC to begin routine shipments of low-enriched (0.94% ^{235}U before irradiation) UO_3 to the K-25 facilities in Oak Ridge [Gifford 1959]. Hanford LEU UO_3 shipments began soon thereafter.

3.3.4 Out-of-Scope Research and Development Spent Fuel

The irradiated fuel research and development program, referred to as the Pile Enrichment program, involved the receipt of unirradiated slugs from Y-12, irradiation in Hanford reactors, and shipment to Idaho.

The J-1 slugs were irradiated at H reactor and the J-2 slugs at C reactor. The "C' slugs were irradiated at C and H reactor. Early in calendar year 1952, as the Idaho Chemical Processing Plant (ICPP) came on line, shipments of these "J" irradiated slugs began [Sturges 1953]. These transactions between Hanford and Idaho are considered out-of-scope for this study.

Prior to and continuing into 1952, Hanford also transferred small research quantities of aqueous uranyl nitrate hexahydrate, processed through REDOX and U-Plant, to Mallinckrodt Chemical Works and the Oak Ridge K-25 facility for subsequent conversion to UO_3 [Richards 1950]. Although uncommon, UNH solutions were shipped offsite by rail in tanker cars. In 1952, Hanford shipped UNH to Brush Beryllium Company in Luckey, Ohio [Freitag 1952]. This company stored the UNH until it could be transferred to Harshaw for conversion to UO_3.

3.3.5 Post Fiscal Year 1970 Shipments

After FY 1970, Hanford shipments continued to Fernald. In the early 1970s, Hanford missions also became more diversified with uranium materials being allotted by Defense Programs to support Research and Development projects such as the Fast Flux Test Facility (FFTF). Additionally, some of the Hanford recycled legacy metal and scrap was shipped outside the United States to support Mutual Defense Agreements and Hanford environmental management missions. Approximately 1,000 MTU were shipped abroad between 1993 and 1996 to support these governmental agreements [De-Minimis 2000].

3.3.6 Shipment Packaging and Scheduling

In the early 1950s, UO_3 product was shipped in steel 55-gallon drums via both truck and rail. Beginning in 1956, T-Hoppers based on a Union Carbide Nuclear Company design

(blueprint #D-KP-K7805AE-2) were used in addition to the 55-gallon drums. The T-Hoppers could be filled with a nominal load of up to 12,000 pounds (~5.4 metric tons of UO_3). Figure 3-9 shows some T-Hoppers stored in the 200 West Area at Hanford.

Figure 3-9 UO_3 T-Hoppers at Hanford Rail Spur, 200 West Area

Early shipments of depleted UO_3 going to Paducah were shipped in drums with weights not to exceed 1,600 pounds of total UO_3 [Elgert 1968]. When rail was the transport method, the drummed UO_3 was sent in lots consisting of 4 drums per pallet and 15 pallets per rail car.

During the 1960s, shipment schedules of trioxide returns to Fernald were keyed to Quarterly Production Forecasts. Shipments for delivery to Fernald usually departed Hanford before the twentieth of each month to allow time for transport [Christy 1968]. Transportation time was ~2 weeks turnaround between Hanford and Fernald. Each T-Hopper was nominally loaded with ~4.5 MTU. Ten T-Hoppers could be loaded per standard railroad flat car. Because only 2 railcars had special tie-downs, shipments were restricted to either 45 or 90 MTU units [Heaberlin 1983].

In 1969, Depleted UO_3 was shipped to Fernald by rail in 55-gallon drums loaded into boxcars due to the shortage of available T-Hoppers [Christy 1969].

In the 1980s, UO_3 process pipeline storage capacity was 45.6 tons of UO_3. Yard storage of UO_3 in 55-gallon drums or T-Hoppers was virtually unlimited (>1,500 MTU). Loading could keep up with maximum production rates.

3.3.7 Transaction Material Control and Accountability (MC&A):

Beginning in the early 1950s, shipment and receipt requests were approved through AEC correspondence. This correspondence was as both letters and teletypes between the various field offices. Transactions were recorded on AEC 101 forms. In later years, this form evolved into the current DOE 741 form but the basic function has remained unchanged. An example of the transfer forms and product acceptance forms are shown in Figures 3-4, 3-5, and 3-6 respectively. Key portions of the form included transfer authority, material type and description, authorized shipper signature, and authorized receiver signature. Accountability values were based on the net weight of the UO_3 which were, in turn, determined by chemical analysis of composite samples with the ^{235}U content determined by mass spectrometry analysis of the representative composite samples. As the planning for shipments evolved, any Hanford shipments which Hanford testing indicated were out-of-specification were reviewed, by formal correspondence, by the receiver site and approved prior to any physical transfers.

In the early 1980s, as the Rockwell Hanford contractor readied for the restart of the PUREX Plant and UNH shipments to the UO_3 Plant, the PUREX Material Control and Accountability Plan [Larson 1982] was prepared in which three analytical quality control programs were implemented for the laboratory measurement systems. The three systems were:

- Maintenance of control charts for each laboratory system
- Strict adherence to the Control of Analytical Measurement Systems (CAMS)
- Statistical tracking and evaluation per the Laboratory Accountability Measurement Program (LAMP) [RHO-MA-138 1978]

3.3.8 Sample Exchange Programs and Sample Shipments

In the late 1940s, the AEC understood the need for establishing a complex-wide set of uranium specifications and measurement methodology. Early specifications for depleted UO_3 were led by Oak Ridge and concurred with by Mallinckrodt, Harshaw, Hanford and NLO. As detailed in Section 4.1, early Hanford laboratory analyses were performed in accordance with HW-24403 (sections 472.2, 285.1, 660.22, 845.10, & 845.14) [McIntosh 1952]. Specifications for enriched UO_3 were based on K-25 operating experience and implemented at Hanford [Smith 1959].

Early in the 1950s, samples were exchanged for comparison and standardization. A triad of measurement programs provided standards and limits for the uranium

transactions. The three programs included 1) the AEC-wide Measurements Program; 2) Fissionable Standards Samples Committee; and 3) Sample Exchange Program.

In the 1950s, Hanford's UO_3 Plant Control Laboratory composited samples of each ten (10) drum lot for each carload of UO_3 product shipped. Samples were analyzed at Hanford and one-half of each sample was sent to the receiving site for check analysis. About 25-30 samples monthly were exchanged with K-25 and Harshaw [Hauff 1952].

For inbound billets in the 1950s, uranium metal quality control of non-radioactive constituents was maintained through an analytical checking arrangement with Mallinckrodt with up to 10 samples per month exchanged. Hanford sampling of metal occurred before it was placed into storage [Hauff 1952]. The Hanford specification [Groot 1952] for receipt of uranium metal was strictly enforced with *"...no deviations from these specifications will be accepted without prior approval"* [McCullough 1952].

3.4 Recycle Uranium Scrap, Waste, and Conversion

3.4.1 Introduction

In the sub-sections below are summaries of Hanford's past waste handling activities that are relevant to recycled uranium. Also included is a discussion of the uranium consumed in the production reactors. Waste and scrap streams from the 300 Area Fuel Fabrication facilities, the separations plants and the UO_3 Plant are discussed. Each of these processes has been previously described in Section 2.0

The uranium waste streams were examined for possibilities of disposition and uranium content. Overall, less than two percent of the uranium handled in all aspects of operation was discharged as waste or local environmental releases.

3.4.2 Reactor Fuel Element Fabrication

Uranium-containing wastes were generated during the fabrication of reactor fuel elements. For the majority of the fuel fabrication activities, uranium slugs received at Hanford were first cleaned and then canned in aluminum cans. For a short time period, Hanford received metal ingots that were extruded, rolled, and cut into slugs or "cored" fuel rods for canning. With the start-up of Fernald, Hanford received billets that were coextruded, sectioned to specified lengths, and finished. The various unit operations included a number of cleaning, degreasing, acid leaching, and autoclave operations using nitric acid, hydrofluoric acid, sulfuric acid, organic solvents, and water. The liquid streams from these operations were treated to recover uranium. The uranium-containing sludge recovered from the treatment activities was processed to recover uranium. After treatment, these liquid wastes were routed to ponds and trenches. During 1984, the reported amount of uranium discharged, via liquid waste, was 0.004 percent [Hillesland 1984].

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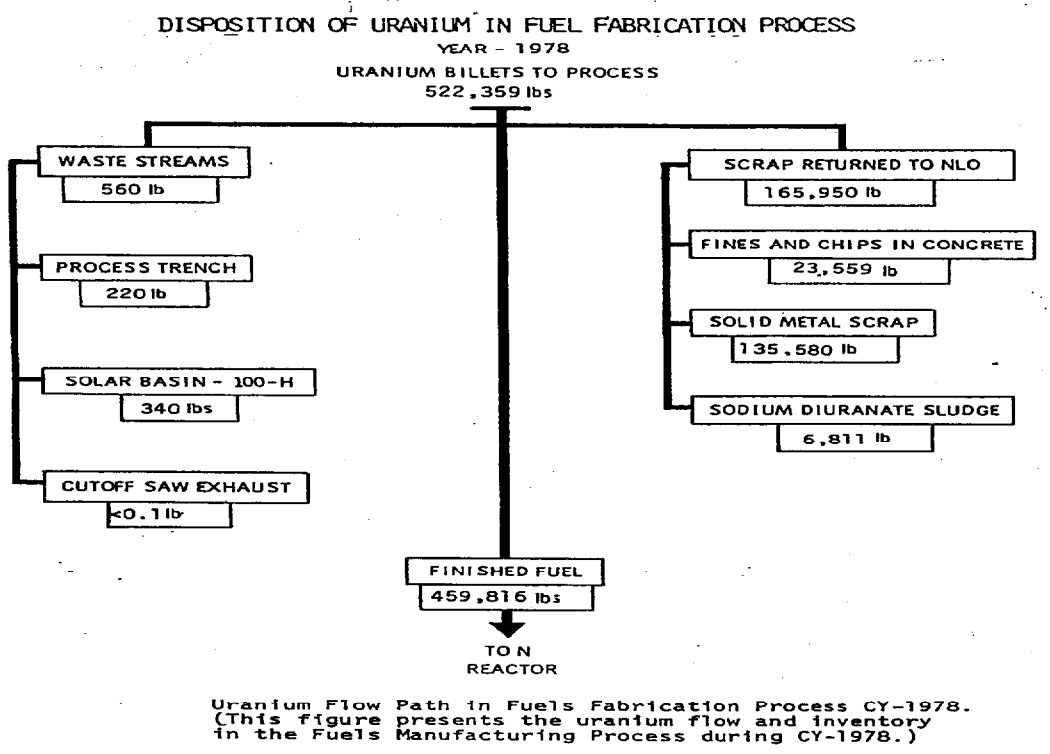
Scraps in the form of chips and turnings from the lathes, rejected fuel slugs and the "butts" from the extrusion processes were salvaged and recycled. The chips and turnings were sorted, broken into smaller pieces, washed, dried, and pressed into briquettes. Initially, the filtered solids and dust were put into an oxide burner and converted to oxide. Later the chips and fines were drummed and sent to Fernald for recycle. Some of the fines and dust were cemented in drums and sent to solid waste disposal. (Additional information on scrap handling can be found in Sections 2.2.7.2, 2.2.8.5, and in Appendix F.)

Airborne effluents from uranium sawing and lathe operations were exhausted through an exhaust system equipped with a water spray scrubber to remove uranium particles, chemical vapors, gases, fumes and smoke particles. A typical annual emissions report from the 333 Building [Riches 1979] stated that the uranium concentration from the cutoff saw exhaust was 4.6×10^{-9} lb/ft^3 in a total air volume of 2.9×10^9 ft^3.

Solid uranium wastes, which included materials in failed and replaced equipment and normal line-generated process waste, were sent to Hanford burial grounds in the 300 and 600 Areas.

The description which follows, is based on the DOE Environmental Assessment [DOE/EA-0030 1980] and provides summary level information of scrap and waste streams from the 300 Area Fuel Fabrication facilities.

Uranium processing and effluent streams follow four principal material flow paths as related to fuel manufacturing. These are finished fuel, in-process storage, scrap returned to National Lead of Ohio (Fernald) for recovery, and waste streams. These streams are shown in Figure 3-10.



Uranium Flow Path in Fuels Fabrication Process CY-1978.
(This figure presents the uranium flow and inventory in the Fuels Manufacturing Process during CY-1978.)

Figure 3-10 Uranium Flow and Inventory in Fuels Manufacturing Process (CY1978) [DOE/EA-0030 1980]

3.4.2.1 Scrap Returned to Fernald

Uranium metal scrap and sludge from uranium-bearing acids were returned to Fernald for reprocessing. Uranium scrap sources included uranium chips and saw fines, solid metal scrap, and sodium diuranate sludge.

3.4.2.2 Liquid Effluent - Chemical Waste Containing Uranium

A chemical waste system was used in the 300 Area to receive and dispose of all concentrated liquid chemical wastes, including three liquid waste streams containing uranium. As shown in Figure 3-11, the system provided for collection, neutralization, and transportation of the wastes to concrete basins in the 100-H Area where the liquids would evaporate to form a solid salt cake. Later, as part of the Hanford Site response to the Comprehensive Environmental Response, Compensation and Liability Act of 1980 (CERCLA) the residual material was stabilized, removed, and buried at the Hanford Environmental Restoration Disposal Facility (ERDF).

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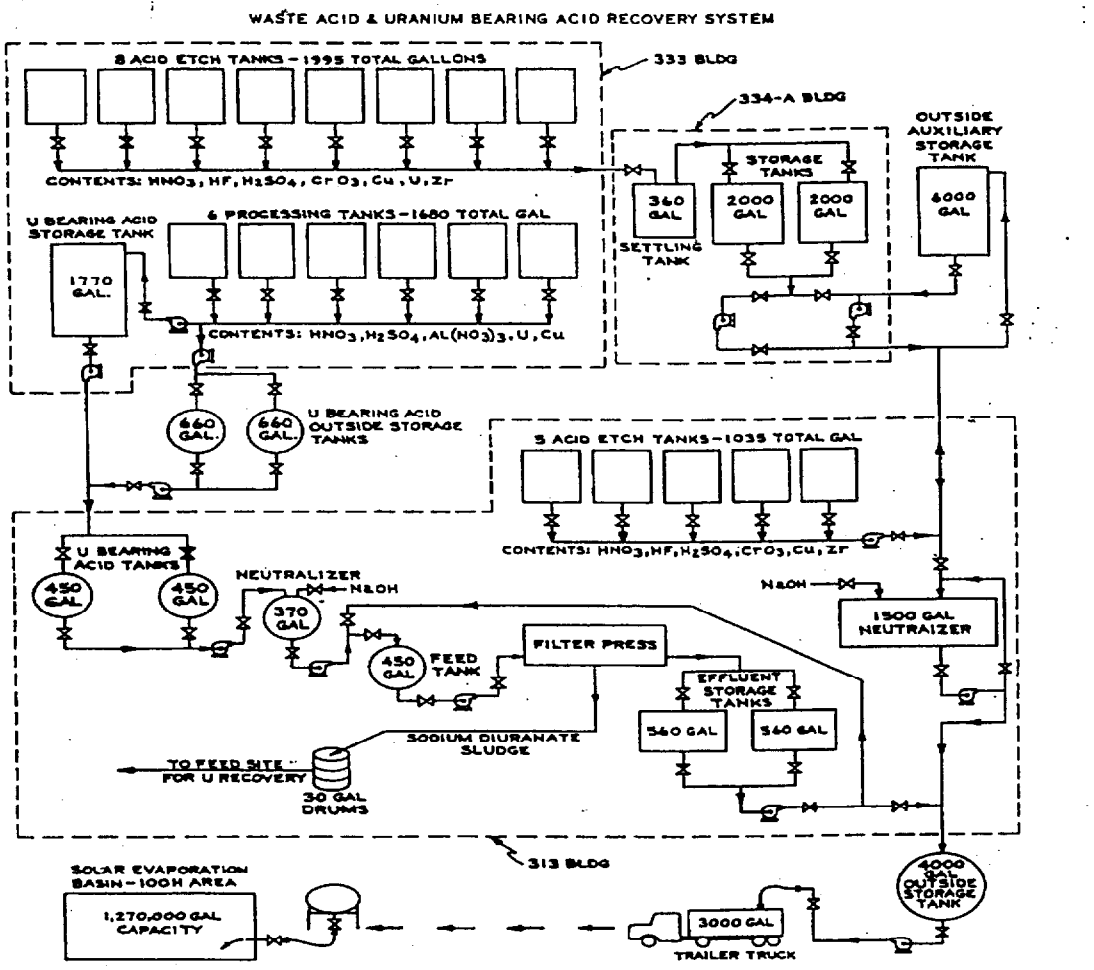
The only routine chemical wastes and uranium particulates to enter the process sewer from Buildings 313 and 333 were from process sewer rinse tanks, air scrubbers, wash stations, cut-off saws, and the concretion facility in the 304 Building.



Waste Acid and Uranium-Bearing Acid Recovery System

Figure 3-11 Waste Acid and Uranium-Bearing Acid Recovery System
[DOE/EA-0030 1980]

Chemical solutions that contained appreciable amounts of uranium were collected in holding tanks, pumped to Building 313 and neutralized with sodium hydroxide. The precipitate was shipped to Fernald for recovery.

Chemicals used and transferred were controlled, and liquids discharged to the process sewer were neutralized. Neutralized waste storage tanks (surrounded by dikes) held 10,000 gallons of liquid waste.

3.4.2.3 Airborne Effluents

All plants had filtered ventilation and air monitoring devices to assure safety of personnel and that atmospheric releases were controlled. It is noted that prior to 1948, T-Plant and B-Plant did not have exhaust filters and had to restrict dissolution activities to periods when atmospheric conditions would permit maximum dilution of the radioactive and non-radioactive off-gases. Ventilation systems were provided at process locations to collect and remove airborne uranium particulates and smoke and to discharge the filtered air outside the buildings.

3.4.2.4 Solid Waste

Solid waste contaminated with uranium was packaged for transfer, by truck, to the burial sites in the 200 and 600 Areas. Some of the solid burial sites in the 600 Area contain unreported quantities of uranium waste. The Waste Information Data System maintained by the Environmental Restoration Contractor has information on each waste site on the Hanford Project. Included in the description of each site is the concentration, when known, of the chemical and radionuclide concentration.

3.4.2.5 300 Area Process Trenches

The chemical wastes and uranium within the process water that entered the process sewer from fuel fabrication were diluted in the sewer before being discharged into the two process sewer trenches.

3.4.3 Hanford Separation Plants

T-Plant, B-Plant, and the REDOX, U-Plant, and PUREX separations plants routinely discharged uranium in a number of waste streams to the environment, waste storage tanks, and to the solid waste burial ground. Plant operations were designed to minimize loss of product and for protection of workers and the environment. As earlier stated, both the T-Plant and B-Plant processed irradiated fuel to recover plutonium from the uranium and fission products, which were transferred to underground tanks. REDOX and PUREX recovered both plutonium and uranium as primary products. U-Plant reclaimed the uranium from the waste that had been discharged from the T- and B-plants.

Solid wastes, such as failed equipment and line-generated wastes, were sent to the Hanford Burial Grounds.

3.4.4 Recovery of Uranium in the U-Plant

After uranium had been removed in the TBP process at U-Plant, residual liquid was returned to the waste tanks and chemically struck to cause precipitation of the fission products. Clarified liquid was then pumped to the BC cribs located just south of the 200 East Area. Approximately thirty million gallons of waste liquors containing about 5,700 kgs of uranium were thus disposed.

Other wastes from the TBP process were disposed to the liquid and solid waste pathways described in Section 3.4.6.

3.4.5 Uranium Trioxide (UO_3) Plant

The major unit operations performed at the UO_3 Plant were concentration of uranyl nitrate hexahydrate (UNH), calcination of UNH to UO_3, packaging of the UO_3 product, and nitric acid recovery. Uranium-containing wastes were generated during routine operation. The waste streams included solid wastes which were buried, the liquid effluents discharged to the ground, and gaseous effluents released to the atmosphere.

The UO_3 process condensates were pumped to the 216-U-12 Crib, though some went to the acid absorber tower for use as reflux water. Uranium-contaminated liquid wastes including steam condensate, chemical sewer, and cooling water were discharged to the U-10 pond.

The vapors leaving the concentrators contained water and very dilute nitric acid which were condensed and discarded as waste. Calcination of the UNH produced oxides of nitrogen, oxygen and water. The gaseous products were drawn through an off-gas scrubber, a gas cooler, and an absorption tower before being discharged to the atmosphere. A portion of the recovered nitric acid was circulated back through the acid scrubber and the remainder was pumped to storage for shipment back to the PUREX Plant. The nitric acid had a low residual level of UNH. The flowsheet [Raab 1978] indicated that the UO_3 content of the scrubber off-gas was negligible. The UO_3 product was conveyed to a cyclone separator where the UO_3 powder and the transporting air were separated. The air was filtered first through two bag filters and then a final filter before discharge to the atmosphere.

Solid contaminated uranium waste, consisted typically of failed equipment and normal line-generated process waste. These solid wastes were buried in the 200 Area waste burial grounds.

Gaseous wastes from concentration, calcination powder handling, and acid recovery operation were filtered and discharged to the atmosphere. Radioactive elements in this stream included uranium.

3.4.6 Summary of Uranium Discharged to Wastes at Hanford

The major uranium-containing waste streams included solid wastes buried in the 200 and 300 Areas and liquid wastes which were disposed of in the 100, 200 and 300 areas. The majority of the liquid wastes were generated by the irradiated-fuel reprocessing plants which discharged process wastes to the underground waste storage tanks. Liquid effluents from the processing plants that contained low levels of radioactivity were also discharged to the ground via French drains, retention basins, ponds, and trenches. Gaseous effluents were a insignificant source of uranium losses.

Waste Management records indicate that on the ~ 2,174 MTU in the form of waste has been disposed at Hanford. The distribution is shown in Table 3-9.

Uranium-bearing low level liquid wastes from the 200 Area facilities, were discharged to approximately 110 cribs, ponds, tile fields, and other similar structures. This does not include the twenty-two trenches of BC Cribs that are located in or near the 200 Areas.

Solid wastes from the 200 Area operations were disposed to approximately 27 burial sites [Maxfield 1979].

Table 3-9 Uranium Waste at Hanford

Location	Waste Tanks (In Kgs)	Liquids to Ground (In Kgs)	Solids to Burial (In Kgs)
100 Area		1,930	
200 Area	958,000	78,000	927,700
300 Area		82,000	126,000
400 Area	0	0	0
Total	958,000	161,930	1,053,700

The reported quantity of uranium discharged to the ground in the 100 Area is based on an estimated 2 Ci of uranium discharged to cribs and trenches [TRAC-0151- VA 1991]. A later report [Diediker 1999] documents all the cribs and trenches in the 100 Area and includes estimates based on sampling. Since uranium was not a major radionuclide in the liquid effluents, only a limited number of uranium analyses are available and only for ^{234}U and ^{235}U which accounts for only a few kilograms of uranium. The quantity of uranium in the 200 Area Waste Tanks is based on accountability records and sampling data [Kupfer 1999]. The report also provided an estimate of 840-920 MTU based on a modeling effort. The current best basis inventory (BBI) maintained by CH2M Hill Hanford Group Corp and based on current tank samples showed the estimated uranium tank inventory as 863 MTU. This is a reduction from an earlier uranium tank waste (10/1/98) BBI estimate of 929 MTU. It has been speculated by Process Retrieval Engineering that core sampling is not getting representative samples of the residual layer of $BiPO_4$ metal wastes, which could cause the BBI to underestimate the uranium tank waste inventory. The reported quantity of uranium discharged to the ground in the

200 Area is based on an estimated 77.9 Ci of uranium discharged to cribs and trenches [Diediker 1999]. An earlier estimate [TRAC-0151-VA 1991] reported 143 MTU based on an estimate of 137 Ci of uranium in the liquid waste. The quantity of uranium in solid waste is based on the reported estimate in each burial ground as of the end of 1998 [Hagel 1999]. The estimate includes a small contribution from solid uranium bearing waste from offsite. The quantity of uranium in liquid wastes to the ground for the 300 Area is based on the data reported in the 1988 hazards ranking report [Stenner 1988]. The waste in the North and South ponds has been excavated and shipped to the Environmental Restoration Disposal Facility. The quantity of uranium in solid waste in the 300 Area is based on data provided by the Environmental Resource Center and reported in the Waste Information Data System. The 300 Area generated solid U waste was actually buried in or moved to the 600 Area burial. Several of the sold waste burial sites in the 600 Area contain unreported quantities of uranium waste.

3.4.7 Uranium Losses Through Transmutation and Fission

Uranium fuel fabricated in the 300 Area Fuel Fabrication Facility was irradiated in one of nine reactors that were operated at Hanford. The reactors primarily produced plutonium for the Defense Program, but a number of other products were produced to support ongoing Defense and Nuclear Energy Programs. During reactor operations uranium was fissioned to produce fission products and uranium was transmuted to other radionuclides, including plutonium.

An estimate of the quantity of uranium consumed in the reactors has been made on the basis of the quantity of plutonium produced at Hanford, the change in the percentage of ^{235}U in the uranium fuel to the reactors, and the percentage of ^{235}U in the uranium fuel discharged from the reactors. Between 1945 and 1989 Hanford produced 67.4 MT Pu. [DOE DP-0137 1996] This would have required the consumption of an equivalent quantity of ^{238}U. Normal uranium (0.711 wt % ^{235}U) or low enriched uranium (0.94-1.25 wt % ^{235}U) was the feed to the reactors. The uranium recovered from processing was slightly depleted in ^{235}U. Assuming that 10% of the uranium received at Hanford for fuel fabrication was returned as fabrication scrap without cycling it through the reactors, an estimated 66 MT of ^{235}U was fissioned in the reactors. If it is also assumed that 10% of the plutonium produced was also fissioned or transmutated, then ~140 MTU was consumed in the reactors. This calculation results in a net loss of uranium in the overall uranium site balance.

3.5 Overall Recycled Uranium Site Mass Balance

In the attempt to segregate out the Hanford Site recycled uranium component, a mass balance including both in-scope and out-of scope uranium was developed. Development of this material balance was very complex because uranium transactions internal to Hanford activities needed to be clearly separated from non-Hanford transactions. In establishing a mass balance, both the Hanford Site contractors and the Pacific Northwest National Laboratory (PNNL) needed to be integrated into the calculations. Two issues related to shipper/receiver correlation of historical transactions

make a precise mass flow extremely difficult. The first issue is that while MC&A records indicate shipments to offsite locations, it was not uncommon for shipments to be diverted, during transit, to secondary locations to address feedstock shortages. Secondarily, for fiscal year transaction reconciliation between sites, quantities leaving one site near the end of a fiscal year may not be received and entered into the receiver site's MC&A records (booked values) until the next fiscal year. Further difficulties with establishing precise mass flows at Hanford are in establishing the accuracy of estimates for normal operational losses (NOL), accuracy of measured discards, accuracy of estimated discards, reconciliation of Inventory Differences (ID) from continual contractor turnovers, accuracy of past decay calculations, and accuracy of Material Unaccounted For (MUF) explanations. An example of one difficulty was when Hanford, within a semi-arid environment, shipped UO_3 powder to the southeast. During transit and upon arrival at the southeast receipt location, the UO_3 absorbed moisture, resulting in larger receipt quantities measured than were reported shipped from Hanford.

Table 3-10 and Figure 3-12 summarize these mass flows. At the right of each entry in Table 3-10 is a reference number which maps to the index below for further details to entered quantities and attendant reference documents. As the table indicates, approximately 115,955.4 metric tons of uranium (all types) were received at Hanford (Hanford and PNNL) from January 1948 through March 30, 1999. Approximately 112,287.3 metric tons were shipped within this same period. Approximately 4,006 MTU remains in the Material Control and Accountability (MC&A) inventory and approximately 2,314 MTU was lost to waste and reactor consumption. This leaves a difference of about 664.1MTU between receipts, on-site holdings, uranium consumed, and shipments. This difference is primarily attributed to uncertainties in the quantities of uranium in waste, that which was consumed in the reactors, and the limited data from the pre-1948 operating period. As indicated in Figure 3-12, the recycled uranium component of the receipt total is approximately 109,143.6 MTU (~94%). The recycled component of the shipment total was approximately 109,792 MTU (~98%). Approximately 6,180 MTU is at the Hanford site in the form of current inventory or waste. An additional approximately 140 MTU was fissioned or transmutated in the production reactors.

Index Mapping for Summary Table 3-10:

Entry #	Table Reference (Receipts)
1.	Appendix B, Table 3.2.1
2.	Appendix B, Table 3.2.1
3.	Appendix B, Table 3.2.1
4.	Appendix B, Table 3.2.2
5.	Appendix B, Table 3.2.3
6.	Appendix B, Table 3.2.4
	Appendix B, Table 3.2.5
	Appendix B, Table 3.2.6
	Appendix B, Table 3.2.7
7.	Appendix B, Table 3.2.8

Entry #	Table Reference (Removals)
8.	Appendix B, Table 3.3.1
9.	Appendix B, Table 3.3.2
10.	Appendix B, Table 3.3.3
11.	Appendix B, Table 3.3.4
	Appendix B, Table 3.3.5
	Appendix B, Table 3.3.6
	Appendix B, Table 3.3.7
12.	Appendix B, Table 3.3.8
13.	Section 5, Table 5.1.1
14.	Section 5, Table 5.1.2
15.	Section 3.4

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Table 3-10 Hanford Mass Balance-Total In-Scope & Out-of-Scope

					Quantity	Units
Hanford Ending Inventory						
	31-Dec-47			In-Process (Fuel Fab, Rctrs, Storage, etc.)	***1,400.3***	MTU
	31-Dec-47			In Hanford Waste Tanks	***1,915.7***	MTU
Receipts:						
HANFORD	*Receipts:*	1-Jan-48	31-Dec-49	Aggregate Receipts (All U Types)	3,402.3	MTU
	From Offsite	1-Jan-50	EO FY 1965	Aggregate Receipts (All U Types)	81,013.2	MTU
		FY 1966	EO FY 1970	Aggregate Receipts (All U Types)	19,119.5	MTU
		FY 1971	31-Mar-99	Aggregate Receipts (All U Types)	12,142.1	MTU
				Hanford Receipt Subtotal	***115,677.1***	MTU
PNNL	*Receipts:*	FY 1965	31-Mar-99	Aggregate Receipts (All U Types)	278.3	MTU
	From Offsite			*PNNL Receipt Subtotal*	***278.3***	MTU
				Receipt Subtotal	***115,955.4***	MTU
				Receipt & 47 Ending Inventory	***119,271.4***	MTU
Shipments:						
Hanford	*Shipments*	1-Jan-48	EO FY 1951	Aggregate Shipments (All U Types)	1,601.6	MTU
	Offsite	FY 1952	EO FY 1965	Aggregate Shipments (All U Types)	68,282.6	MTU
		FY 1966	EO FY 1970	Aggregate Shipments (All U Types)	28,643.5	MTU
		FY 1971	31-Mar-99	Aggregate Shipments (All U Types)	13,515.7	MTU
				Hanford Shipment Subtotal	***112,043.4***	MTU
PNNL	*Shipments:*					
	To Offsite	FY 1965	31-Mar-99	Aggregate Shipments (All U Types)	***243.9***	MTU
				PNNL Shipment Subtotal	***243.9***	MTU
				Shipment Total	***112,287.3***	MTU
3/31/99 Inventory:						
Hanford				Current Unirradiated In-Scope Inventory	1,862.6	MTU
Hanford				Current Irradiated & MOX Out-of-Scope Inventory	2,137	MTU
PNNL				Current Inventory	6.4	MTU
				Inventory Subtotal	***4,006***	MTU
				Subtotal Transaction Difference	***2,978.1***	**MTU**
Waste & Fission Loss:						
Hanford				*Uranium in Waste Tanks*	958	MTU
				Uranium in Solid Waste	1,054	MTU
				Uranium in Ponds, Cribs, & Ditches	162	MTU
				Uranium Lost thru Pu Production & Fission	140	MTU
				Total Difference	***664.1***	MTU

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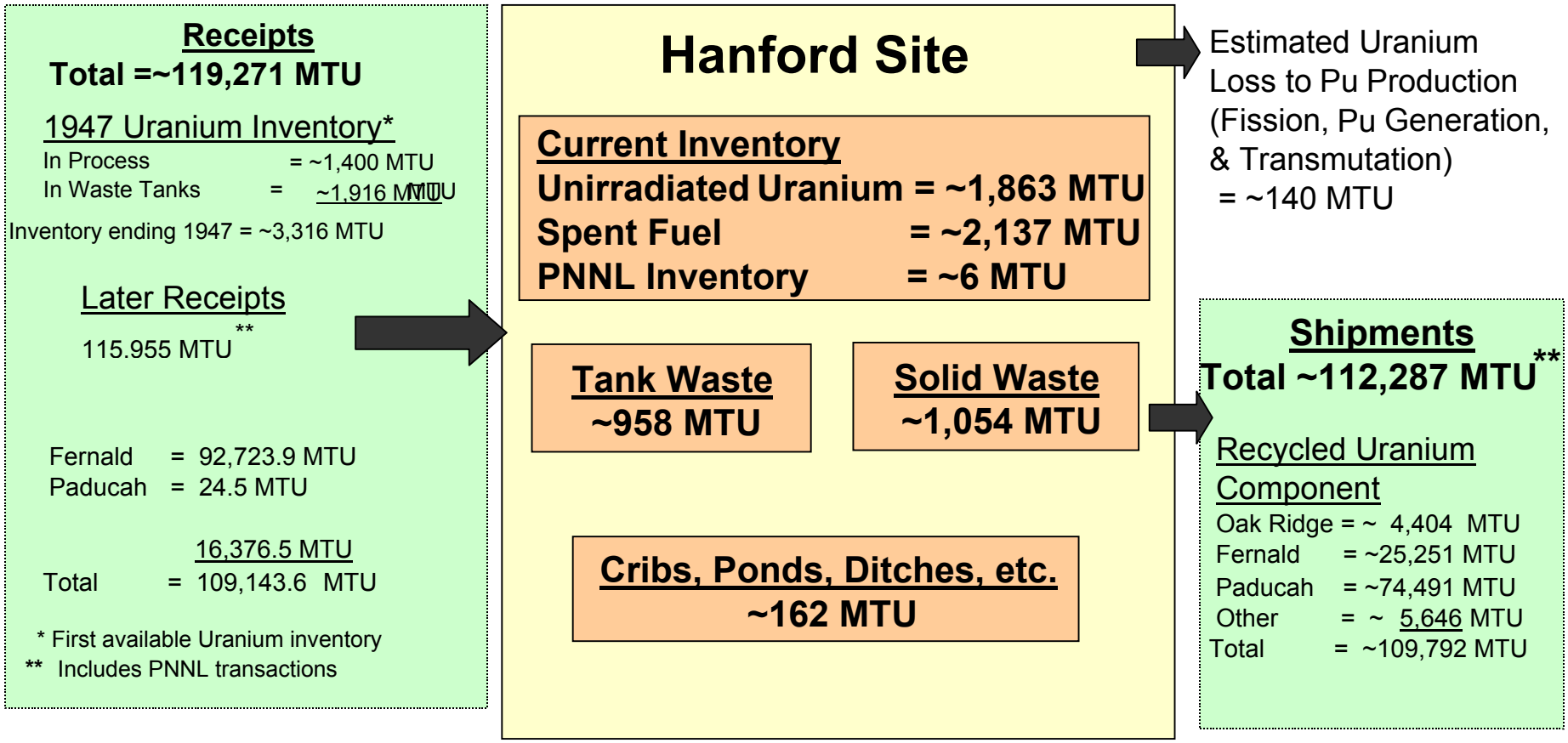
Figure 3-12 Hanford Uranium Mass Flow

December 1947 through March 1999



Note: The difference (~664.1 MTU) between receipts, on-site holdings, uranium used in reactors, and shipments are primarily attributable to limited available data from the early years of Hanford, the uncertainties of the quantities of uranium in waste, and that consumed in the reactors.

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