

# **Review of Generation and Flow of Recycled Uranium at Hanford**



**Richland Operations Office**

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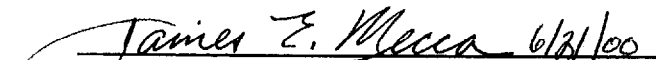
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## EXECUTIVE SUMMARY

### Hanford Recycled Uranium Project

On August 8, 1999, Energy Secretary Richardson announced a set of activities to address the extent of potential exposure to recycled uranium and its constituents, and the quantities of uranium involved at Department of Energy (DOE) operated sites. The DOE-HQ Recycled Uranium Project was to gather the pertinent information and provide a report of its findings to the Secretary by June 2000. On September 15, 1999, selected field offices were directed to support this Recycled Uranium Project.

The Richland Operations Office (RL) assembled a multi-contractor team of senior staff in response to the Headquarters directive to gather and consolidate the requested supporting information and to provide this information in a formal report in support of the June 2000 date. Based on the direction contained in the Secretary's letter, Hanford facilities and activities involving the production, treatment, and handling of recycled uranium and the trace impurities of plutonium (Pu), neptunium ( $^{237}\text{Np}$ ), and technetium ( $^{99}\text{Tc}$ ) isotopes were investigated.

### Background

"Hanford Engineering Works" was established in secrecy during World War II to produce plutonium for an atomic bomb in support of the ongoing defense effort. Hanford produced the Pu used for the first atomic explosion test in New Mexico in July 1945. Since the first Pu production, Hanford continued to grow and support defense and other missions as directed. During its operating period, 1943 through 1993, Hanford built and operated 9 production reactors, five separations plants, several reactor fuel manufacturing facilities, a uranium trioxide ( $\text{UO}_3$ ) production facility and several Pu processing facilities. Additional facilities were built to support the production of plutonium, recovery of uranium, waste treatment, and provide site infrastructure. Plutonium was Hanford's primary product and recovered uranium was a secondary product. Peak nuclear materials production was reached in the 1960s, when all nine production reactors were in operation. Altogether, Hanford supplied Pu for the United States nuclear weapons program for more than four decades. Weapons material production was halted in the late 1980s.

The Hanford Site presently consists of ~1,450 square kilometers (~560-square-miles), located just north of the city of Richland, in the south central part of Washington State. The Hanford Site is managed by the DOE Richland Operations and River Protection Offices.

### Hanford's Role in Recycled Uranium

During Hanford's early years of operation, irradiated fuel was processed in T-Plant and B-Plant to recover Pu. Uranium from the irradiated fuel remained in the high level waste, which was sent to large underground storage tanks. In early 1952, operation of the Reduction-Oxidation Plant (REDOX) was initiated to process irradiated fuel,

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recovering both plutonium and uranium. At about this same time, Hanford initiated recovery of uranium from B-Plant and T-Plant tank waste in U-Plant, and operation of the UO<sub>3</sub> Plant was started for conversion of the recovered uranyl nitrate hexahydrate (UNH) to UO<sub>3</sub> powder for shipment offsite. Subsequently, in 1956, the Plutonium-Uranium Extraction Plant (PUREX) facility initiated operation to also process irradiated fuel and recover both Pu and uranium. PUREX became the sole irradiated fuel processing plant at Hanford after 1967 and ceased operation in early 1990. PUREX production eventually accounted for approximately 69 percent of all uranium recovered for recycle at Hanford. All recovered uranium at Hanford, which was in the form of UNH, was calcined to a shippable powder in the UO<sub>3</sub> Plant. The UO<sub>3</sub> powder was sampled and packaged into either drums or specially designed "T-Hoppers" for shipment.

### Data Examination

This study involved searching, reviewing, and analyzing documents which have been prepared throughout the history of the site. These searches and document reviews involved personnel on the RL Team with varied technical expertise and knowledge of past Hanford operations and previous studies. Due to the sheer volume of the records to potentially be searched and the allocated time and available resources, automated keyword-based data searches were conducted in parallel with the searches by the field experts. The computerized screening of records and documents produced since 1943 was then screened for data to supplement the records located by the field experts.

### Significant Information

The following list is a summary of significant findings of this study:

<b>Hanford Uranium Summary</b>	
Total uranium received at Hanford	~119,271 MTU
Total uranium shipped from Hanford	~112,287 MTU
Total uranium in inventory	~4,006 MTU
Uranium sent to waste (all forms)	~2,174 MTU
Uranium lost to fission & transmutation	~140 MTU*
<b>Total difference (~0.56% by weight)</b>	<b>~664 MTU</b>

\* Estimated uranium consumption in reactors

- Hanford received, fabricated as fuel, irradiated, and processed **~119,271** metric tons of uranium (MTU) to produce **~67** MT of Pu for defense and non-defense purposes.
- Hanford has shipped **~112,287** MTU (which includes **~109,792** MT of recycled uranium as UO<sub>3</sub> product oxide and fuel fabrication scrap and **2,495** MT of unirradiated uranium in various forms). Approximately **74,491** MT of the recycled

## EXECUTIVE SUMMARY

uranium went to the Paducah Gaseous Diffusion Plant (GDP) in KY, ~4,404 MT of recycled uranium went to the K-25 GDP and the Y-12 Plant at Oak Ridge, TN, and ~25,251 MT of recycled uranium was shipped to Fernald, OH. An additional ~5,646 MT of recycled uranium was sent to over 100 other destinations for research and miscellaneous non-defense and defense needs.

- Approximately ~4,006 MT of uranium remains at Hanford, excluding uranium in tanks and solid waste and uranium which was discharged to the cribs. This uranium is in various forms: metal received for making fuel, unused fuel, irradiated fuel (not in the scope of this study), uranium as oxide in mixed-oxide fuel (at the Fast Flux Test Facility and in vaults at the Plutonium Finishing Plant) and recovered uranium as  $UO_3$  for recycle.
- In the ~50 years (1943 through the mid-1990s) Hanford was in operation, ~2,174 MTU waste was generated. (Approximately 958 MTU now reside in the waste tanks, ~1,054 MTU is in solid waste, and ~162 MTU of liquids present on the Hanford site were discharged to cribs.)
- With the exception of a few years in the 1940s, the metal turnings and scrap produced during fuel rod manufacture were shipped offsite for recovery. Most of this scrap metal was converted to uranium oxide before shipment. It has been estimated that, overall, ~ 10 percent (~11,927 MTU) of the uranium received might have gone to scrap during fuel fabrication and was shipped offsite for recovery. Shipping records for the ~112,287 MTU shipped do not show the distinction between the shipment of scrap and the shipment of recovered uranium as  $UO_3$  but most of this ~11,927 MTU would have been recycled uranium. No Hanford process has been identified which would have changed the as-received ratio of Pu to uranium, or concentrated the constituents in the scrap prior to shipment.
- An estimated ~140 MTU was consumed during reactor operations and the generation of plutonium.
- A material difference of ~0.56 wt% (664.1 MTU) is indicated in the data reviewed between uranium received and uranium which was used up in the reactors, shipped, and uranium currently on site. The uranium currently on site includes the stored inventory of unirradiated uranium, uranium in irradiated fuel, uranium in tank waste and solid waste, and uranium in wastes in the cribs. This difference can be primarily attributed to limited available data from the early years of Hanford's operations, uncertainties in the quantities of uranium in tank waste and other waste forms, and uncertainties in the estimated amount of uranium that was consumed during reactor operation and the generation of Pu.
- Hanford first began receiving recycled uranium metal billets for reactor fuel rod manufacture starting about July 1952. The recycled uranium used to produce these billets had been processed through the GDPs and was reported to contain

## EXECUTIVE SUMMARY

approximately 10 parts Pu per trillion parts uranium. After about 1963, as a result of a manufacturing change at Fernald, the metal billet Pu concentration rose to a level "not to exceed 10 parts plutonium per billion parts of uranium." Hanford did not routinely perform a Pu analysis of the incoming billets.

Information provided by Fernald indicates that the metal produced from recycled uranium contained  $^{99}\text{Tc}$  ranging from < 0.01 to 6.1 ppm and  $^{237}\text{Np}$  with an upper limit of ~500 ppb.

The prospect of an ingestion or inhalation dose in dealing with this metal is remote.

- In 1951, a tentative Pu specification for  $\text{UO}_3$  was established at 100 parts per billion (ppb), based upon the expected composition of a blended UNH product mix from U-Plant and REDOX Plants. Preliminary specifications were identified by Oak Ridge in 1952 which required the Pu specification for  $\text{UO}_3$  to be lowered to 10 ppb. This limit was subsequently firmed up in 1953 and remained in place from that time until  $\text{UO}_3$  production was terminated in 1993.
- Shipments of recycled  $\text{UO}_3$  powder from Hanford to the GDPs contained only trace amounts of Pu, usually less than 10 ppb. **The preponderance of Hanford recycle  $\text{UO}_3$  powder shipments had Pu concentrations of 5 or less ppb in the recycled uranium.** Six shipments of  $\text{UO}_3$  have been identified which contained Pu concentrations of **12, 13, 16, 19, 22, & 30** ppb. These shipments involved ~193 MTU containing an average plutonium impurity level of ~18 ppb (~3.4 g Pu). Documentation reviewed indicates that the receiver sites were typically notified of these conditions and accepted these limited quantities of recycled uranium prior to their shipment from Hanford.
- Analytical results on every lot of  $\text{UO}_3$  powder shipped to the GDPs have not been located. Thus a quantitative assessment of the total Pu shipped with the recycled uranium was not possible. Based upon the findings that the predominant Pu concentration was in the range of **1 to 5** ppb, it is estimated that approximately **110 to 550** grams of Pu (with a mean of 330 grams) was included with the **~109,792** MTU shipped from Hanford.
- Hanford did not routinely analyze the  $\text{UO}_3$  product produced before 1980 for  $^{237}\text{Np}$  or  $^{99}\text{Tc}$ , as it was not a specification requirement. Hanford did analyze the recycled  $\text{UO}_3$  powder for total beta and gamma emissions and conformed to the required specification levels of less than a 100% increase in beta activity and less than a 300% increase in gamma activity above that of aged natural uranium. In some later campaigns where analyses were performed, the measured  $^{237}\text{Np}$  concentrations typically ranged from 20 to 500 ppb, and  $^{99}\text{Tc}$  concentrations ranged from 3-12 ppm. A rough estimate, based on limited analytical data, indicates that the ~109,792 MT of recycled uranium shipped offsite might have contained 2 to 55 Kg Np and 330 to 1,320 Kg Tc.

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- Limited comparisons which could be done on the level of constituents in UO<sub>3</sub> product containing recycled uranium from Hanford, with analytical results reported in available historical documents from the receiving sites, indicates that the analytical results have been reasonably consistent between sites.
- During this study, documentation reviewed has not indicated that any process within those facilities which handled recycled uranium concentrated the impurities in the recycled uranium. However, time has not been available to perform a detailed assessment of all uranium processing steps utilized at Hanford to assure that impurities in uranium were never concentrated. The UO<sub>3</sub> Plant calciners, which converted the recovered UNH to UO<sub>3</sub> powder, did operate at elevated temperatures in an oxidizing environment. It is reasonable to believe that any volatile fission products in the recycled uranium could have volatilized to the off-gas system and then could have been either plated out on equipment surfaces, accumulated in off-gas scrubber solutions, or released to the environment. Documentation has been found to indicate that some of the ruthenium volatilized during UNH calcination, with a decrease in concentration ranging from a factor of <1 to 6.
- The primary facilities which handled recycle uranium at Hanford were the UO<sub>3</sub> Plant and the fuel fabrication facilities. The UO<sub>3</sub> Plant operated intermittently from 1952 to 1994, and reactor fuel fabrication operations occurred during 1942 to 1987. Some of the facilities used for fuel fabrication operations continue to be

	1940s	1950s	1960s	1970s	1980s	1990s
300 Area Fuels Fab.						
REDOX						
U-Plant						
UO <sub>3</sub> Plant						
PUREX						

used for the storage of unirradiated uranium fuel and fuel fabrication material. The separation facilities (REDOX, and PUREX), which processed irradiated fuel, and the U-Plant, which recovered uranium from high-level waste, only involved handling recycle uranium during concentration and loadout of the recovered UNH. This UNH was subsequently transferred to the UO<sub>3</sub> Plant for conversion to an oxide powder for shipment. The U-Plant operated from 1952 to 1958, REDOX Plant operated 1952 to 1967, and the PUREX Plant operated 1956 to 1990.

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The operation, maintenance, and waste handling operations associated with all of these facilities contributed to some personnel exposure and environmental releases. However, distinguishing exposures to trace quantities of transuranics and fission products in recycled uranium from those associated with normal Hanford operations (which involved the handling and processing of significant quantities of irradiated fuel, high-level waste, and Pu) is considered extremely difficult. Any such dose assessment is further complicated by the past practice of transferring personnel between facilities to meet work needs, necessitating the development of a historical worker profile in order to establish which portions of the dose can be attributed to the various facilities and process operations.

Plutonium was Hanford's principal product and all production processes were designed and operated to maximize plutonium recovery. The primary Hanford facilities which had the highest potential for uranium uptake by personnel were the UO<sub>3</sub> Plant, which handled large quantities of dry UO<sub>3</sub> powder, and the fuel fabrication facilities in the 300 Area of Hanford which handled uranium metal and uranium fabrication scrap.

An Occupational Potential Exposure (OPE) estimate suggests that ~1,128 staff at the Hanford site worked in areas directly involving the handling and processing of recycled uranium. Of these personnel, it is estimated that ~456 could have had moderate OPE (some potential or incidental exposure to recycled uranium but at levels not expected to have any measurable health effect). This is only a rough estimate. For a more thorough analysis of worker contact with recycled uranium, including an examination of Hanford's uranium bioassay records, a more detailed review would be required.

# Section 1 Hanford Uranium Mass Balance Project

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## Section 1.0 Hanford Uranium Mass Balance Project

### 1.1 Project Overview

On August 8, 1999, the Secretary of Energy announced a comprehensive set of actions to address issues at the Department of Energy's (DOE) Paducah Gaseous Diffusion Plant in Paducah, Kentucky, that may have the potential to affect the health of the workers. One of the issues with DOE complex-wide significance involved the need to determine whether radioactive fission products and plutonium in uranium feed and waste streams existed in concentrations that present potential health or environmental concerns. The fission products and transuranic contaminants are contained in uranium that has been irradiated in a nuclear reactor and then processed in a separations plant to recover the uranium for reuse.

A working group was established to address this issue from a DOE complex-wide perspective. The Hanford Uranium Mass Balance Project was established to provide Hanford-specific data to the working group for inclusion in a complex-wide report. The Project Team was established, staffed with present and former Hanford workers, many with direct experience related to the facilities, processes and materials involved in the recycling of uranium or with the identification and retrieval of historical data at Hanford.

Between October 1999 and April 2000, a systematic search of available historical data was conducted and technical members of the Project Team evaluated relevant information. This report represents the results and conclusions of their evaluation.

### 1.2 Purpose and Scope

The purpose of this Project was to develop and provide data to the DOE Working Group that is responsive to a letter from the Deputy Secretary of Energy [Glauthier 1999] to all DOE elements dated September 15, 1999, and two follow-up memorandums from EH-1 [Michaels 1999]. Specifically, the data was to be sufficient to permit the working group to:

- Identify the mass flow of DOE recycled uranium from early production to March 1999, including ultimate use and disposition, and create an inter-site flow sheet for public availability.
- Identify the characteristics and contaminants in the major uranium streams, specifically, the technetium, neptunium, plutonium or other isotopic content of concern to worker or public health and safety.
- Conduct site mass balance activities sufficiently thorough to identify any significant implications for personnel exposure or environmental contamination.



**Hanford Uranium Mass Balance Project**

- Conduct an occupational radiation exposure profile project at the Paducah, Portsmouth, and former Oak Ridge K-25 facilities.

The Hanford Uranium Mass Balance Project included an evaluation of shipments, receipts, and current inventories of recycled uranium to quantitatively estimate the flow and characteristics of recycled uranium to and from Hanford. It also included an evaluation of all Hanford facilities involved in processing recycled uranium, particularly with respect to the potential for concentrating plutonium or radioactive contaminants in the recycled uranium.

The uranium materials within the scope of this project are:

- All uranium (depleted, natural, or enriched, and in all physical and chemical forms) that has ever been irradiated in a reactor and separated from all or some of the fission products and transuranic products.

The uranium materials considered out-of-the-scope of this project are:

- Irradiated fuel and targets which have not been processed to separate all or some of the fission products and transuranic products from the uranium.
- Uranium in waste or under environmental management.
- Uranium in sources, samples, or under NRC agreement or State controls.

This information is intended to enable DOE to assess the historical potential for worker exposure from recycled uranium and its trace transuranic and fission product impurities.

### 1.3 Project Implementation Strategy

DOE Richland Operations Office (RL) management determined that the Project Team would be staffed with present and former Hanford chemists, engineers and other workers with knowledge of the Hanford facilities, processes and materials related to the recovery and reuse of recycled uranium. The Team also included personnel with experience in DOE nuclear material control and accountability, and document classification and declassification requirements and processes.

Hanford currently has approximately 75,000 boxes of historical records in archives, both on site and off. A discussion of the document research process used on this study is provided in Appendix E. The Project organization and functional activities are depicted in Figure 1-1.

In addition to the database searches, the RL Project Team made extensive use of the first hand knowledge of Team members to identify and search out specific

# Section 1

## Hanford Uranium Mass Balance Project

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specifications, flowsheets, and analytical and shipping documentation known to have been prepared and used at Hanford.

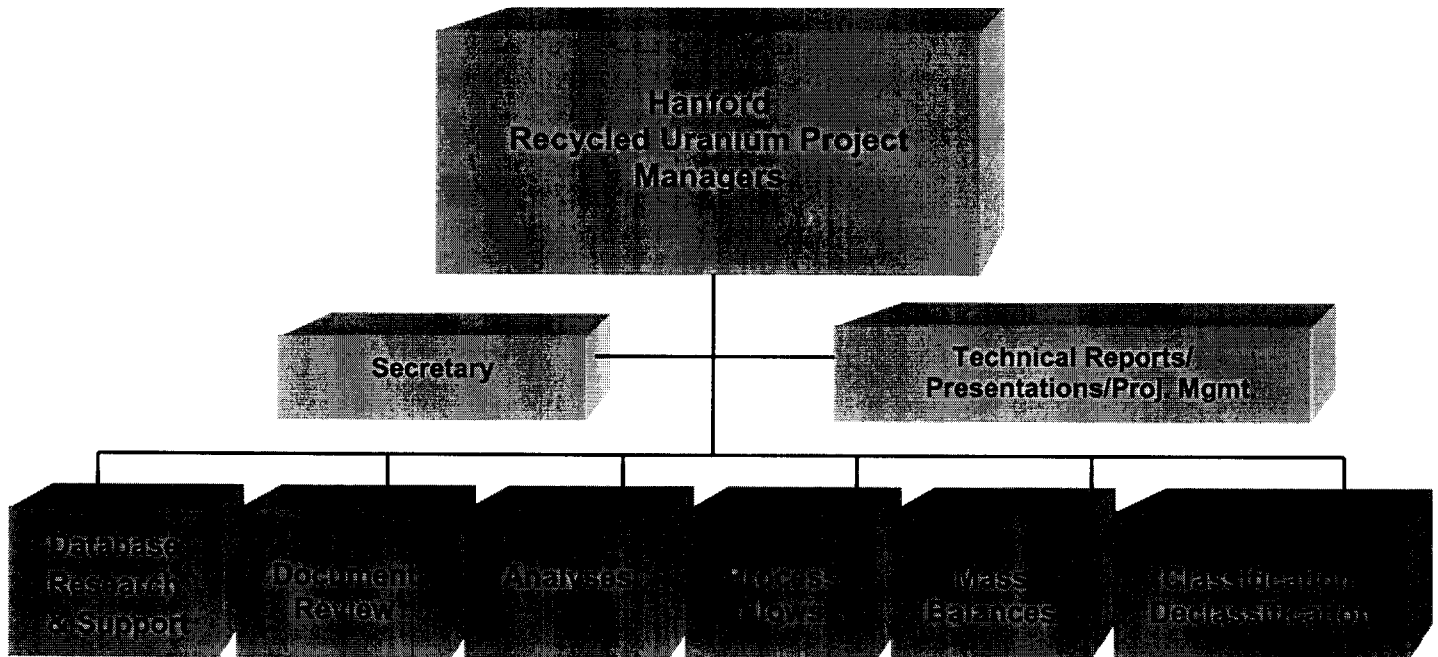


Figure 1-1 Hanford Recycled Uranium Project Functional Breakdown

### 1.4 Assumptions

The following assumptions were made by the RL Project Team during their review:

- Only production scale facilities were considered “in-scope.” Facilities and materials utilized for research and development activities were considered to be “out-of-scope” for this project.
- Uranium is assumed to be “recycled uranium” only after it has been irradiated and then processed to separate it from the plutonium and fission products as pure UNH.
- Any uranium received at Hanford beginning in July 1952 and thereafter is assumed to be recycled uranium. This is the earliest that Hanford believes recycled uranium could have been returned to Hanford, since shipments of recycled uranium from Hanford did not begin until March, 1952.

**Hanford Uranium Mass Balance Project**

- Radioactive contaminants in the uranium trioxide shipped from Hanford for which no radiochemical data has been found are assumed to be in the same range as those for which analytical data was located.

**References**

Glauthier 1999

Memorandum, T. J. Glauthier, Deputy Secretary of Energy, to All Department Elements, *Paducah Gaseous Diffusion Plant -- Follow-Up Activities*, U. S. Department of Energy, Washington, DC, September 15, 1999

# SECTION 2 HANFORD SITE HISTORICAL OVERVIEW

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## 2.0 Hanford Site Historical Overview

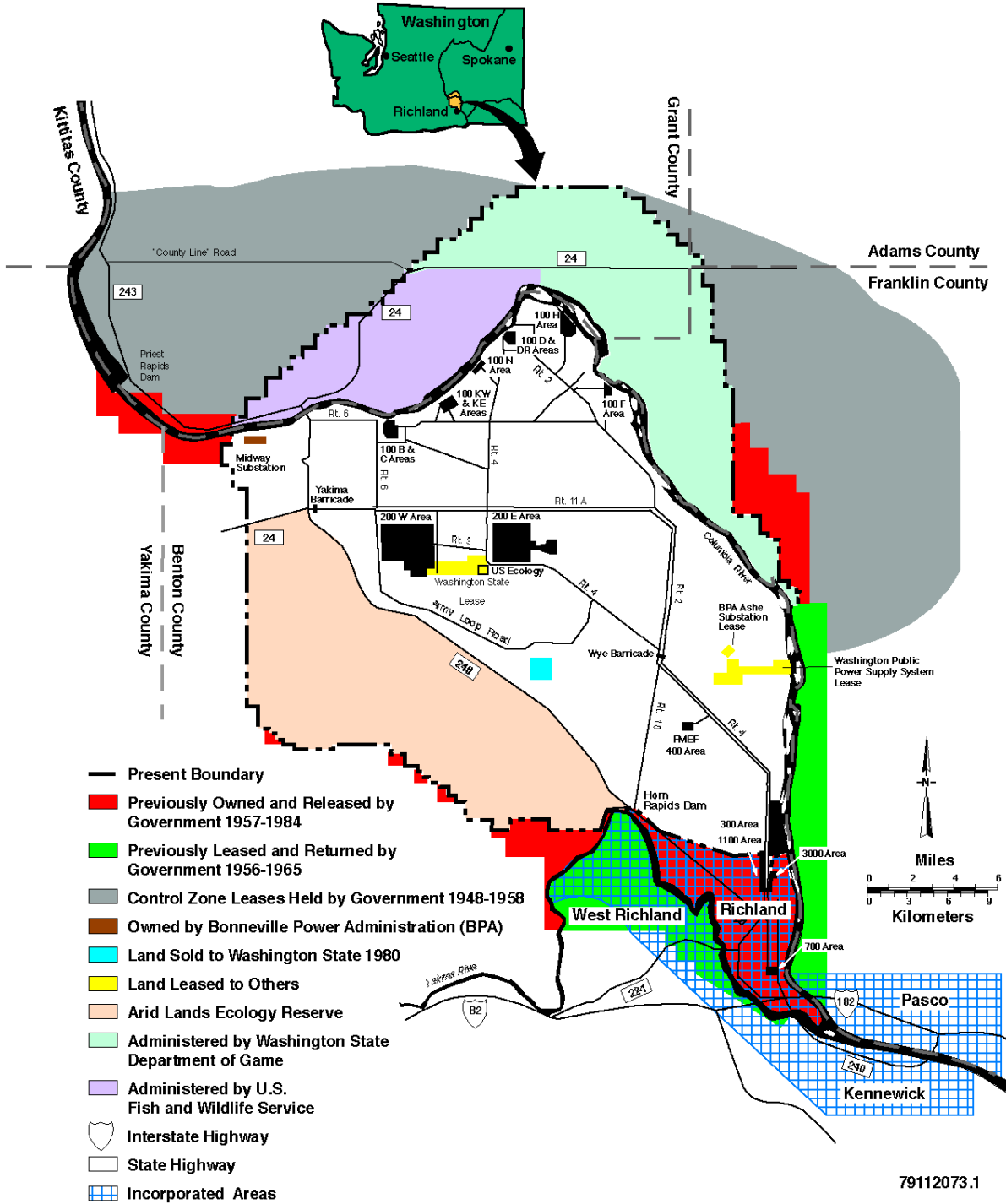
### 2.1 Site Description

The Hanford site was established by the Manhattan Project as the plutonium production site for the U. S. World War II defense effort. The site initially consisted of ~1,735 square kilometers (~670 square miles) of primarily remote, semiarid land. Over time, this has been reduced to ~1,450 square kilometers (~560 square miles) as parcels of land no longer needed by the site were made available for other uses. The site has access to significant water and power supplies and nearby barge shipping, road, air, and rail facilities. Construction was initiated in March 1943 to build facilities to produce plutonium for the first atomic bombs. The principal early facilities included B-, D-, and F-Reactors, the 313 Fuel Fabrication Facility, the T-Plant and B-Plant fuel processing facilities for plutonium separation, and the 231 Isolation Process facility for final plutonium purification and concentration. Waste storage tanks, laboratory facilities, warehousing, roads, power plants, housing, and a myriad of other support facilities were simultaneously built during the construction period. Initial plutonium production commenced in September 1944 when the first reactor was brought on line. The first batch of refined plutonium was available for the war effort in February 1945.

Buildup of the Hanford site continued for many years in support of nuclear weapons program needs. Additional facilities were eventually needed to satisfy planned plutonium production requirements and to improve process efficiencies. An additional six reactors and four processing facilities were constructed and operated, including: the Reduction Oxidation (REDOX) Plant, U-Plant, UO<sub>3</sub> Plant, and the Plutonium-Uranium Extraction (PUREX) Plant. During the plutonium production years at Hanford, uranium was received at the site, fabricated into nuclear fuel, irradiated for plutonium production, and processed to recover the plutonium. Until about 1952, the waste from plutonium separation, which included fission products and unused uranium, was stored in large, underground waste tanks. After 1952, uranium was mined from these tanks and recovered for reuse. All subsequent fuel processing operations included uranium recovery and recycle. Most of this uranium was shipped offsite for recycle and contained residual trace quantities of transuranics and fission products. By 1994, all plutonium production and uranium recovery activities were shutdown and a cleanup mission for the Hanford site was initiated. A brief historical timeline of Hanford's history is provided in Appendix H.

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**Figure 2-1 The Hanford Site, Richland Washington**

Figure 2-1 shows a map of the Hanford Site. Fuel fabrication facilities were located in the 300 Area (South corner of the site). General fabrication, administrative, and other

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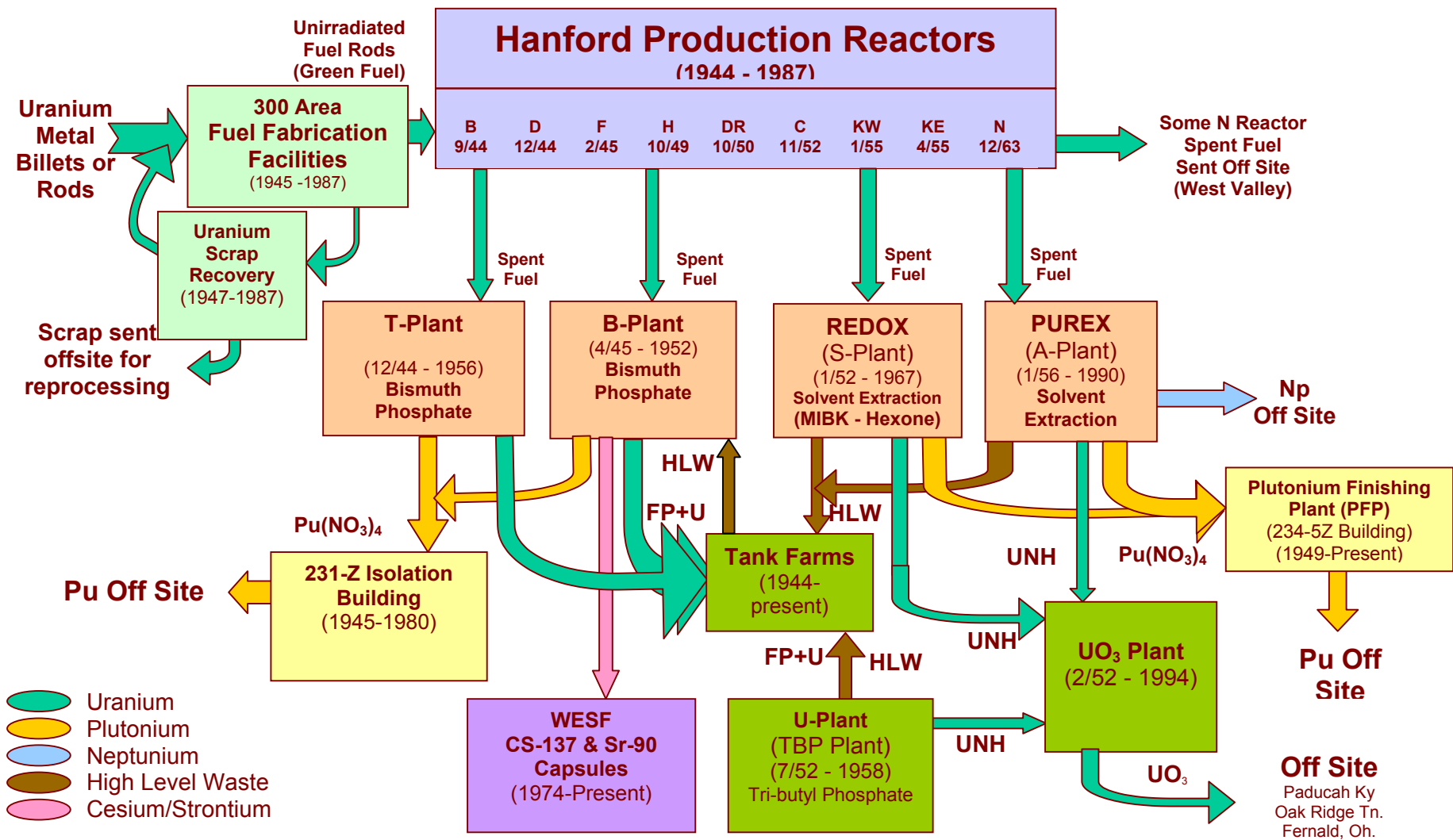
support functions were located nearby in facilities in the 700, 1100, and 3000 Areas. Completed fuel was shipped to the reactors at the 100 Areas (B, C, D, DR, F, H, KE, KW, and N) located along the south shore of the Columbia River in the northern portion of the Site for use in the reactors. After irradiation, the fuel was stored in pools at the reactors for a cooling period and then transported in special rail cars to the separation processing facilities located in both the 200 W and 200 E Areas. Discarded high level waste from the separation plants were transferred to storage in underground storage tanks located in both the 200 W and 200 E Areas. All recovered solutions of uranium were transported to the  $UO_3$  Plant located in the 200 W Area for conversion to oxide.

### 2.2 Key Uranium Processing Facilities

As part of the Manhattan Project and its successors, the U. S. Atomic Energy Commission (AEC), Energy Research and Development Administration (ERDA), and the U. S. Department of Energy (DOE), a number of specialized facilities were constructed at the Hanford site and operated between 1943 and 1986 to produce fuel for the nine plutonium production reactors and to recover plutonium and uranium from the irradiated fuel. A historical overview of all the major plants, process flows, and facility interfaces at Hanford is shown in Figure 2-2. All of the uranium received at Hanford for non-research reactor operation was fabricated into fuel in the 300 Area throughout Hanford's production mission. This fuel was used in nine production reactors which operated over various time periods. Essentially all of the irradiated fuel went to one of four separation processing facilities; T-Plant, B-Plant, REDOX, and PUREX. In addition, the U-Plant was operated for a short time period to recover uranium from high level waste from the early T- and B-Plants, which did not have the capability to recover uranium during irradiated fuel processing. All of the high level waste from the processing of irradiated fuel was transferred to underground storage tanks. Recovered plutonium was refined and converted to a suitable chemical form in either the 231-Z Isolation Building or the Plutonium Finishing Plant. Recovered uranium (as recycle uranium) was converted to a stable oxide for shipment in the  $UO_3$  Plant. The remainder of this section provides a brief description of the facilities, processes, and operating history for the major Hanford uranium processing plants.

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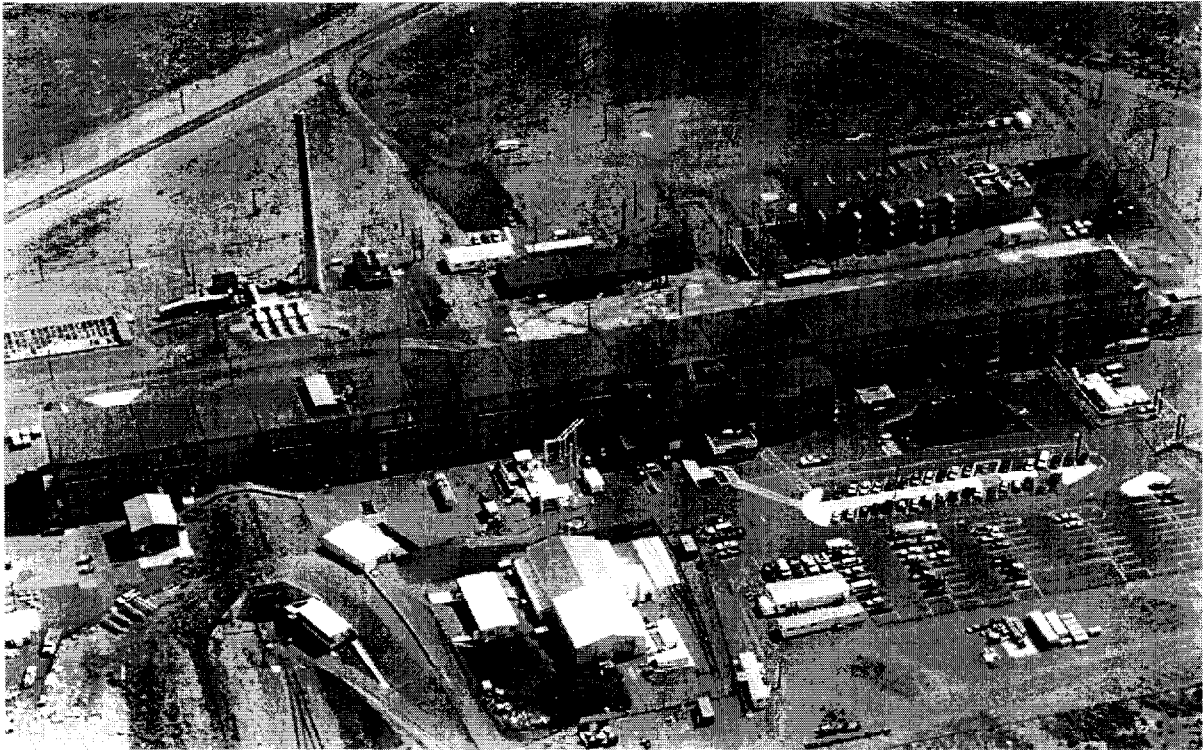
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**Figure 2-2 Hanford Major Process Flows and Facility Interfaces**

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### 2.2.1 T-Plant

T-Plant was the first of three separations plants built at Hanford by the Manhattan Project.

#### 2.2.1.1 Plant Description

T-Plant (the 221-T Cell Building), located in the 200 West Area of Hanford, is 85 feet wide by 875.5 feet long by 102 feet high. It is a reinforced concrete, windowless structure. Approximately 25% of the building is located below grade. The building enclosed a bismuth phosphate plutonium extraction process. The process equipment was located in 20 heavily shielded cells that provided needed radiation shielding for the personnel processing irradiated uranium fuel. The process involved dissolution of irradiated uranium fuel from the reactors and extraction of plutonium. Process equipment maintenance was accomplished remotely. Shielded transfer piping provided the path for liquid chemical transport between the cells [Gerber 1996].

#### 2.2.1.2 T-Plant Material Flowsheet

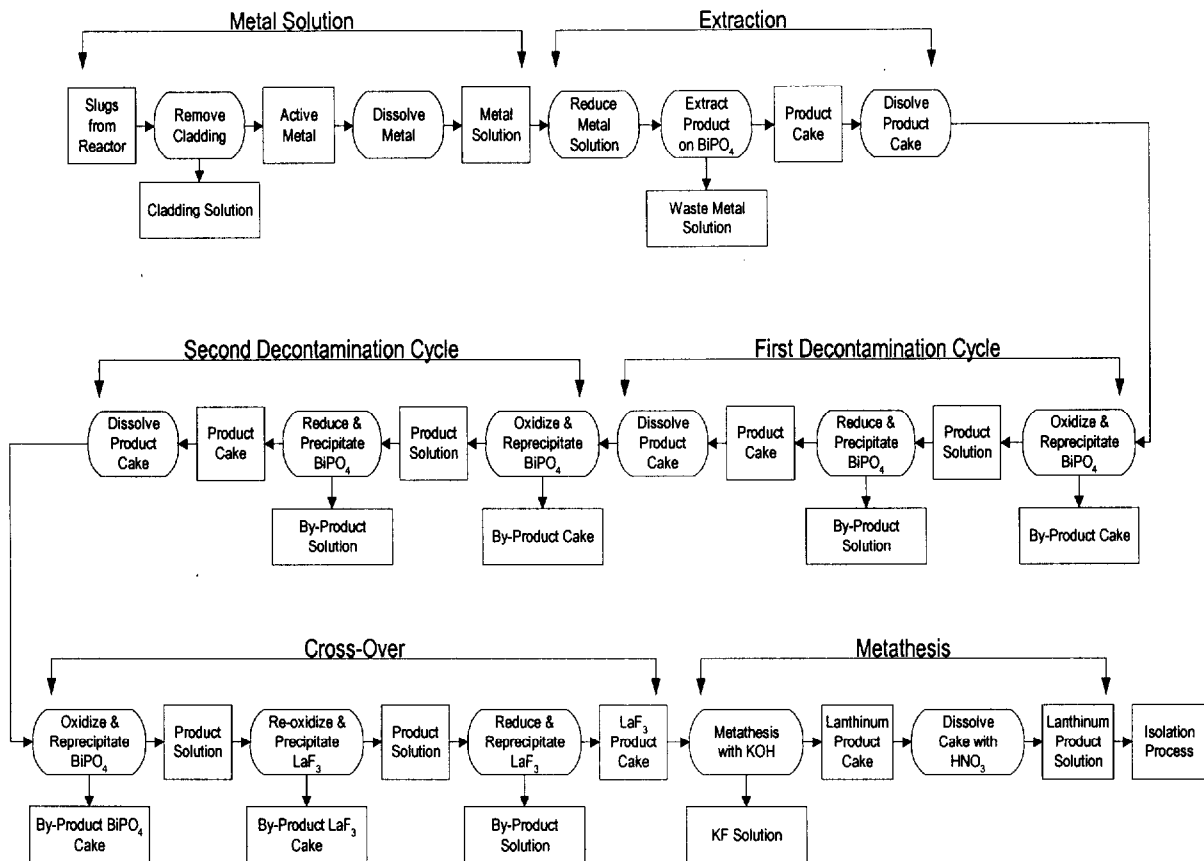
The material flowsheet was developed early in the facility construction period. Initially the facility was expected to process about one ton of irradiated uranium per day. Over years of operation, changes to the processes and modification to the bismuth phosphate chemistry resulted in improved performance. A simplified process flow diagram for the bismuth phosphate separation process is depicted in Figure 2-3. This



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process was developed by Glenn T. Seaborg in the early 1940s and applied at Hanford to achieve separation of the plutonium produced from irradiated uranium. Uranium was not recovered, and both the fission products and uranium were sent to large underground waste storage tanks.



**Figure 2-3 T-Plant Process Flow Diagram**

The process consisted of removing the aluminum cladding from the irradiated fuel rods (also known as “slugs”) in dissolver tanks using hot sodium hydroxide. The cladding waste was drained from the dissolver tanks and transferred to the underground waste tanks. The declad slugs were washed with water to remove any residual hydroxide. Nitric acid was then added to dissolve the bare uranium slugs and form a uranium nitrate solution. The uranium nitrate solution was chemically adjusted with sulfuric acid and sodium nitrite to assure extractability of the plutonium from the uranium solution. Bismuth nitrate and phosphoric acid were added to co-precipitate plutonium and bismuth as insoluble phosphates. The solution was centrifuged from the bismuth phosphate co-precipitate. Waste solutions containing uranium and fission products were treated and sent to the underground waste tanks. The solid cake was water washed and dissolved in concentrated nitric acid. The nitrate solution was chemically adjusted to permit precipitation of metal contaminants upon addition of bismuth nitrate while maintaining the plutonium in solution. The solution was again chemically treated and

## SECTION 2 HANFORD SITE HISTORICAL OVERVIEW

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bismuth nitrate and phosphoric acid added to co-precipitate the plutonium, further reducing the metal contaminants. This precipitation, re-solution and re-precipitation process was repeated two more times to further reduce the metal contaminants and reduce volume. Final purification of the plutonium was accomplished by repeated co-precipitation using lanthanum nitrate and hydrofluoric acid to form the lanthanum fluoride which served as the carrier. Upon completion of the purification steps, the plutonium was dissolved in nitric acid and transferred to the Isolation Process Facility (231-Z building) for final treatment and concentration.

### 2.2.1.3 Feed Specifications

Feed for the extraction process was irradiated natural uranium and the expected plutonium content was low. During the 10 years of T-Plant operation, the irradiated fuel feedstock varied in plutonium and fission products content as the reactor operations were improved and power levels increased.

### 2.2.1.4 Product Specifications

Plutonium nitrate solution was the principal product of T-Plant and the nitrate solution was further purified at the 231-Z Facility. The uranium and fission products were discharged to the underground waste tanks. Waste transferred to the underground tanks was chemically adjusted to minimize corrosion of the tanks using specifications based on maintaining alkalinity and nitrate/nitrite concentrations. Since uranium did not play an important role in corrosion control, no purity requirements were established for the waste uranium [HW-10475-ABC 1944].

### 2.2.1.5 Operating History

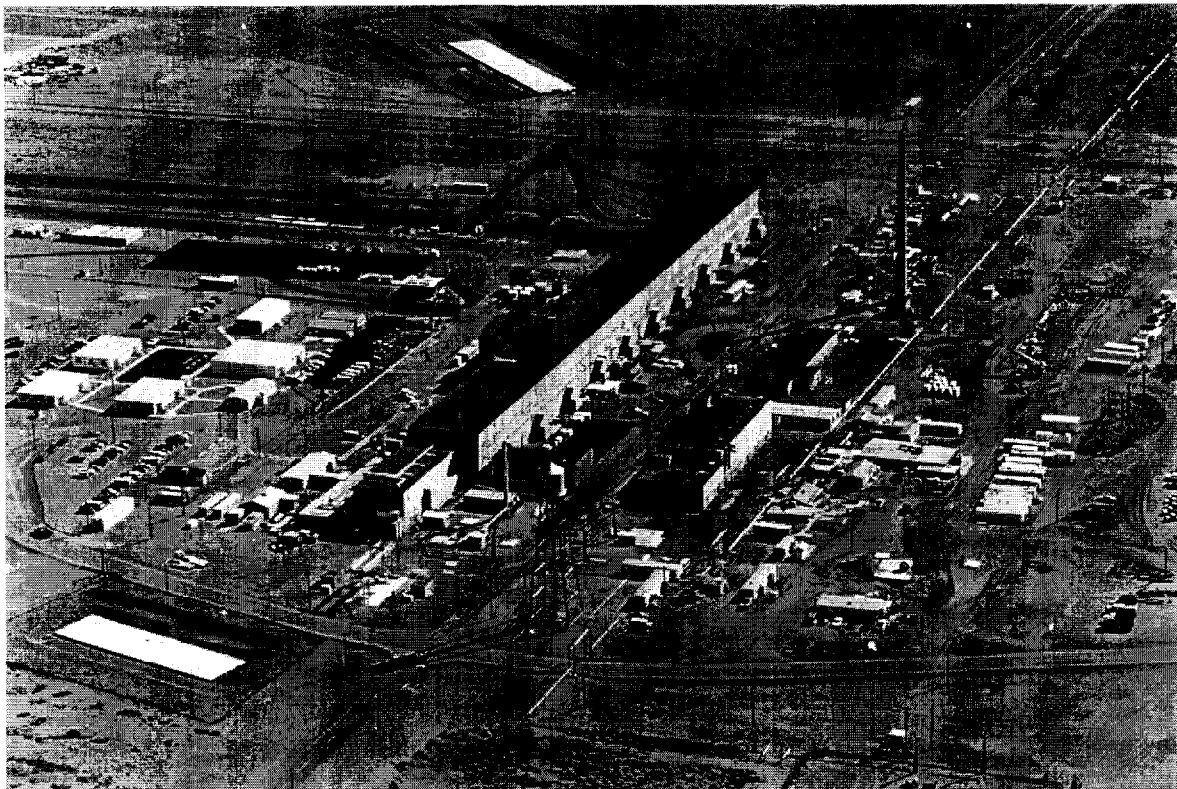
Processing of irradiated uranium fuel commenced on December 26, 1944, in the T-Plant. A number of operational improvements and installation of a third fuel dissolver in 1954 increased plutonium production rates. T-Plant was shut down in March 1956 following startup of the PUREX plant in January 1956.

### 2.2.1.6 Current Status

T-Plant is used on an irregular basis as an equipment decontamination and repair facility supporting Tank Farms operations. Although recently the 224-T Building was used for TRU waste storage, the TRU has now been removed and 224-T is now being deactivated.

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### 2.2.2 B Plant

B-Plant was second of the three separations plants initially built by the Manhattan Project.

#### 2.2.2.1 Plant Description

B-Plant (the 221-B Cell Building) is located in the 200 East Area and was constructed in the same time frame as T-Plant. B-Plant started processing irradiated uranium fuel on April 13, 1945. Physically, B-Plant is nearly identical to T-Plant. It is 65 feet shorter in length than T-Plant because it did not include the two equipment development cells provided in T-Plant. Like T-Plant its mission was to recover plutonium from irradiated uranium fuel using the bismuth phosphate process. The process equipment was also located in heavily shielded process cells [Gerber 1996].

#### 2.2.2.2 Material Flowsheet

B-Plant shared the same flowsheet as T-Plant. Process modifications to improve efficiency were similar to those made at T-Plant, but B-Plant did not operate as a plutonium separations plant for as long as T-Plant.

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### 2.2.2.3 Feed Specifications

The feed specifications for B-Plant were the same as those for T-Plant, described earlier.

### 2.2.2.4 Product Specifications

Like T-Plant, B-Plant's principal product was plutonium nitrate solution. The uranium and fission product wastes delivered to the underground tanks were chemically adjusted to assure adequate control of expected tank corrosion using specifications based on maintaining alkalinity and nitrate/nitrite concentrations [HW-10475-ABC 1944].

### 2.2.2.5 Operating History

B-Plant began processing irradiated uranium fuel in April 1945 using the bismuth phosphate process. Plutonium recovery continued until 1952 when the plant capacity became unnecessary once the combined output of T-Plant and REDOX was sufficient to satisfy production needs. In 1968, the plant was converted to a waste fractionation plant. Cesium and strontium were removed from the high level tank wastes and encapsulated [Gerber 1996].

### 2.2.2.6 Current Status

The cesium and strontium capsules are currently being stored in water filled basins in an addition on the west end of the plant. Present plans call for vitrification of these capsules as high level waste. The remainder of the plant has been shutdown.

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### 2.2.3 U-Plant

U-Plant was the third of the original three separation plants to be built by the Manhattan Project. This facility was also known as the TBP-Plant and the Metal Recovery Plant. It was initially used to train operators for B- and T-Plants. Later, it was modified to recover uranium in waste slurry “mined” from the high-level wastes in Hanford’s tanks.

#### 2.2.3.1 Plant Description

U-Plant is located in the 200 West Area and is almost identical to T-Plant. It is 65 feet shorter overall because, like B-Plant, it does not include the two development cells provided in T-Plant. It was not used to separate plutonium from irradiated fuel as process improvements and other efficiency improvements in T- and B-Plants were sufficient to meet the plutonium recovery schedule. U-Plant was used as a training facility for the two other plants. By 1952, U-Plant was modified to separate, recover, and recycle uranium from the high-level T-Plant and B-Plant wastes in the underground storage tanks. As such, it was a significant element in the Hanford uranium recycle process [Gerber 1996].

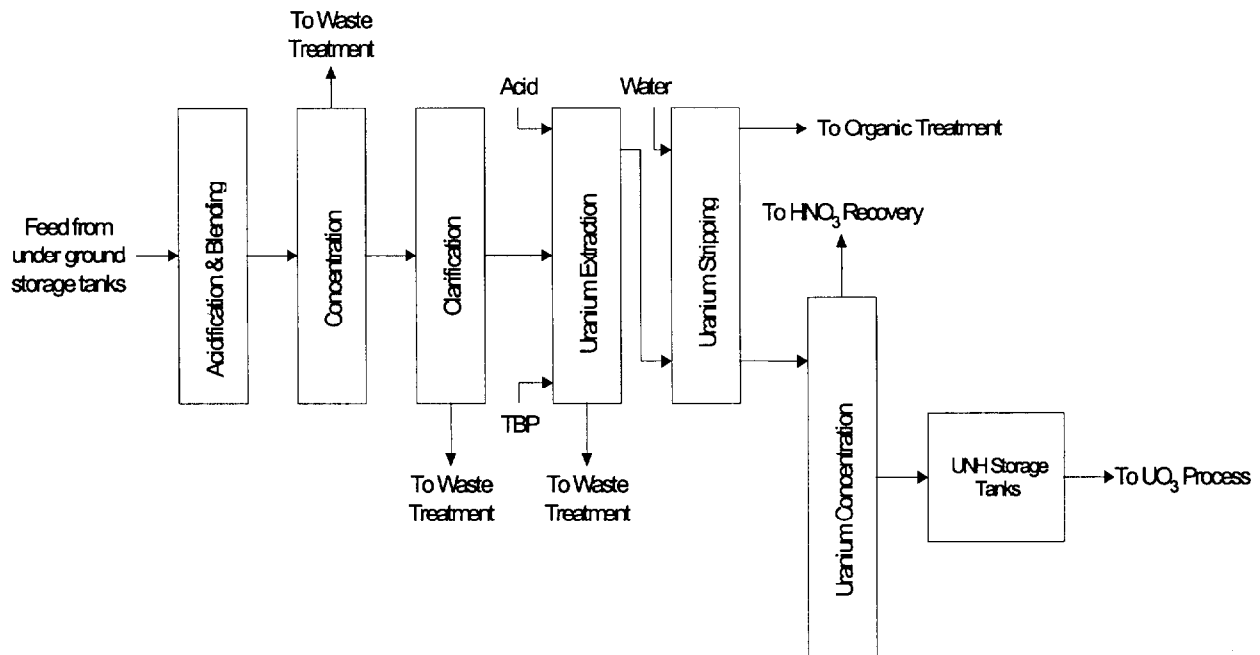
#### 2.2.3.2 Material Flowsheet

A simplified U-Plant process flow diagram for the recovery of uranium from retrieved B-Plant and T-Plant tank waste is depicted in Figure 2-4 and is based upon the use of

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tributyl phosphate (TBP). The TBP was found to complex very well with both uranium and plutonium to allow their separation from fission products and from each other after proper chemical adjustments. The process consisted basically of contacting the clarified and concentrated acidic uranium solution that had been sluiced from the waste storage tanks with TBP carried in a hydrocarbon solvent to complex the uranium with the TBP. This process was done as a one-pass counter-current solvent extraction process using packed columns. The uranium complexed with the TBP and thus transferred to an organic phase, while the fission products remained in the aqueous phase. The acidic aqueous waste from the column was neutralized and returned to the underground waste tanks for storage. The uranium was then stripped from the TBP-uranium complex in the organic phase in another packed column with acid of a specific molarity. The resultant uranium solution was then concentrated in an evaporator to a consistent concentration for feed to the  $UO_3$  Plant. The concentrated uranium nitrate solution (uranyl nitrate hexahydrate (UNH)) was analyzed to assure that it met feed specifications for the  $UO_3$  Plant and then transferred to that facility for conversion to shippable powder. Product solutions not meeting the stringent specification of the  $UO_3$  Plant were recycled back through the extraction process. In order to accommodate the required throughput rate, there were two extraction trains in U-Plant.



**Figure 2-4 Simplified U-Plant Tributyl Phosphate (TBP) Process Flow Diagram**

### 2.2.3.3 Feed Specifications

Feed for U-Plant came from the underground storage tanks which contained high level waste from the B and T separation plants. The uranium-bearing tank wastes consisted

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of sludge and supernatant liquor (sludge washings and solutions). The sludge contained approximately 75 percent of the uranium. The plutonium content of the uranium waste was about two to four grams per metric ton (MT) of uranium (2-4 ppm Pu). Approximately 20 MT of slurried tank waste was required to produce one ton of recovered uranium for conversion to  $UO_3$ . A description of the chemical constituents of the "mined" uranium feed can be found in the Uranium Recovery Technical Manual [HW-19140 1951].

### 2.2.3.4 Product Specifications

The U-Plant product specifications were dictated by the specifications for the  $UO_3$  powder produced in the  $UO_3$  Plant. The initial specification in the 1951 technical manual [HW-19140 1951] indicated the UNH product from U-Plant should contain less than 80 ppb Pu. The  $UO_3$  Plant did not further refine the UNH product from the U-Plant process. Blending of the U-Plant product with product from REDOX was expected to help assure the concentration of transuranics and fission product impurities were at acceptable levels. U-Plant did have the capability to concentrate the UNH prior to calcination, however this did not alter the ratio of any impurities to uranium.

### 2.2.3.5 Operating History

Uranium was scarce in the late 1940s. Escalating demand for weapons materials led to the decision to reclaim uranium from the underground storage tanks. This was first discussed in 1947 when a decision was made to develop a process for extracting uranium from the Hanford waste tanks to supplement the scarce uranium supplies [Peterson 1947]. Over the next few years, a uranium recovery process based upon TPB was developed at Hanford and served as the design basis for both the U-Plant conversion and the PUREX separations operations. U-Plant began recovering uranium from tank wastes in 1952 and completed its mission in 1958. UNH product from U-Plant was routinely blended with UNH product from REDOX. During U-Plant's operating period, ~7,200 MTU was recovered from high-level waste for conversion to  $UO_3$  and recycle.

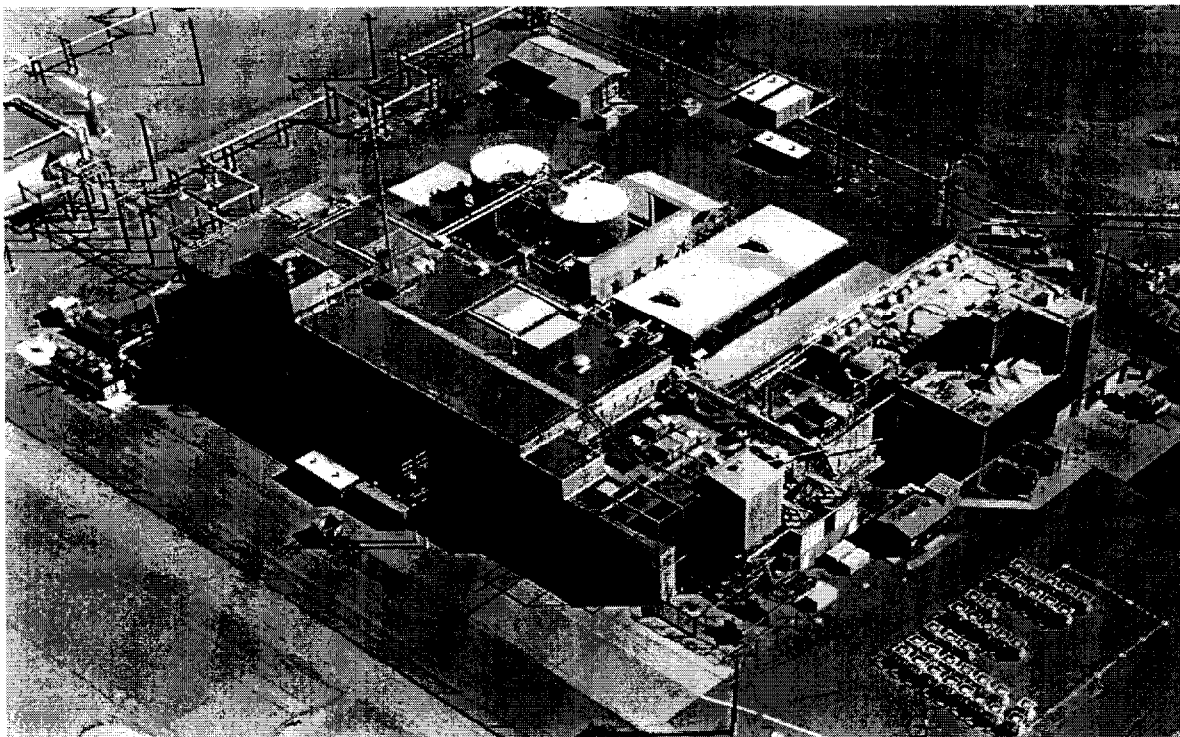
Worker exposure to uranium was normally low, as processing occurred remotely in heavily shielded and ventilated canyon cells. The uranium solutions were of low concentration until the solution was evaporated to create the UNH product. Transfer of concentrated UNH to the  $UO_3$  plant was by pipeline. Liquid wastes containing fission products and plutonium were transferred to underground waste storage tanks. Solid wastes were packaged and sent to the Hanford burial sites for disposal.

### 2.2.3.6 Current Status

U-Plant is presently undergoing decontamination and decommissioning. It's final state is the subject of an ongoing Canyon Disposition Initiative at Hanford.

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### 2.2.4 UO<sub>3</sub> Plant

The UO<sub>3</sub> Plant was built to convert UNH solution into shippable uranium trioxide (UO<sub>3</sub>) powder.

#### 2.2.4.1 Plant Description

The results of process improvements in the T-Plant and B-Plant operations as early as 1945 demonstrated that U-Plant was not needed to process irradiated fuel. The 224-U Building at the U-Plant complex was subsequently modified to convert UNH into UO<sub>3</sub>, hence its designation as the UO<sub>3</sub> Plant. The 224-U Building was a three-story, frame and concrete block structure which had just under 12,000 square feet, and had been constructed to house a part of the plutonium separation and concentration process used at Hanford in the 1940s. Conversion of the 224-U Building into the UO<sub>3</sub> Plant was completed in 1951.

The basic UO<sub>3</sub> process consisted of concentrating and then heating liquid UNH until it was calcined into a stable, orange-yellow UO<sub>3</sub> powder. At the same time, nitric acid was recovered for reuse. It was not possible to operate the UO<sub>3</sub> process at Hanford until a feed supply of UNH became available in 1952 with the startup of the REDOX Plant and then, within a few months, the U-Plant. The earlier separation processes used at B-Plant and T-Plant were unable to recover the uranium for recycle. However, the newer solvent extraction processes used at REDOX and U-Plant allowed recovery of uranium as a concentrated UNH.

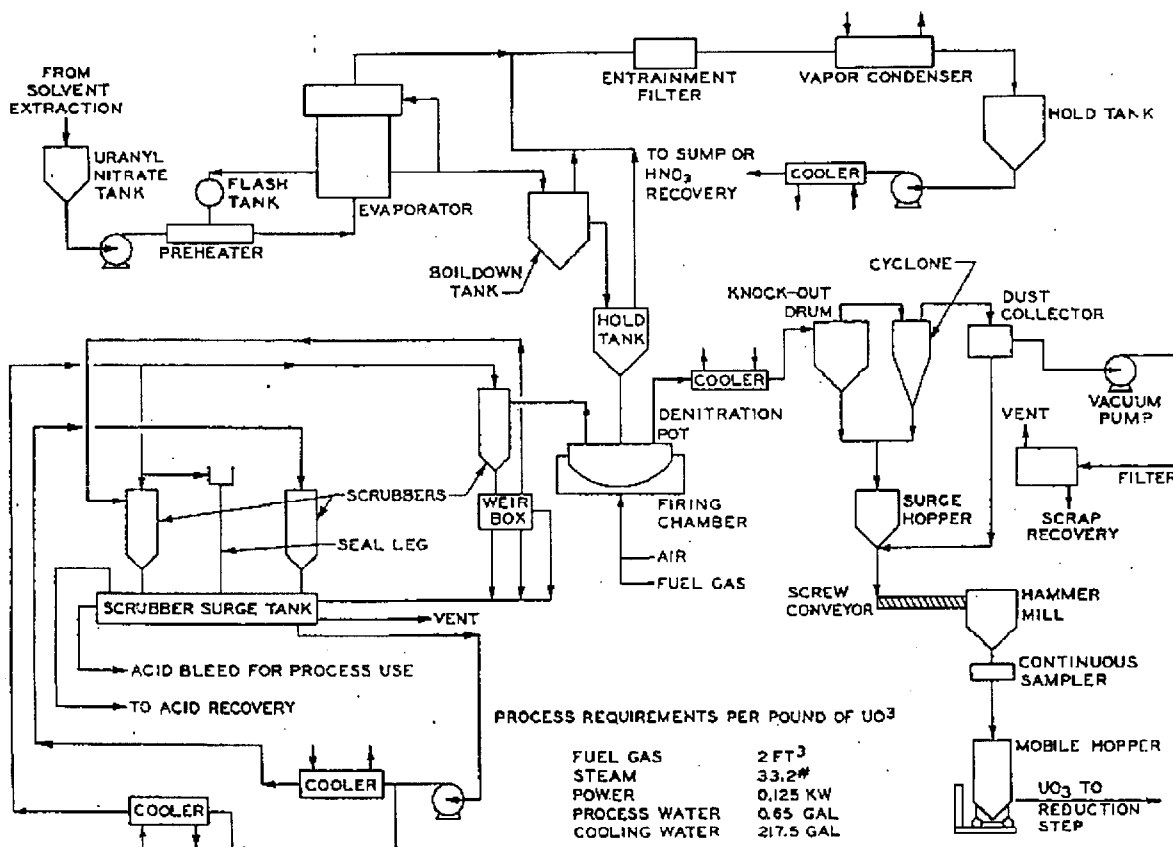


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## 2.2.4.2 Material Flowsheet

The initial  $UO_3$  process operations utilized a batch calcination process involving 18 stirred kettles, as shown in Figure 2-5. The concentrated UNH was initially heated in the stirred kettles until it was dry and then further heated until the UNH decomposed into  $UO_3$ . The nitric acid resulting from the drying and calcining processes was recovered and concentrated. The concentrated nitric acid was returned to the separation plants for reuse. The  $UO_3$  powder was removed from the kettles and pneumatically transferred into storage bins. The air used to transport the  $UO_3$  was filtered before discharge to the atmosphere. The condensate stream was sampled to verify compliance with existing regulations and discharged to the cribs. The  $UO_3$



**Figure 2-5  $UO_3$  Plant Process Diagram Involving Batch Pot Calciners**

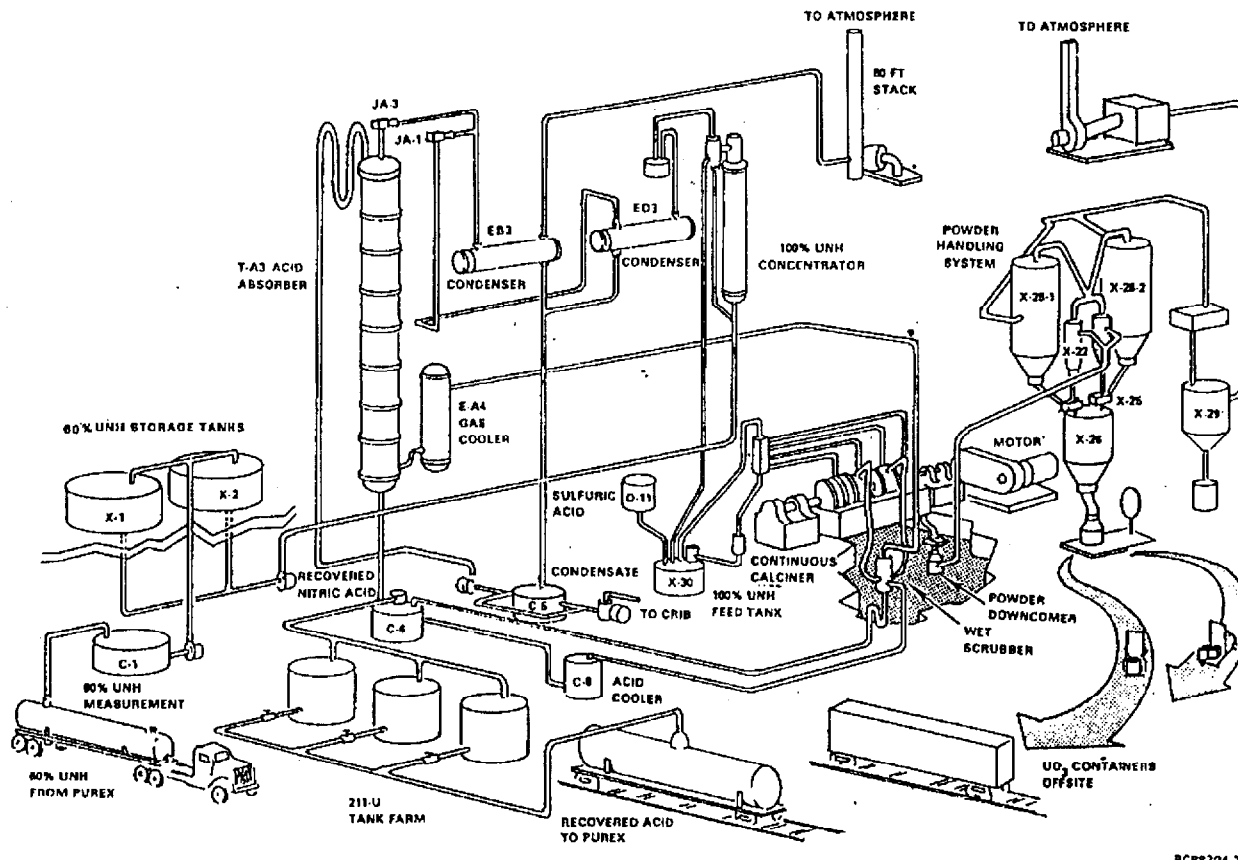
product was sampled and tested to assure compliance with product specifications. At times, the powder was ground to a specific particle size to meet chemical reactivity specifications. Sulfuric acid was added to the UNH to control the hydrofluorination reactivity of the  $UO_3$  powder at the gaseous diffusion plants. Off-specification  $UO_3$

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powder was either blended with acceptable  $UO_3$  product to bring the impurities to within specification requirements, or waivers were obtained before shipment.

In 1956, the 18 kettle calciners were replaced with 6 stirred continuous calciners as shown in Figure 2-6 to improve the product quality and increase the production rate. In addition, an evaporator further concentrated the UNH feed solution from the separation plants to allow more effective calcination. The concentrated UNH was sprayed on a heated  $UO_3$  powder bed in the continuous calciners. The UNH quickly dried, decomposed and was calcined to  $UO_3$  powder. The  $UO_3$  product overflowed the calciner and was pneumatically transferred to the holding bins pending acceptance testing and subsequent packaging into T-hoppers or drums. Nitric acid driven off in the calcination process was recovered and returned to the separation plants for reuse.

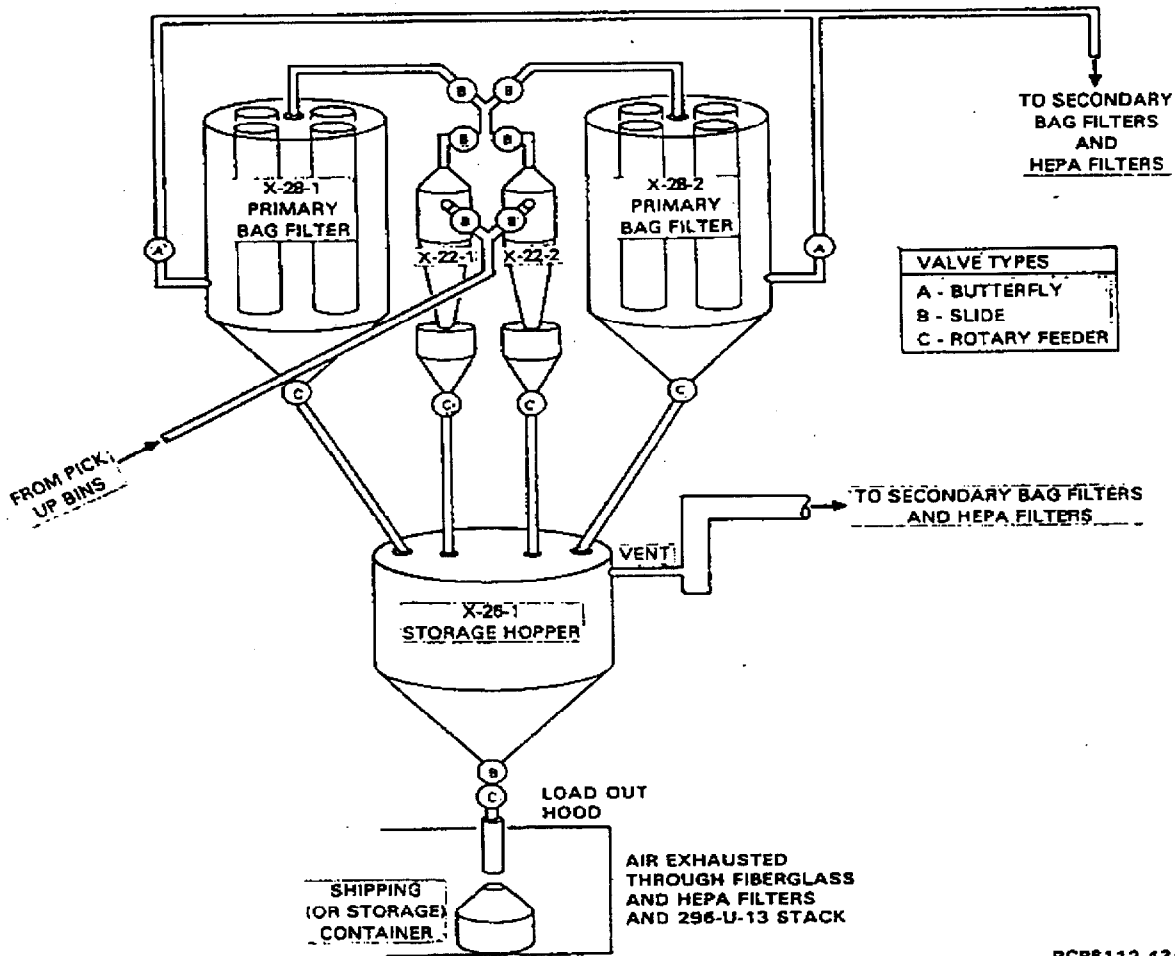


**Figure 2-6  $UO_3$  Plant Process Diagram Involving Continuous Calciners**

During the time when  $UO_3$  Plant operated with continuous calciners, the product loadout system was configured approximately as shown in Figure 2-7. Powder in the pickup bin was fluidized and transported to cyclone separators on the fourth floor of the 224-UA tower. The heavy powder dropped out of the cyclone into the storage hopper. The remaining air and powder fines were filtered on primary bag filters, secondary filter

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**Figure 2-7 UO<sub>3</sub> Product Loadout System**

bags, and then on high efficiency particulate air (HEPA) filters, which were added during the 1972 to 1984 shutdown time period. The powder was sampled for acceptance testing [Gustavson 1950].

Acceptable powder in the storage hopper was loaded into approved containers in the 224-UA loadout room. A forklift transported these containers to the 2714-U storage area. From this area, the UO<sub>3</sub> powder was shipped offsite by railcar or truck.

Of all Hanford uranium recycle activities, operation of the UO<sub>3</sub> Plant presented one of the greatest potentials for worker inhalation exposure to uranium and its contaminants because the product was a powder. In this facility, liquid uranium solutions were converted into dry UO<sub>3</sub> powder in ventilated batch kettles or continuous calciners. The calciners were ventilated to recover the nitric acid produced during calcination for reuse. The dry powder was handled pneumatically to minimize worker exposure. Packaging of the UO<sub>3</sub> into drums and T-Hoppers and maintenance on calciners and off-gas filters

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offered the highest potential for exposure to airborne powder. The transfer operation was performed within a ventilated enclosure to assist in dust control.

More detailed information on the UO<sub>3</sub> Plant is provided in Appendix G.

### 2.2.4.3 Feed Specifications

Feed specifications for the initial operation of the UO<sub>3</sub> Plant are provided in the "Uranium Recovery Technical Manual" [HW-19140 1951]. This specification indicates that the product material from REDOX and U-Plant was tightly controlled, as the UO<sub>3</sub> process provided no further purification of the uranium. The need for process control was recognized in the late 1940s and early 1950s before the plant came on line. The need to maintain the plutonium contamination to very low concentrations was recognized and included in the technical manual. Decisions were made in the late 1940s [Peterson 1947] to enrich the depleted uranium back to normal concentrations. Discussions followed regarding "firm specifications" for the final uranium product to be delivered [Greninger 1950].

The separation plants were originally designed on the basis that the recovered uranium would be sufficiently decontaminated with respect to Pu and gross beta and gamma radiation to permit essentially direct physical handling of the final product in its last form at Hanford. It was also recognized at this early stage that subsequent processing at other plants might result in fractionation or concentration of either fission products or of plutonium and cause a need for more highly specific or greater decontamination than would be required at Hanford. In a 1951 letter [Gamertsfelder 1951], it is stated that "...reclaimed uranium should contain no more than one part plutonium in  $7.8 \times 10^6$  parts uranium." in order that the hazard due to breathing air contaminated with reclaimed uranium should be no more than 10% greater than for ordinary uranium.

### 2.2.4.4 Product Specifications:

A "tentative" UO<sub>3</sub> product specification was initially defined in the "REDOX Technical Manual" [HW-18700 1951]. This tentative specification established the following constituent limits:

- |  |   |
|--|---|
| • Beta Activity from Fission Products  | Not more than 30% of beta activity of natural uranium   |
| • Gamma Activity from Fission Products | Not more than 300% of gamma activity of natural uranium |
| • UO <sub>3</sub> Purity               | 97% minimum   |
| • Plutonium                            | 100 parts per billion parts of uranium                  |

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Negotiations continued on UO<sub>3</sub> specifications in 1952, when preliminary specifications were considered which indicated a desired maximum plutonium concentration of 10 ppbp uranium [Hurd 1952]. In 1953, based on operating experience, representatives from Hanford and Oak Ridge agreed upon the properties of the Hanford UO<sub>3</sub> to be included in a firm specification [Smith 1953]. These properties included fission product activity, plutonium content, purity (UO<sub>3</sub> content), particle size, and volatile impurity content, and specified that "The maximum acceptable plutonium concentration shall be ten parts of plutonium per billion parts of uranium. Plutonium shall be determined on each carload composite." The 1953 revised specification is given in [Smith 1953]. The new constituent levels were established as follows:

### Firm Specifications Properties:

- Gamma Activity - the average gamma activity for any ten consecutive carload shipments shall be 100% the gamma activity of aged natural uranium. Defined as follows: for the purpose of establishing the average acceptable gamma activity specification, shipments of uranium oxide to K-25 will be considered in designated blocks of ten consecutive carloads. The average acceptable gamma activity due to fission products for a block shall be 100% the gamma activity of aged natural uranium. For the purpose of establishing the maximum gamma activity specification, one carload of oxide shall be considered a unit. The maximum acceptable gamma activity, due to fission products, for a unit shall be 300% the gamma activity of aged natural uranium.
- Beta Activity - the maximum acceptable beta activity, due to fission products, shall be 100% the beta activity of aged natural uranium. Beta activity shall be determined on each carload composite.
- Plutonium Content - the maximum acceptable plutonium concentration shall be ten parts of plutonium per billion parts of uranium. Plutonium shall be determined on each carload composite.
- UO<sub>3</sub> Content - the minimum acceptable UO<sub>3</sub> content shall be 97%. The UO<sub>3</sub> content shall be determined on each lot of 8 drums.

During the operating history of UO<sub>3</sub> production, numerous changes were made to the product specification to better control specific isotopes contributing to beta-gamma exposure of workers. Figure 2-6 shows a copy from one of the early Hanford UO<sub>3</sub> product specifications, indicating an allowed maximum plutonium concentration of 10 ppbp uranium [Smith 1959]. A more complete discussion on specification development and compliance is provided in Section 4.

Product specifications were also discussed, but not adopted, for <sup>233</sup>U, <sup>232</sup>U, <sup>237</sup>Np, and <sup>99</sup>Tc. In 1962 [Judson 1962] it was proposed that the maximum concentration of <sup>233</sup>U be set at 90 ppm on a <sup>235</sup>U basis, and that <sup>232</sup>U be set at 110x10<sup>-4</sup> ppm on a <sup>235</sup>U

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HW-59136	
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<u>Analysis</u>	<u>Method Ref.</u>
<u>HW-24403</u>	
Sodium	1000.1, 769
Calcium	1000.1
Aluminum	1000.1
Iron	1000.1, 515.25
Chromium	1000.1, 341.1
Nickel	1000.1
Density, bulk	847.2
Density, packed	847.5
<b>3.22 Properties with Established Limits</b>	
<b>3.22.1 Gamma Activity</b>	
Gamma activity due to fission products shall be determined on each carload composite. For the purpose of setting the average acceptable gamma activity, shipments of uranium oxide will be considered in designated blocks of ten consecutive carloads. The average acceptable gamma activity due to fission products for a block shall not exceed 100 percent of the gamma activity for aged normal uranium. For the purpose of setting the maximum acceptable gamma activity specification, one carload shall be considered a unit. The maximum acceptable gamma activity for a unit, due to fission products, shall be 300 percent of the gamma activity of aged normal uranium.	
<b>3.22.2 Beta Activity</b>	
Beta activity due to fission products shall be determined on each carload composite. The maximum acceptable beta activity due to fission products shall be 100 percent of the beta activity of aged normal uranium.	
<b>3.22.3 Plutonium Content</b>	
Plutonium shall be determined on each carload composite. The maximum acceptable plutonium concentration shall be ten parts of plutonium per billion parts of uranium.	

**Figure 2-8 Copy Of Early UO<sub>3</sub> Product Specification**

basis. In 1971, it was recommended a Np specification of <1 ppm for a lot composite and <0.3 ppm on 10 lot composites [Elgert 1971]. And in 1982 a <sup>99</sup>Tc specification of 0.4 ppm was proposed [Miskho 1982]. At that time it was implied that there was a 400 ppm limit for <sup>99</sup>Tc, but it has never been part of the Hanford specifications for UO<sub>3</sub> product.

### 2.2.4.5 Operating History

The facility began test runs in January 1952, and was in full operation the following month. Thus, for the first time, a full cycle of uranium into and out of Hanford was completed. The first UO<sub>3</sub> calciners simply were large pots that heated the UNH in batches. During the initial operation of U-Plant, the UNH product resulted in UO<sub>3</sub> product which required additional purification to remove non-radioactive impurities. This material was shipped off-site for purification. By the end of 1953, however, process improvements in both the REDOX Plant and U-Plant resulted in UNH so pure that the UO<sub>3</sub> Plant product no longer had to be sent offsite for further purification. This UO<sub>3</sub> was able to be shipped and used directly at Oak Ridge.

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During 1954, UO<sub>3</sub> Plant capacity increased to 18 tons per day with the addition of two gas-fired calciners. Overall production in 1954 was limited, however, by the quantity of feed available from the REDOX and U-Plants. A key improvement that year was the use of vacuum cleaning techniques that enabled the plant to recover 90-95 percent of the oxide powder associated with failed filter bags.

During 1955, monthly UO<sub>3</sub> production averaged 106 percent that of 1954, while the unit costs per ton dropped to 92 percent those of the previous year. In 1956, equipment modifications, including new pot agitators, shafts, seals, bearings and supports, as well as new pot cover assemblies, off-gas systems, and gasketing were employed.

In the same time frame, plans went forward to construct the 224-UA Building, a major addition to the UO<sub>3</sub> Plant, with six large, new, continuous action calciners. These calciners were developed and designed at Hanford. They had large troughs with paddle agitators that turned and mixed the UNH/UO<sub>3</sub> bed throughout the process. The caking and clogging problems that had plagued the pots were obviated by the below-grade valving of the continuous calciners. The new valves used air to agitate the powder, and provided a seal between the calciner and the powder pickup bin, while passing a continuous stream of UO<sub>3</sub>.

The new calciners also produced a pebbly product that consisted of spheres with an average diameter of 200 microns (about 1/100th of an inch), as opposed to the granular oxide product of the pots. The first three continuous calciners began operation in the last quarter of 1956 at the same time specially designed T-Hoppers began to replace the 900 pound drums as shipping containers. The T-Hoppers left the site on specially fitted rail flat cars and served as feed hoppers for the Oak Ridge plant customer.

Installation of the last three of the continuous calciners was completed in early 1957. At that time, the 18 pot units were retired from service, and all processing was done through the continuous calciners. Late that year, design was initiated for new facilities which were needed to segregate regular UNH feed from that generated by the processing of enriched metal (E-Metal) in the REDOX Plant. The UO<sub>3</sub> powder that resulted from processing the two types of UNH streams had significantly different nuclear reactivity levels. It was necessary to maintain separation of these streams for the customer at Oak Ridge. Routine transfers of enriched UO<sub>3</sub> from Hanford to Oak Ridge began in early 1959.

In 1958, U-Plant finished its uranium recovery mission and was shut down. However, the quantity of PUREX Plant UNH product being shipped to the UO<sub>3</sub> Plant far surpassed that which had come from U-Plant. Together, the UO<sub>3</sub> and PUREX Plants went on to set and surpass production records almost continually, while the REDOX Plant continued to supply a small stream of enriched UNH until its shutdown in 1967.

During 1959, the concentration equipment and the acid recovery system at the UO<sub>3</sub> Plant were automated. In 1960, the calciners were also automated so that they could be operated and shut down remotely. In 1963, production of UO<sub>3</sub> shipped offsite rose to

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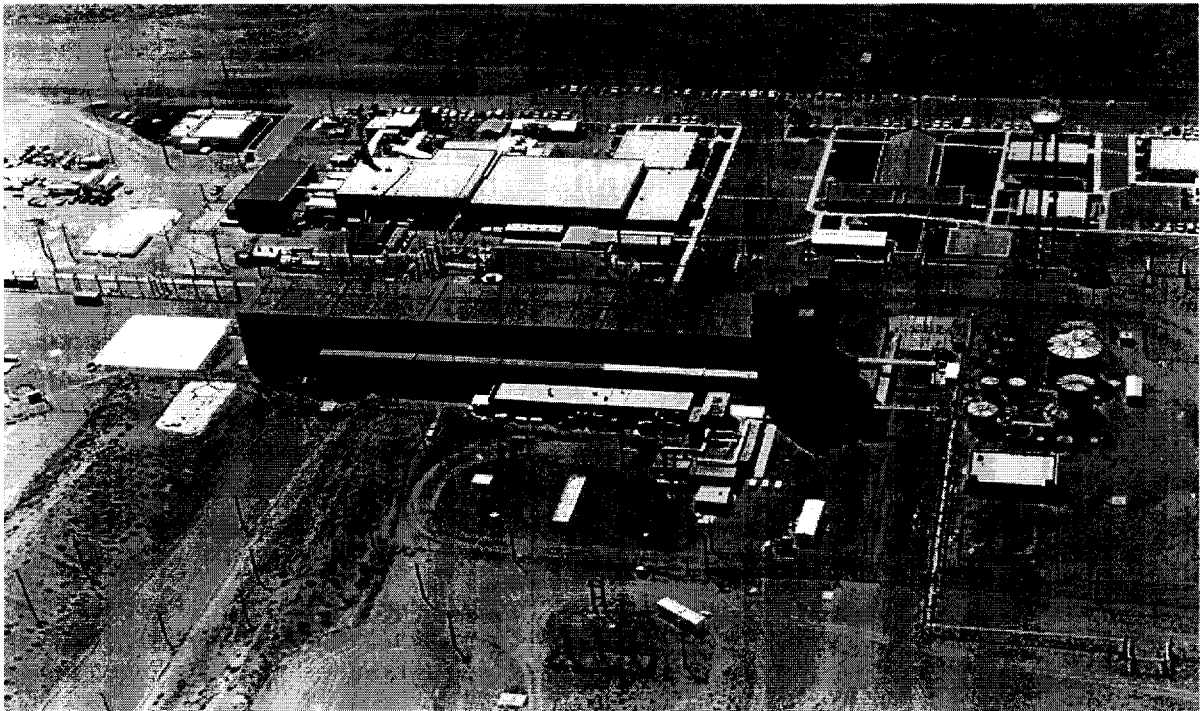
about 12,000 tons per year, and capability was added for processing UNH derived from processing metal enriched to 1.25%  $^{235}\text{U}$  (125 Metal).

Beginning in 1967,  $\text{UO}_3$  Plant operations were tied exclusively to those of the PUREX Plant. That year, UNH concentrator modifications in the  $\text{UO}_3$  Plant improved heat distribution and allowed the calciner feed to maintain a uniformly higher specific gravity, thus producing more powder in the same operating time. Both the  $\text{UO}_3$  and PUREX plants closed in 1972, and PUREX resumed operations in late 1983 -- closely followed by  $\text{UO}_3$  in early 1984 [Gerber 1996].

In the 1980s, approximately 2-3 campaigns were processed per year. A typical processing campaign was ~22 days at a rate of 34 MTU/day (70% of instantaneous rate). This process rate was based upon all 6 continuous calciners being used. Campaigns would range from 21-32 days.

### 2.2.4.6 Current Status

The  $\text{UO}_3$  Plant has been deactivated and is awaiting decontamination and decommissioning.



### 2.2.5 REDOX Plant

The REDOX separation plant was the second generation process facility designed to extract plutonium from irradiated uranium fuel. It recovered uranium as a co-product. It



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was the technological answer to the need to increase plutonium production and uranium recovery to satisfy growing national defense needs.

### 2.2.5.1 Plant Description

Experimentation and design for the REDOX (reduction oxidation) Plant began in 1947 with actual construction beginning in late 1949. The facility commenced operations in 1952. The building is 467 feet long by 161 feet wide by 82 feet high. At one end of the building is a "penthouse", 132 feet high, which housed the extraction columns. It is constructed of thick, steel-reinforced concrete. The processing of irradiated fuel was accomplished in nine below-grade, thickly shielded, concrete cells. Support facilities, including the 222-S laboratory, were constructed in the same time frame. Like the earlier T- and B-Plants, the process first dissolved the irradiated fuel cladding and then dissolved the uranium core. The plutonium was separated from the uranium in a continuous process utilizing methyl isobutyl ketone (hexone). The plant design-basis production rate was about 3 MT uranium per day [Gerber 1996].

### 2.2.5.2 Material Flowsheet

The REDOX process offered substantial improvement over the T- and B-Plant separation processes by employing continuous solvent extraction. Under specific conditions, plutonium and uranium were found to extract into hexone solvent, allowing separation from the fission products, which remained in aqueous solution. Figure 2-9 shows a simplified flow diagram of the process.

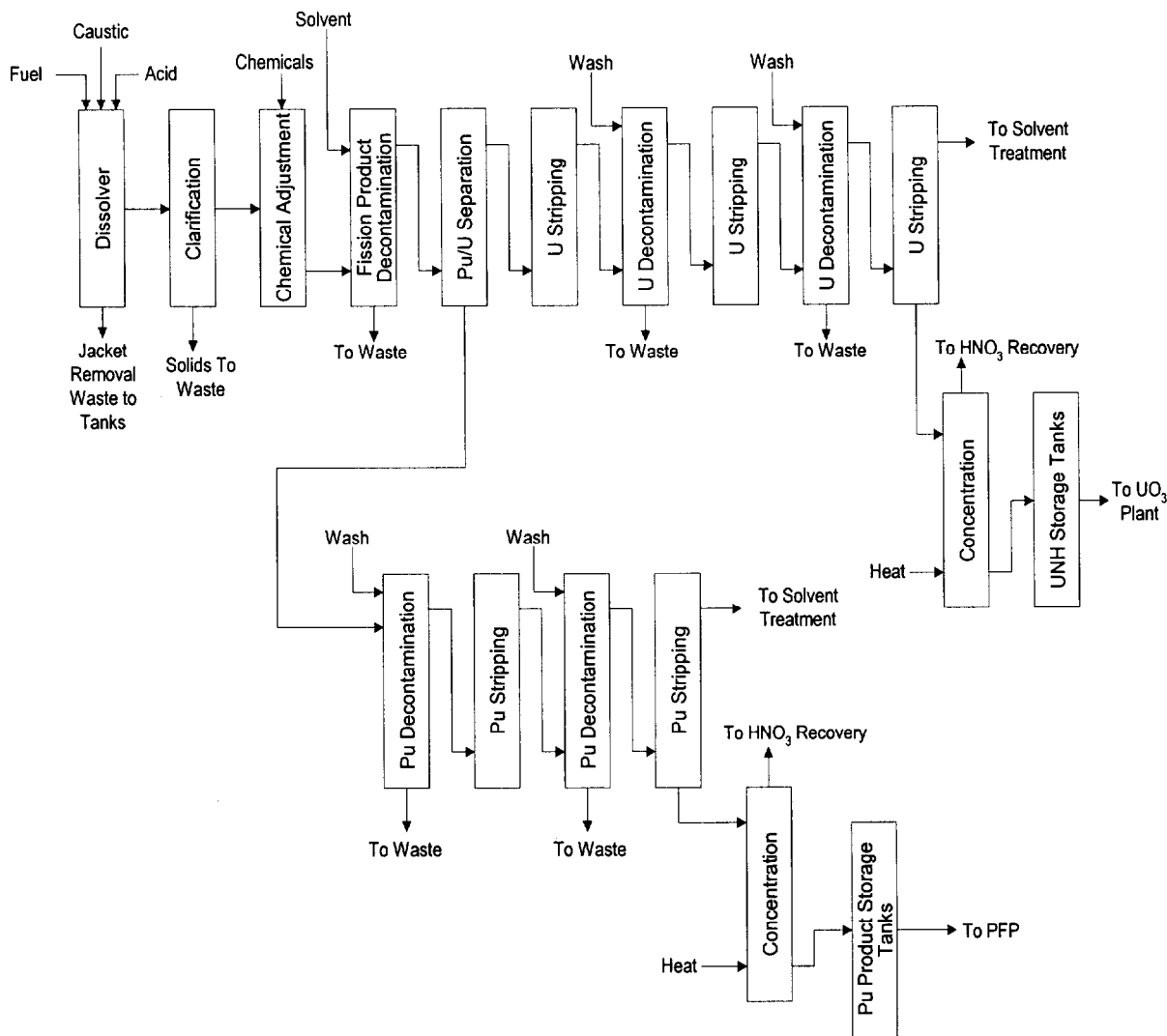
The irradiated reactor fuel was removed from the shipping cask and transferred to a dissolving tank to permit selective removal of the protective aluminum cladding using a caustic solution. The coating waste was neutralized and sent to underground waste tanks for storage. The bare irradiated uranium slugs in the dissolver tank were then reacted with nitric acid to dissolve the uranium and accompanying plutonium and fission products. The resulting uranium nitrate solution was first treated with sodium dichromate and sodium hydroxide to adjust the plutonium valence state and then was contacted with an acidic hexone solvent in a countercurrent extraction column.

The uranium and plutonium formed a complex with the acidified hexone and were separated from the fission products. The aqueous waste was neutralized, treated and transferred to the waste tanks for storage. The plutonium/uranium/hexone complex was treated again to adjust the plutonium and uranium valences to permit separation of the plutonium from the uranium in the next countercurrent extraction column, where the plutonium was stripped from the hexone complex into a nitric acid solution. The uranium/hexone solution was further treated and the uranium removed by a nitric acid wash. Once the separation had been completed, the uranium and plutonium streams were separately treated in two more similar extraction/separation steps through countercurrent extraction columns to further remove impurities and provide product nitrate solutions meeting stringent impurity specifications. Off-specification product

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solutions were sent back into the extraction process for rework. The hexone solvent was washed, neutralized and re-distilled for recycle into the extraction process



**Figure 2-9 REDOX Process Flow Diagram (Simplified)**

### 2.2.5.3 Feed Specifications

The irradiated fuel was aged before processing to eliminate some of the fast decay fission products and to assure that the product beta and gamma radiation limits were met.

### 2.2.5.4 Product Specifications

The uranium product specifications were driven by the UO<sub>3</sub> product specification requirements. The UO<sub>3</sub> Plant processing of UNH product from REDOX, did not further

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refine the uranium, thus the feed UNH from REDOX had to meet the final  $UO_3$  product specification limits. The plutonium content of three trial lots of  $UO_3$  prepared from material processed through the REDOX Plant in 1952 was less than 5 parts per billion parts (ppbp) uranium [Richards 1952]. It was also reported in June 1952 that the average plutonium concentration in REDOX recovered uranium was less than 1 ppb [HW-24605 1952].

### 2.2.5.5 Operating History

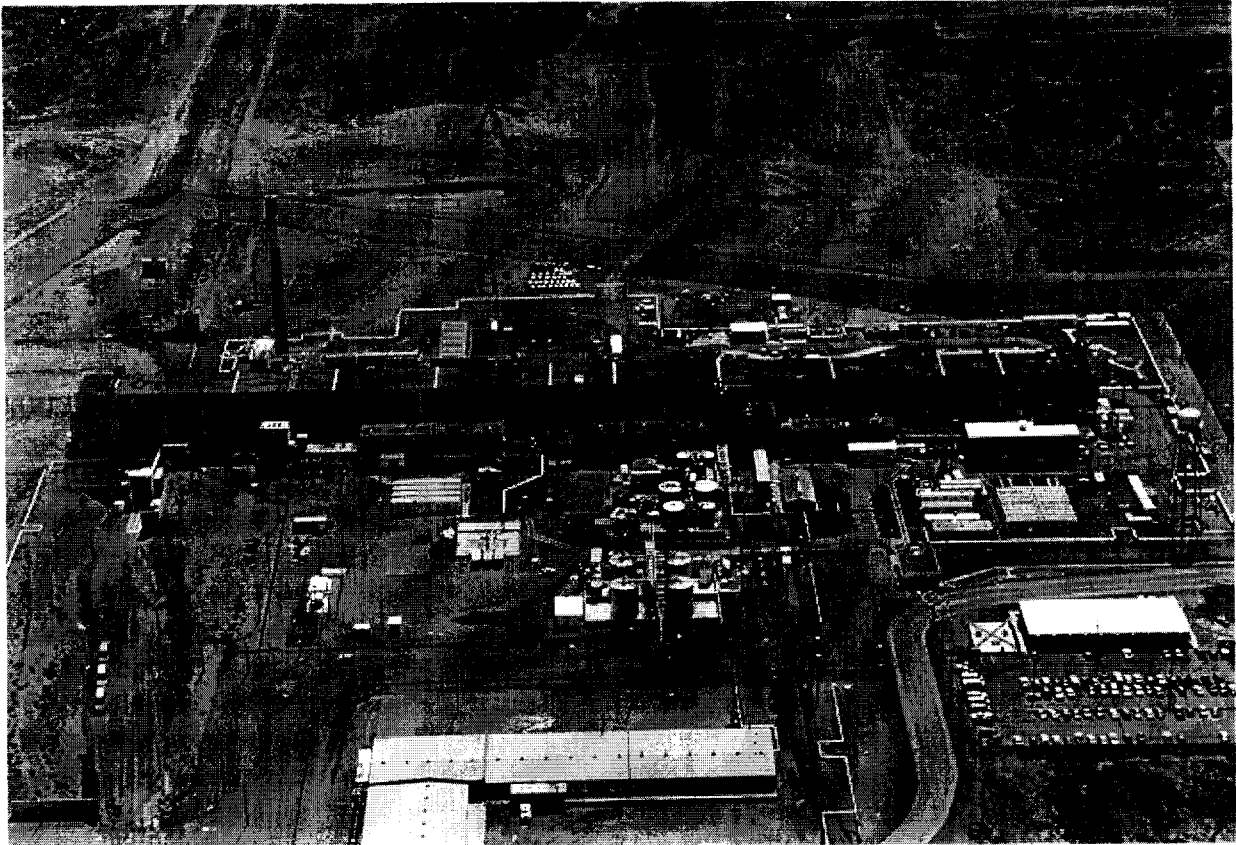
The REDOX plant commenced "hot" operations in January 1952. By April 1952 the plant achieved its design rate production throughput. At the end of 1952 the plant had exceeded its throughput rate by 50% for several months. A series of three "Capacity Increase" projects began in 1953 with the result that the production throughput rate being increased by a factor of 2-3 times that achieved in 1953. By the end of 1954 the throughput rate reached 8 tons per day. Additional improvements brought the throughput rate to 11-12 tons per day by 1958. Part of the capacity increases included construction of the 233-S Plutonium Concentration Building. Completed in 1957, this building carried out the third and final plutonium concentration cycle. Processing of enriched irradiated fuel assemblies (E-metal) began at REDOX in 1958. E-metal throughput initially was limited to 3 tons per day due to criticality considerations in the plant. After installation of multipurpose annular dissolvers and other process improvements, the plant throughput rate reached 12 tons per day for enriched fuel. The REDOX Plant operated until 1967 when it was shut down [Gerber 1996].

### 2.2.5.6 Current Status

The REDOX Plant is shut down and awaiting decontamination and decommissioning. The 222-S laboratory is currently in operation supporting waste management and environmental control processes.

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### 2.2.6 PUREX Plant

The PUREX Plant was designed to utilize a third generation separation process to extract plutonium from irradiated uranium fuel. It utilized tributyl phosphate in a continuous separations process to isolate and refine both plutonium and uranium.

#### 2.2.6.1 Plant Description

The PUREX Plant, Building 202-A, as originally built, was a concrete rectangle 1,005 feet long, 104 feet high (with approximately 40 of those feet below grade), and 61.5 feet wide. The shielding capacity of the concrete was designed such that personnel in non-regulated service areas would not receive radiation in excess of 0.1 millirem per hour (mr/hr). The main "canyon" portion, is ~860 feet long and contains twelve major shielded process cells that are 14 feet wide, of varied lengths, and 42.5 feet deep (including the three foot thick cover blocks). Adjoining the north wall of the main 202-A building was a 750-foot long, 60-foot wide service area. It contained three control rooms (central, head end, and power unit), the PUREX process control laboratory, the aqueous make-up and storage area, and the acid concentration vault. An underground solvent storage and make-up facility was located adjacent to the service side of the 202-A Building. Other design features in the PUREX Plant included: (1) an irradiated fuel element storage basin, (2) a railroad tunnel designed to permit unloading of

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contaminated cask cars without compromising the ventilation system, and (3) a "soft wall" at the east end of the building that consisted of concrete blocks. These blocks could be removed for the installation of an additional crane, or to enlarge the building at some future date [Gerber 1996].

### 2.2.6.2 Material Flowsheet

PUREX operated under a number of different flowsheets that were the result of process and equipment improvements and changing reactor fuel compositions. Additionally, some campaigns involved neptunium and the processing of thorium based reactor fuels. A typical process flow diagram for PUREX processing of N-Reactor irradiated fuel is shown in Figure 2-10. Not shown on this diagram is the Plutonium Oxide Production and Rework Facilities that were added in the PUREX N-cell in the early 1980s. This process allowed conversion of recovered plutonium nitrate to plutonium oxide without having to send the solution to the PFP for conversion to the oxide.

The PUREX process was the next generation separations process. It utilized tributyl phosphate (TBP) to complex with plutonium and uranium under specific conditions and to cleanly separate the uranium and plutonium. The irradiated reactor fuel elements were removed from the storage basin and transferred into three dissolvers. The aluminum cladding was dissolved from the uranium fuel rod with sodium hydroxide. The cladding waste solution was treated to meet waste tank corrosion specifications and transferred to the waste tanks.

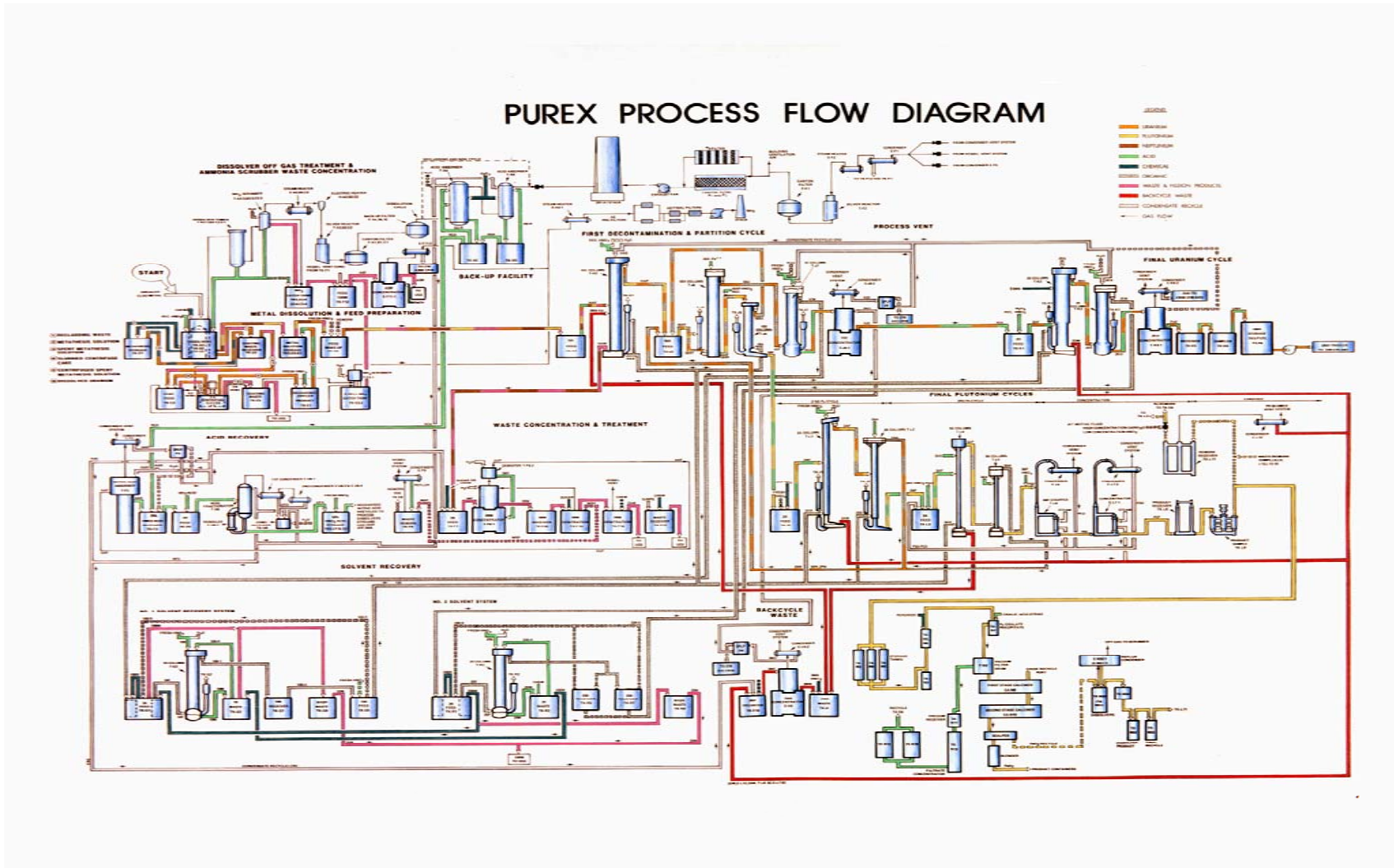
The PUREX Plant also processed zirconium clad fuel, which required the use of an ammonium fluoride and ammonium nitrate decladding solution at near boiling conditions. The zirconium-containing decladding waste from the dissolvers was centrifuged and treated to meet Tank Farm waste solution corrosion specifications. The centrifuged solids contained recoverable amounts of uranium and were accumulated and subsequently treated for uranium and plutonium recovery. Next, nitric acid was added in two increments to the dissolvers to dissolve the uranium, plutonium, and fission products into a solution that permitted transfer and separation. The dissolvers were maintained at elevated temperature to facilitate fuel dissolution.

Once the uranium and plutonium and fission products were dissolved, the solution was fed continuously into a pulsed extraction column where the uranium, neptunium, and plutonium were stripped away from the nitric acid solution into a normal-paraffin-hydrocarbon (NPH) solvent containing TBP. The fission products remained in the aqueous solution and were discarded after treatment to the waste tanks. The decontaminated solution of uranium, neptunium and plutonium in the TBP complex was next pumped through a second pulse column where the plutonium was selectively stripped out of the NPH/TBP complex into an aqueous nitric acid solution.

The NPH/TBP complex containing uranium and neptunium was sent to the next pulse column where the uranium and neptunium were stripped from the TBP complex using a weak aqueous nitric acid solution. The uranium/neptunium solution went to the

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**Figure 2-10 PUREX Process Flow Diagram**  
(excluding the Plutonium Production and Rework Facilities)

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evaporator for concentration before entering the final uranium cycle. The concentrated uranium/neptunium solution was routed to a feed tank for acid adjustment before entering a pulsed stripping column where the uranium/neptunium solution was contacted with NPH/TBP solution. In this column, the uranium was selectively extracted into the NPH/TBP while the neptunium remained with the aqueous flow. The NPH/TBP/uranium complex was then sent to another column for stripping uranium into an aqueous solution which was subsequently concentrated in an evaporator and, after sampling, transferred to the  $\text{UO}_3$  feed tank.

The plutonium stream from the second pulsed column was sent to the second and third plutonium cycle extraction columns where it was contacted with NPH/TBP solution repeatedly to remove any residual fission products and trace uranium. Following the completion of the two cleaning cycles the plutonium solution was concentrated to meet product specifications.

Product solutions not meeting specification were recycled back through the process for cleanup. If needed, waste solutions from the columns were scavenged for uranium, plutonium and neptunium before treatment to meet waste tank acceptance criteria. The used NPH/TBP solutions were treated to remove impurities, re-acidified and returned to the process. Nitric acid off-gasses were recovered, concentrated into nitric acid, and returned to the process.

### 2.2.6.3 Feed Specifications

PUREX feed specifications were driven by the type of reactor fuel that was to be recovered for its plutonium content. The process was flexible and permitted feeds of different enrichment. Criticality control of the fuel dissolution process drove the size and configuration of the plant dissolvers. PUREX processed irradiated fuel initially containing up to 2.1%  $^{235}\text{U}$ .

### 2.2.6.4 Product Specifications

The plutonium and uranium product compositions were derived from the feed requirements imposed by the  $\text{UO}_3$  Plant and the Plutonium Finishing Plant (PFP). A typical specification for the UNH product solution is shown in Figure 2-11. For additional information on specification development, see Section 4.

### 2.2.6.5 Operating History

The PUREX Plant was originally designed to process up to 200 MT of irradiated uranium per month. It achieved this rate and higher over the years it operated. In 1956 alone, the PUREX plant processed 56 percent of the annual plutonium output of Hanford for that year, which was 59% above that of 1955. In September 1956, PUREX demonstrated a sustained, instantaneous rate of 16 MTU/day of irradiated uranium and an on-line efficiency of 99 percent. The following year, the total output of plutonium from Hanford increased by 54 percent over that of 1956, with PUREX processing 71



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percent of this new total. The plant demonstrated an instantaneous production rate of 20 MTU/day, with a reduction in the amount of residual fission product activity in the product of 25 fold below design specifications in 1957.

108	HW-31000
In terms of a Purex-Plant uranium product for inter-area shipment, the following approximate specifications should be met:	
Pu	≤ 10 parts per billion parts of uranium
Gamma activity due to fission-products	≤ 200% of aged natural uranium
Beta activity due to fission-products	≤ 200% of aged natural uranium
Total metallic impurities (T.M.I.)	≤ 200 parts per million parts of uranium
<u>Note:</u> The fission-product specification for inter-area shipment is dependent upon the individual fission products present in the uranium product. If, as is expected, Pu constitutes a substantial fraction of the activity, it is permissible to exceed the final UO <sub>2</sub> specification since Pu is largely volatilized in the calcination of uranyl nitrate to the oxide.	
<u>C. PRINCIPLES AND OUTLINE OF THE PUREX PROCESS</u>	
The Purex process is designed to separate uranium and plutonium from each other and from the fission products with which they are associated in irradiated slugs. The process is one of solvent extraction, in which the components are separated from one another by controlling their relative phase distribution between aqueous solutions and an immiscible organic solvent, tributyl phosphate dissolved in a hydrocarbon diluent. In the following subsections the basic principles of the process are briefly described and the several steps which make up the process are outlined. This section is intended only as an introduction to the process, more complete information being contained in Part II (Chapters II through X).	
1. <u>Basic Principles</u>	
1.1 <u>Properties of uranium of process importance</u>	
The Purex process utilizes the preferential extractability of uranyl nitrate by tributyl phosphate to separate uranium from plutonium and the fission-product elements.	
Metallic uranium is soluble in nitric acid to form an aqueous solution of UO <sub>2</sub> (NO <sub>3</sub> ) <sub>2</sub> ·xH <sub>2</sub> O. A rapid dissolution rate of the metal in nitric acid is favored by a high concentration of acid, and elevated temperature.	

Figure 2-11 Example of PUREX Product Specification

In 1958, the decision was made to send virtually all of the standard irradiated uranium from the 100 Areas production reactors to PUREX, and to divert processing of enriched uranium containing 0.9475 wt% <sup>235</sup>U ("94 Metal") to the REDOX plant. REDOX equipment was reconfigured and handling techniques were changed to accommodate the higher enrichment levels of the 94 Metal. Additionally in 1958, the PUREX facility began the recovery of neptunium (<sup>237</sup>Np) on an occasional batch basis from its normal product stream. The plant became the AEC's prime supplier of this isotope. For short periods of time, PUREX demonstrated the capacity to operate at 3.6 times its original

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design capacity. In late 1965, other PUREX systems were modified to allow the plant to sustain normal operations at a 4.0 capacity factor, or 33 MTU/day [Gerber 1996].

Beginning in 1963, the PUREX plant was modified to allow for the processing of various fuel types, including fuel from N-Reactor with elements much larger than the four to eight inch long "slugs" from Hanford's single pass reactors. In 1967, the REDOX plant closed, and PUREX became the sole, operating separations facility at Hanford. In 1972, the PUREX plant entered a temporary shutdown period that lasted for 11 years. All of Hanford's single-pass reactors had closed, and most of the available (aged) N-Reactor fuel had been processed. The initial PUREX shutdown was planned for 18 months, to allow the accumulation of N-Reactor fuel. During the shutdown period, other issues arose, including environmental concerns that led to providing upgraded filtration systems, seismic safeguards, backup power sources and many other projects. Increased safety concerns about shipping plutonium in nitrate form from PUREX in the 200-E Area to the Plutonium Finishing Plant in the 200-W Area, led to an additional delay. The shutdown period was extended while facilities were added within the PUREX plant to convert plutonium nitrate to plutonium oxide.

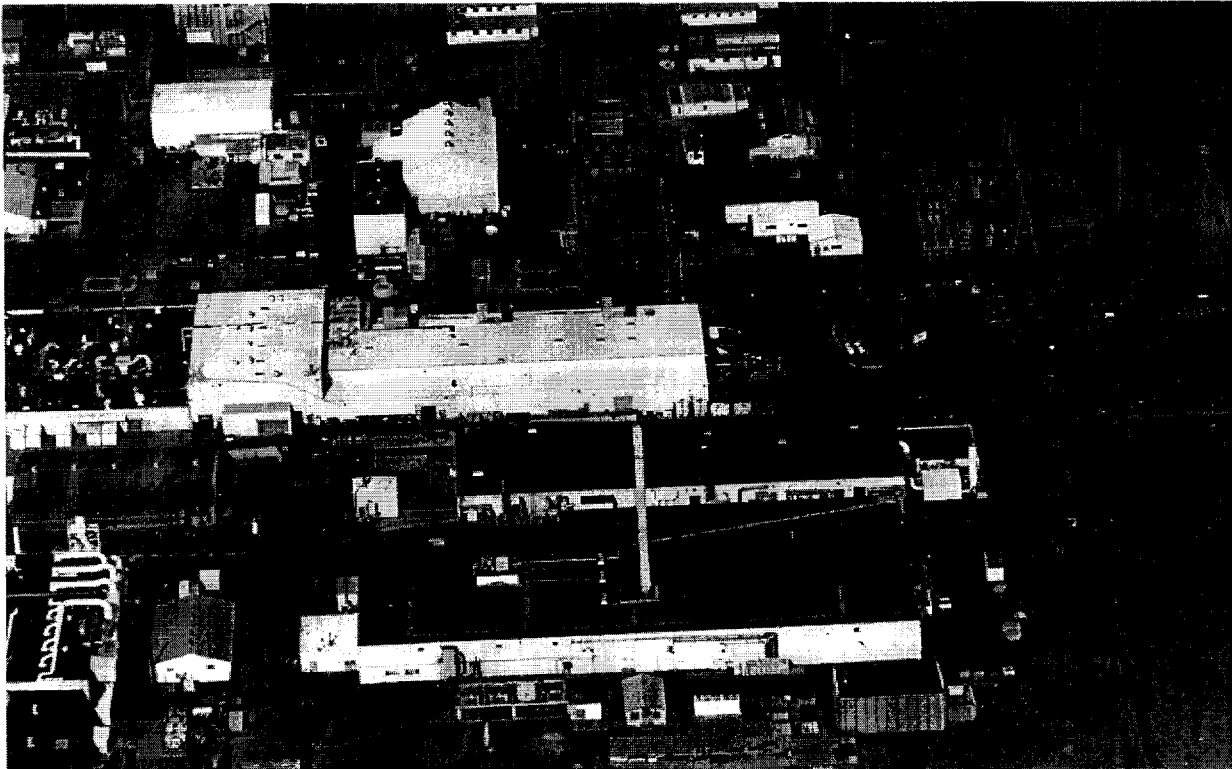
In 1983, the PUREX plant reopened with an operating limit allowing it to process up to 3,000 MTU/year of N-Reactor fuel, or about eight MTU/day. However, the highest sustained (but short-term) production rates in the ensuing years hovered near seven MTU/day, and the highest long-term rates were about three MTU/day. The PUREX facility closed for about six weeks in 1988, for a safety issue, and again for a year beginning in December 1988, after steam pressures briefly fell below levels necessary to support back-up safety equipment. Additional equipment repairs and improvements to waste handling systems also occurred during that closure period. After a stabilization run lasting only a few weeks, the plant again closed in early 1990 in order to prepare additional environmental and safety documentation and facility upgrades. In total, PUREX processed approximately 69 percent of all the irradiated fuel produced at Hanford. In October of that year, the PUREX Plant was placed on standby status by the Secretary of Energy, James Watkins. A final closure order was issued by the DOE in December 1992 [Gerber 1996].

### 2.2.6.6 Current Status

The PUREX Plant has been deactivated and is awaiting final disposition.

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### 2.2.7 Fuel Fabrication Complex

The Fuel Fabrication Complex in the 300 Area occupies approximately 3.9 square kilometers (1.5 square miles) or 390 hectares (960 acres) in the southeastern portion of the Hanford Site along the west bank of the Columbia River, approximately 12 kilometers (7 ½ miles) north of the center of Richland.

#### 2.2.7.1 Facility Description

In March 1943, construction of a fuel fabrication complex was started in the 300 Area to support reactor fuel fabrication and other production activities. The first major building was available in autumn of 1943 and housed Hanford's first step in the plutonium production process. Since the 300 Area's fuel fabrication activities were the least likely of the production processes to experience a serious accident, it was considered safe to locate it near populated areas (Richland). An early aerial photograph of the 300 area is provided in Figure 2-12.

Nuclear fuel in the form of solid, rod-like cylinders (fuel slugs) was fabricated from metallic uranium received from off-site production facilities. These fuel fabrication activities consisted of foundry and machining operations to convert uranium metal feed into finished fuel elements.

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**Figure 2-12 Early Photograph of Fuel Fabrication Facilities In The 300 Area (Circa 1945)**

Initial fuel fabrication activities (1943 through early 1960s) only involved fuel for Hanford's single pass reactors. This fuel-making process was known as the "triple-dip" process. This work took place in two buildings in the 300 Area, known as the 313 Metal Fabrication Building and the 314 Press Building (also known as the Metal Extrusion Building). These were built to perform the fuel fabrication and canning tasks.

The 313 Building contained numerous electrical furnaces and metal presses; three fuel canning areas; a welding area; a can cleaning area; a control room; various supply tanks; a tool room and shop; and various offices, storerooms, and rest rooms. During its operating life, eight major modifications were made adding space required to meet changing needs.

The 314 Press Building enclosed about 17,000 square feet. It contained a 1,000-ton extrusion press, electric furnaces, a rod-straightening machine, a 7.5-ton overhead crane, an autoclave area, a control room, a shop and repair area, pumping units for the press, and various offices and sanitary rest rooms.

The co-extrusion process utilized in the fabrication of N-Reactor fuel was carried out in the 333 Fuels Manufacturing Building, which was constructed of steel frame with double metal insulated panel exterior walls and lightweight metal panels for interior partitions.

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The foundation and floors were poured concrete. The roof consisted of insulated metal paneling covered with felt and roll tarpaper and a tar and gravel surface. The structure was 300 feet by 140 feet, with a total area of 48,817 square feet. In 1980, in response to anticipated increases in production, a small addition was placed on the northwest corner of the 333 Building. It consisted of two stories; the ground level for an open bay shop and the second story for offices. The addition was 33 feet by 104 feet, and extended from the HVAC (heating, cooling and ventilating) supply units on the west side of the building to the north exterior wall.

The co-extrusion process was carried out with various equipment pieces, but the most prominent and unique of these was a Loewy Press that actually pressed all of the fuel components (U core and all of the cladding components) together in one unit. Each N-Reactor fuel element was 26 inches long, weighed approximately 52 pounds and had a tube-in-tube configuration with a coolant channel running down the entire length of the element. Projections also were welded onto each element, as the N-Reactor process tubes were smooth or "ribless." The co-extrusion process provided a better, more uniform bond between core and jacket than had been possible with older methods based on dipping. The new method was beneficial in smoothly cladding the inner and outer tubes.

### 2.2.7.2 Material Flowsheet

The basic process flow for fuel element preparation for the single pass reactors was to receive and inspect uranium billets from offsite for visual flaws and correct dimensions. Then a sample was irradiated in the 305 Building test reactor. If the reactor tests were acceptable, the lot was accepted and entered the manufacturing process. In the 314 Building, uranium billets were heated in a muffle-type furnace with an interior, inert gas atmosphere. The inert atmosphere, which involved either helium or argon, was used to reduce the oxidation of metal during heating. The uranium was then transferred through a closed passageway to the extrusion press, which also operated in an inert atmosphere. After being extruded, the rods were out-gassed, straightened, and sent to the 313 Building for machining and jacketing. In the 313 Building, uranium fuel rods were machined into fuel cores in lengths of either 4 inches or 8 inches, with 1.3-inch diameters. Known as "slugs," these cores were "canned" or jacketed into finished elements, and then tested and inspected in this building. This jacketed fuel was then sent to the 314 Building for autoclave and radiographic inspection. Figure 2-13 illustrates the fuel fabrication process for the single pass reactors.

Additional fuel fabrication activities were initiated in the early 1960s for the fabrication of N-Reactor fuel. This process, illustrated in Figure 2-14, is significantly different than single pass reactor fuel process. The fuel was larger in diameter, longer, and consisted of two fuel elements, one within the other. It also had a centered annulus that was created by the co-extrusion tube-in-tube process. The two sizes were made, tested and then assembled to form a finished fuel rod.

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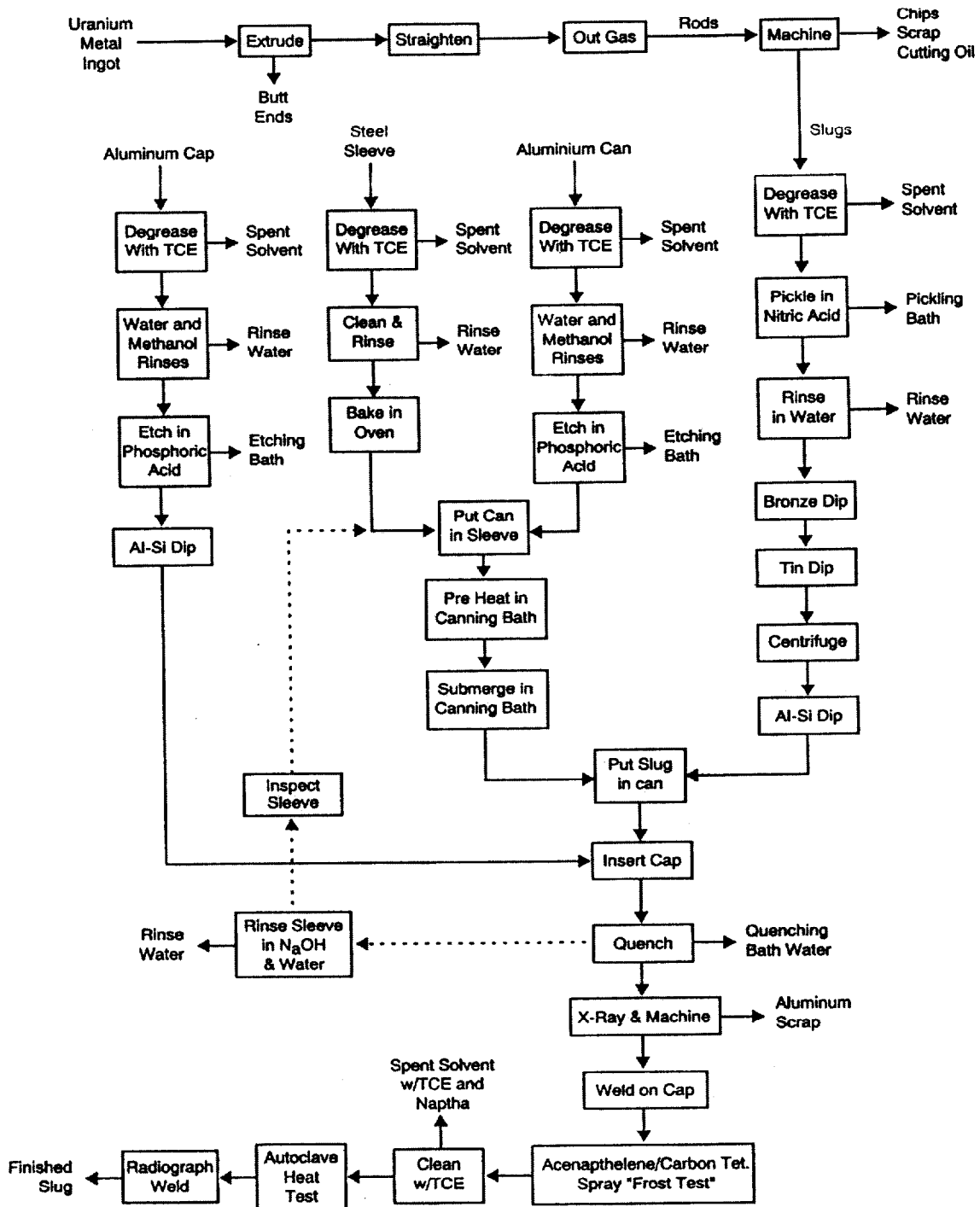


Figure 2-13 Fuel Fabrication Process for Single-Pass Reactors.

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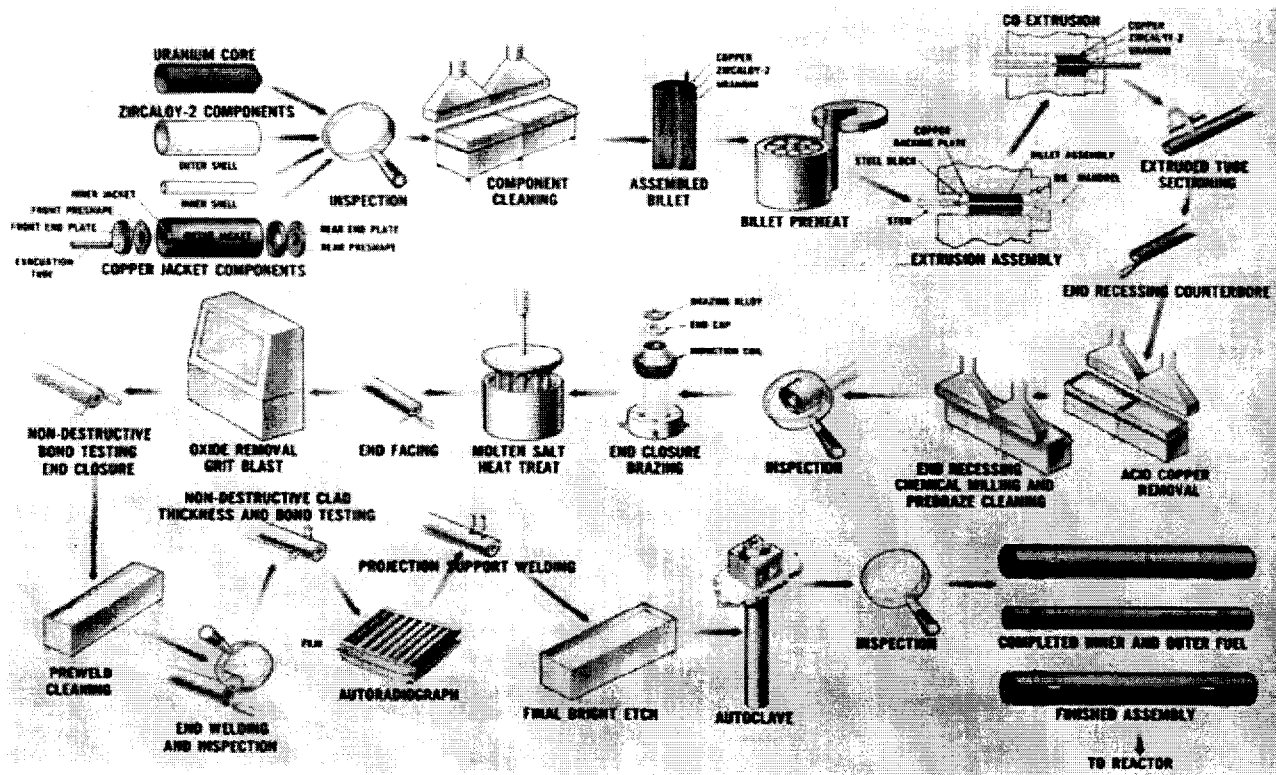


Figure 2-14 N-Reactor Fuel Fabrication Process

More detailed information on past fuel fabrication processes and activities at Hanford can be found in Appendix F.

Over the years, several other ancillary or off-shoot processes have taken place in the 313 and 314 Buildings. Among these have been uranium scrap recovery operations, experimental and/or small-scale fuel making ventures, and waste treatment activities. From its earliest days, concern of the Manhattan Engineer District (MED) about the adequacy of uranium supplies brought strict policies that mandated the reclamation of all possible uranium scraps at federal atomic sites. During the earliest fuel fabrication operations (1943 to mid 1944) at Hanford, difficulties with early fuel canning techniques produced thousands of rejected cores and other scraps, including lathe turnings and metal oxides that formed when canned slugs failed in autoclave tests. In June of 1944, Du Pont reported that "all available space" around the 313 and 314 Buildings was filled with cans of scrap, and the fabrication area fence had to be moved about 30 feet east of the fresh fuel storage building 303-J to allow for more storage space. In addition, beginning with the startup of extrusion press tests in January 1945, extrusion butt ends, oxides, and container residues collected, along with acids from the slug pickling process and from the slug recovery process were generated.

At first, the various types of scrap were shipped to offsite reclamation processing centers. By 1946, the accumulating volume of uranium scraps brought a change in policy at Hanford. This change was the result of scrap storage expense and risks associated with potential fire and security hazards during shipment. Consequently, a

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"chip recovery" operation began in the 314 Building to process scrap. It operated only a few days a month and involved collecting all chips and turnings from machining operations, sorting them, breaking them into small pieces, washing, drying, and then pressing them into briquettes. At first, the briquettes themselves were shipped offsite. In May, however, the MED ordered briquetting to be discontinued due to a number of uranium chip fires within the centrifuging step at other sites.

A "melt plant" was established in the 314 Building in late 1947. In that process, uranium scrap could be recovered as metal for fuel fabrication. This was accomplished by combining uranium tetrafluoride ( $UF_4$  or "green salt") and either calcium chips or magnesium chips, placing this mixture in a dolomite-coated steel vessel, which was then heated until free molten uranium separated from magnesium fluoride or calcium fluoride, and then allowed to cool. The molten uranium settled into large buttons shaped like Derby hats (called "Derbies" by Hanford workers). The Derbies were separated from the slag (calcium fluoride and magnesium fluoride salt) utilizing a jackhammer to break up the slag. These Derbies were then melted in a vacuum furnace, and cast into ingots. These ingots were then rolled into new uranium rods, either offsite or at Hanford, and used to make additional fuel rods.

In the spring of 1946, an additional scrap recovery operation known as the "oxide burner" began on the north side of the 314 Building. All uranium-bearing powder and particulate matter that could be collected from the fuel fabrication facilities, as well as the tailings or settlings from washes and quenches, was burned to convert it to a stable oxide (powder) form. The  $UO_2$  was then collected in 5-gallon containers for shipment offsite [Gerber 1992].

Between 1952 and 1954 both the vacuum furnace melting and the oxide burning processes were phased out and replaced with a process which slurried all the scrap into sodium diuranate, stored it in drums, and returned it to the Feed Materials Processing Center (FMPC), Fernald, Ohio, for recovery [Gerber 1996].

The concentration of any transuranics and fission products in the scrap from fuel fabrication activities would have been the same as that of the uranium metal received at Hanford for fuel fabrication. During our review of historical documentation for this study, we have found no information to suggest that the scrap processing activities would have altered the ratio of impurities to uranium.

### 2.2.7.3 Feed Specifications

Natural uranium was used for billet fabrication until about 1952 when the use of recycled uranium was phased in. The billets were accepted for use based upon material certification and chemical analysis received from the manufacturer. The scrap material was returned on the basis of the same billet receiving certifications and analysis data since the fuel fabrication process did not make any significant chemical changes.



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### 2.2.7.4 Product Specifications

Product specifications for the reactor fuel assemblies were based upon conforming to the design requirements of the reactor. Fuel was inspected dimensionally and by radiograph, ultrasonic, and other standard quality measurements. Chemical constituent control was confirmed by supplier certifications. Welds were examined and weld integrity verified.

### 2.2.7.5 Operating History

The earliest uranium received for the fabrication of reactor fuel arrived at Hanford in October 1943 as extruded rods. The rods were delivered to the Riverland Yards, which were an official part of Hanford and located just east of the Midway power substation and west of the 100-B Reactor Area. Because railroad track had not yet been completed to the 300 Area, the rods were taken by rail to the Construction Camp about 20 miles north of Richland, and then trucked to the 300 Area. Once railroad service to the 300 Area was connected in January 1944, uranium was delivered to the fabrication area by rail.

Newly arrived uranium rods were unpacked and visually inspected (in sample amounts) for cracks and for overall dimensions. A random amount from each lot was taken to the 305 Test Pile Building just west of the 313 Building, and irradiated at a low level to check for warping, cracking, and embrittlement under irradiation. If the sample withstood the process in good form, the entire lot was accepted. Operations began in December 1943. The first uranium fabrication operation at Hanford was machining, in which bare uranium rods were machined to specific core dimensions in the 313 Building. The following month, operators began degreasing the machined cores before inspection, using a commercial product that contained primarily trichloroethylene, Detrex™, a solvent degreaser. Core canning operations actually began in the 313 Building in March 1944.

In the 314 Building, autoclaves for fuel element testing started to operate in July 1944. A scrap recovery process began the following month. Out-gassing and straightening operations started in the 314 Building in September 1944, but Hanford's uranium rods still were being extruded offsite. Beginning in November 1944, uranium was transported to Hanford as billets, which were stored until the extrusion process began to operate in the 314 Building in January 1945. The press testing phase lasted into mid-spring, and then fuel operations commenced. Improved performance ended required shift work in the metal preparation buildings in June 1945, and work proceeded on a straight, 6-day-per-week schedule. From that time until 1948, a complete cycle of metal preparation was conducted at Hanford.

### 2.2.7.6 Current Status

Fuel and target fabrication in the 300 Area ceased permanently in 1987 with the closure of the N-Reactor. Some of the facilities have been decommissioned. Based on the

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integrated site baseline priorities, cleanup and restoration of the 300 Area presents many challenges. A portion of the 313 building now produces commercial aluminum extrusions. Other buildings are expected to be leased if suitable tenants can be found and after the facilities are decontaminated to guideline levels which allow occupancy by non-rad workers.

### 2.2.8 Other Uranium Handling Facilities

Several other Hanford facilities were involved in handling depleted uranium. These are discussed below. Much of this work supported reactor research activities at both this and other DOE sites.

#### 2.2.8.1 308 Building Mixed Oxide Fuel Fabrication

The fabrication of mixed oxide (plutonium oxide and uranium oxide) fuel in the 308 building utilized both depleted and natural uranium. Operations were conducted in gloveboxes to protect the workers from inhaling the material.

#### 2.2.8.2 306 Building

Depleted uranium oxide fuel pellets were fabricated in rooms 158 and 159 of this facility. These operations were conducted in open-faced hoods.

#### 2.2.8.3 234-5Z Plutonium Finishing Plant (PFP)

In 1972, the flowsheet and piping in the PFP were modified to allow separation and recovery of plutonium from some plutonium-uranium materials. The separated UNH stream was accumulated and trucked to the PUREX plant. At PUREX, the UNH was offloaded and discarded to the underground waste storage tanks since there was no need for the material.

#### 2.2.8.4 321 Building

Development and testing of a continuous calciner for production calciners to replace the batch kettles at the UO<sub>3</sub> Plant was performed in the 321 Building. The calciner development proved successful and 6 units were installed in 224UA building. About 200,000 pounds of uranium, as UNH, was trucked from the 200 West area to the 321 Building and processed in calciner development activities. The UO<sub>3</sub> product powder was subsequently returned to the UO<sub>3</sub> Plant and blended into the plant's product stream.

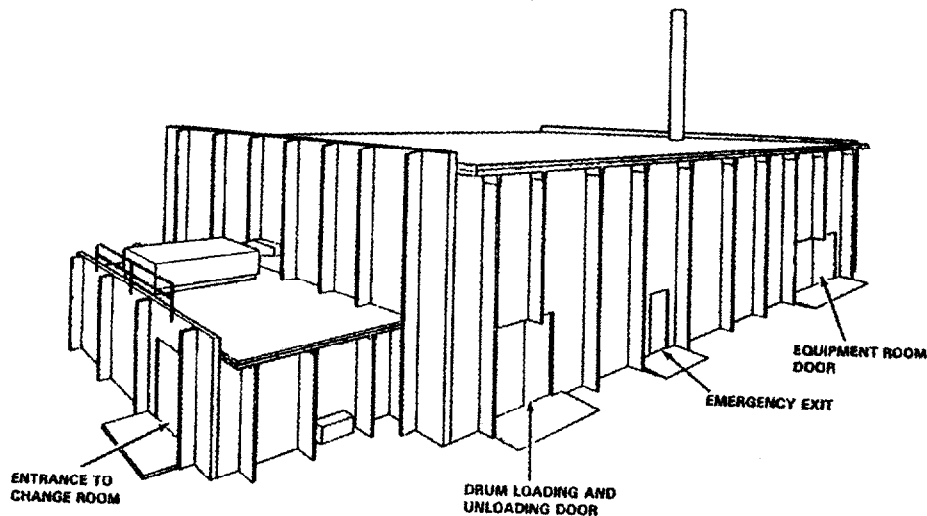
#### 2.2.8.5 303-M Uranium Oxide Facility

A small 303-L Building was constructed in 1961 for burning uranium metal scraps to an oxide form that would be suitable for shipment to the FMPC for recovery. Burning was stopped in 1971 due to operating problems. The building was removed in 1976. In

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1983, a new building, 303-M Uranium Oxide Facility, was constructed on the same site. This high bay, 51 ft by 35 ft by 25 ft (high) concrete structure with a one story extension 20 ft by 13.5 ft on the north side was used to convert more than 115 tons of uranium scrap to oxide during it's brief operating period of 1984 to 1987 [Gerber 1992]. A drawing of this facility is shown in Figure 2-15.



**Figure 2-15 303-M Uranium Oxide Facility  
[Prezbindowski 1983]**

### 2.3 Activity Summary

Hanford operation started in 1943 to support the defense effort of World War II. After W.W.II, it continued to support the growing defense effort. In doing so, the initial facilities were expanded and new facilities built to meet the congressional mandates for defense. In 1993, all production efforts supporting defense were terminated and the site was redirected to a clean-up mission. This clean-up mission is under way and some facilities have already been decontaminated and either removed or turned over to private industry for new uses.

The first major facilities at Hanford included B-, D-, and F-Reactors, T-Plant, B-Plant, a Fuel Fabrication complex and a plutonium purification plant. In addition to these major facilities, supporting structures, steam plants, housing, water, and personnel support facilities were simultaneously built. The first reactor was started in September 1944. The first batch of plutonium was shipped from the site in February 1945 to Los Alamos where it was converted into the first atomic device.

After the war, it was recognized that the uranium needed to continue and expand plutonium production was in short supply and new sources of uranium would be

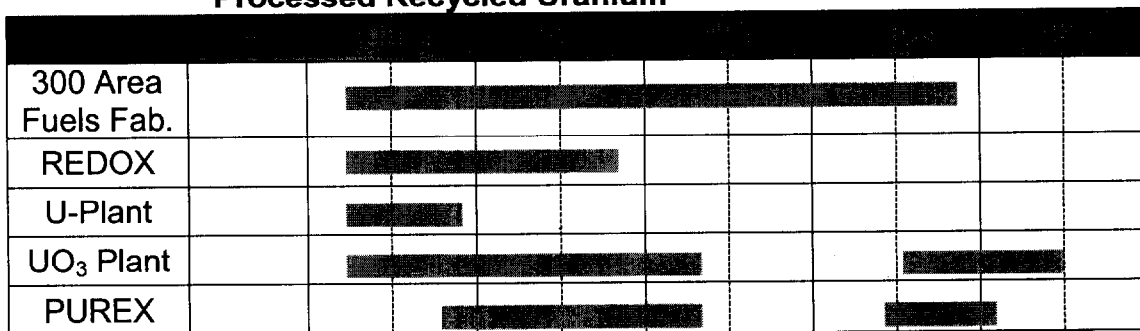
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required. One source was determined to be the irradiated uranium then residing in the high-level waste stored in Hanford's underground waste tanks. In 1947, reuse of this uranium was discussed and actions were taken to develop recovery processes for this waste. By 1952, U-Plant had been converted to process the high-level waste to recover uranium for recycle. The high purity UNH product needed to be converted to a safe, shippable oxide form. Simultaneously with the recovery process development and implementation, a uranium conversion process was developed and the UO<sub>3</sub> Plant built to provide a stable, transportable UO<sub>3</sub> powder. The uranium trioxide powder was to be shipped to the gaseous diffusion plants for enrichment and conversion to uranium metal billets. In the same time frame, the REDOX process was developed and the REDOX Plant was constructed to support the increase in the nation's plutonium needs. The REDOX facility, commissioned in 1952, recovered both plutonium and uranium as co-products. REDOX began transferring recovered uranium as UNH to the UO<sub>3</sub> Plant a month or two before UNH was available from U-Plant.

As increased plutonium product was required to meet defense needs, the PUREX process was developed to support the planned production increases and the PUREX separations plant was built, coming online in 1956. PUREX performance permitted the shut down of the REDOX and T-Plant facilities. The PUREX uranium output was also sent to the UO<sub>3</sub> Plant for conversion to oxide. In 1972, PUREX operations were shut down. In 1983, the PUREX plant was reactivated to meet national plutonium requirements created by congressional direction. The UO<sub>3</sub> Plant was also brought back on line to process the UNH output of the PUREX plant. In 1993, all plutonium operations were halted and PUREX Plant and the UO<sub>3</sub> Plants were shutdown to await decommissioning. Figure 2-16 summarizes the operational periods for the major Hanford Plants.

**Figure 2-16 Operating Intervals During Which Major Hanford Facilities Processed Recycled Uranium**



Record searches to support the Uranium Mass Balance Project indicated that Hanford produced a high quality uranium product meeting specifications from the beginning of production. The searches indicated that the recognition of a need for specification occurred several years before the first uranium trioxide production batch was produced. This specification need was driven by both reactor and worker health considerations. Detailed information on recycled uranium specifications and measured impurities is presented in Section 4.

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### References

Elgert 1971

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## SECTION 2 HANFORD SITE HISTORICAL OVERVIEW

DOE/RL-2000-43

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## Section 3 Recycled Uranium

DOE/RL-2000-43

### 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<sub>3</sub> 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 Plant & Y-12 Plant, Oak Ridge, Tennessee

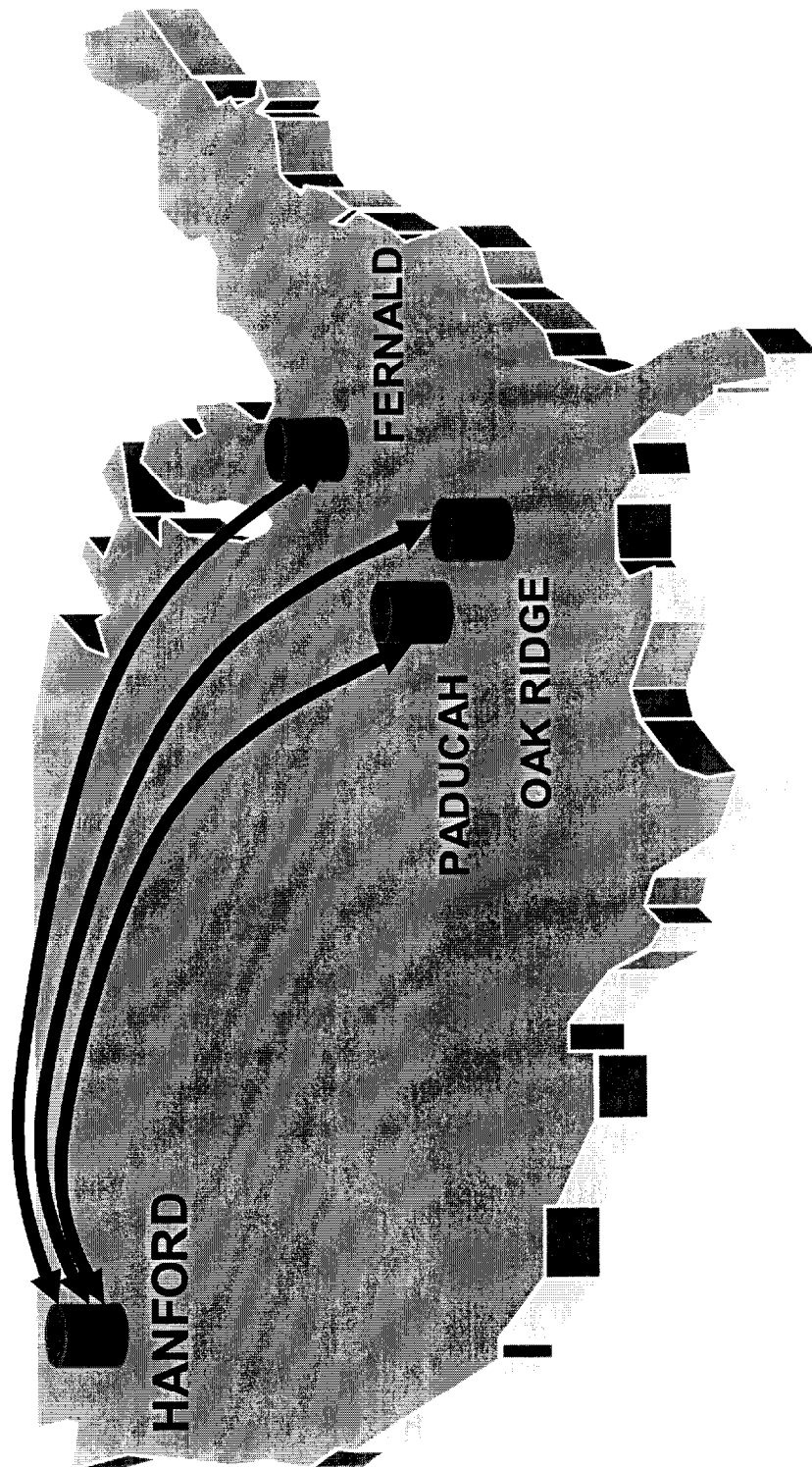
##### Minor Tier 1 Sites:

- 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.

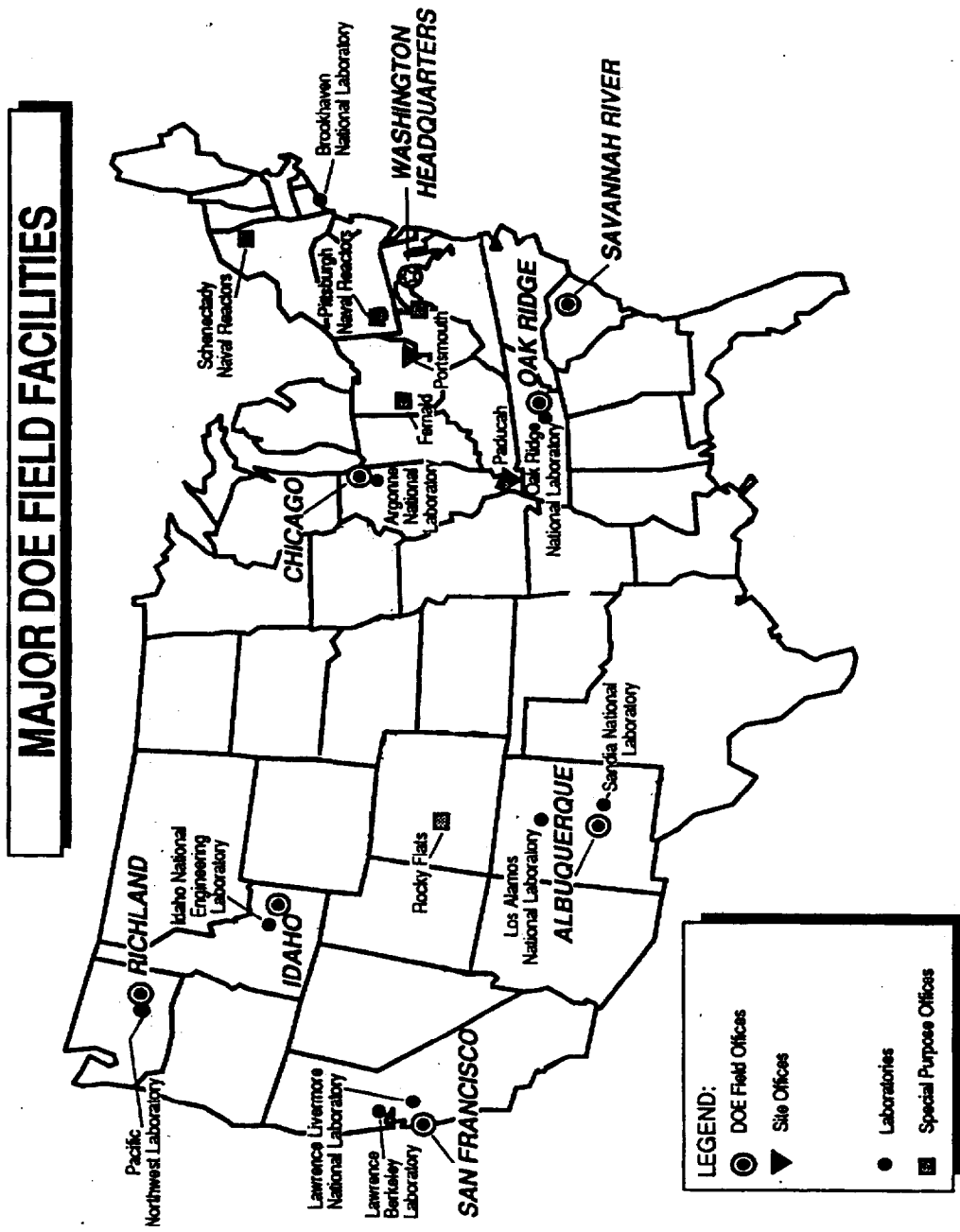
Section 3  
Recycled Uranium  
DOE/RL-2000-43

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





# Section 3 Recycled Uranium



III

Figure 3-2 Major DOE Field Facilities

# Section 3 Recycled Uranium

DOE/RL-2000-43

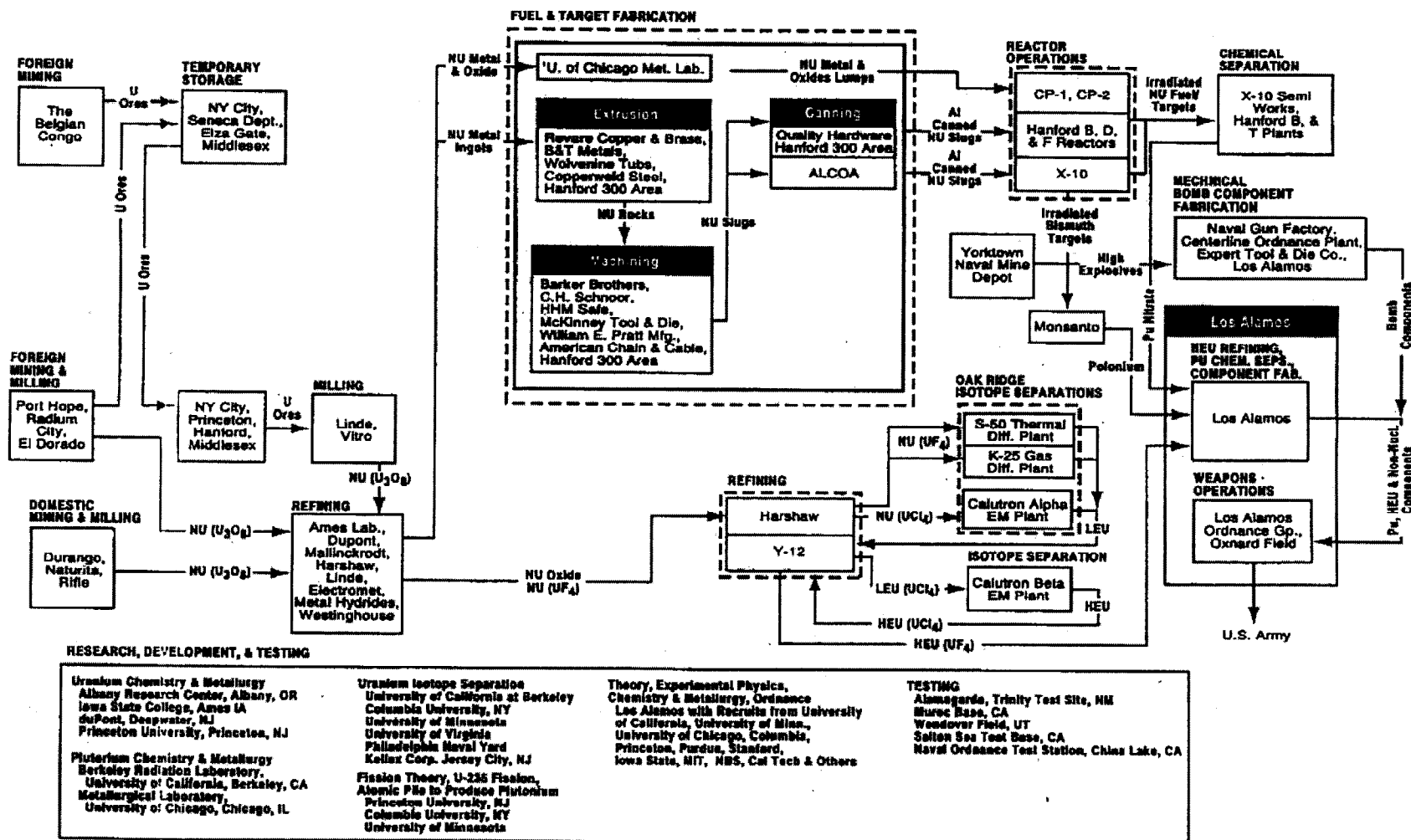
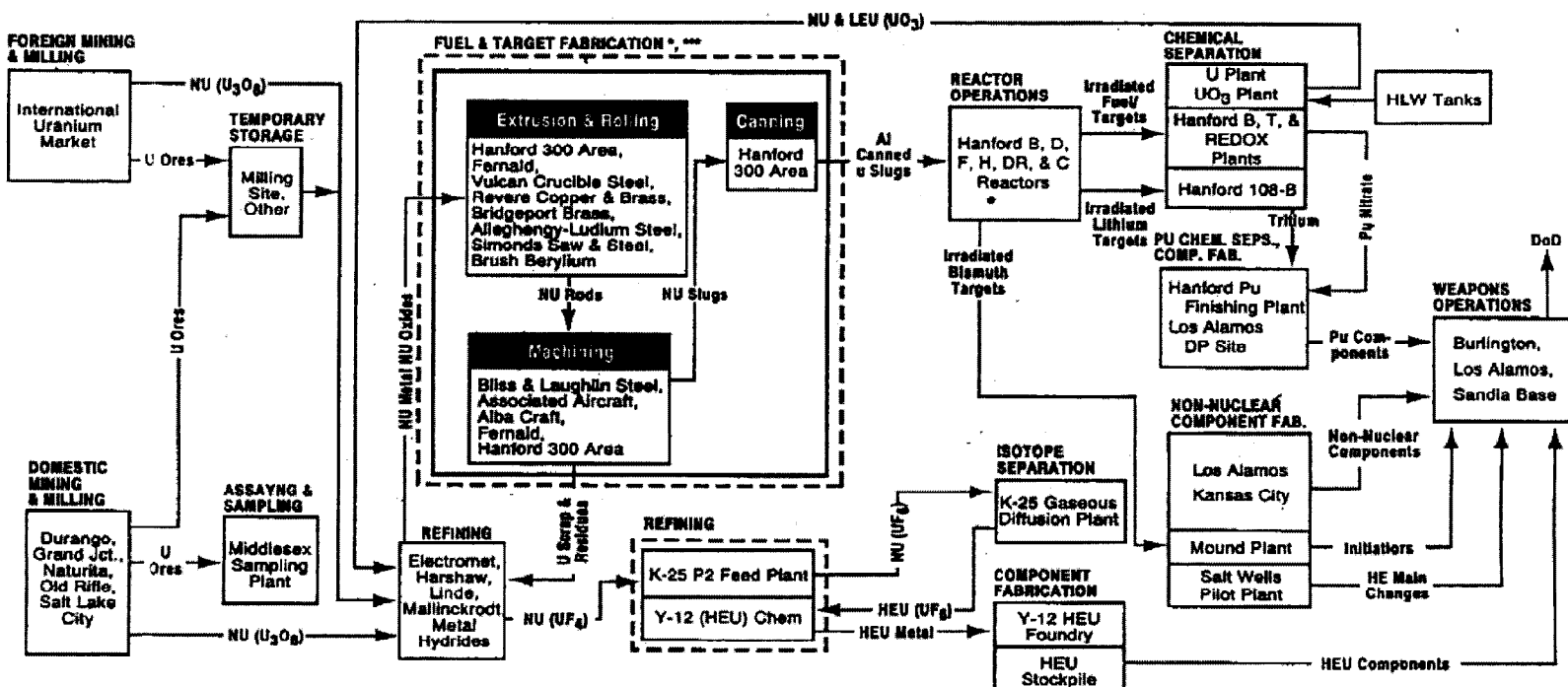


Figure 3-3A Material Flow – Manhattan Engineer District: 1942 – 1946 [DOE/EM-0319 1997]

# Section 3 Recycled Uranium

DOE/RL-2000-43



\* Not Shown: Hanford reactors started using LEU fuel from the Gaseous Diffusion Plants, as early as 1956.  
 \*\*\* Not Shown: Hanford 300 Area Manufactured Lithium (1948-1952) and Bismuth (1949-early 1950's) Targets.  
 \* Australia, South Africa, Portugal, Belgian Congo.

### RESEARCH, DEVELOPMENT, AND TESTING

RESEARCH & DEVELOPMENT	TESTING AREAS
Los Alamos Scientific Laboratory, Los Alamos, NM (Nuclear Component Design)	Bikini Test Area, Bikini Atoll
Sandia Laboratories, Albuquerque, NM (Non-Nuclear Component Design)	Eniwetok Proving Ground, Eniwetok Atoll
	Nevada Proving Ground, Nye County, NV (Later the Nevada Test Site)
	Seiten Sea Test Base, Imperial County, CA
	Other Facilities

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

# Section 3 Recycled Uranium

DOE/RL-2000-43

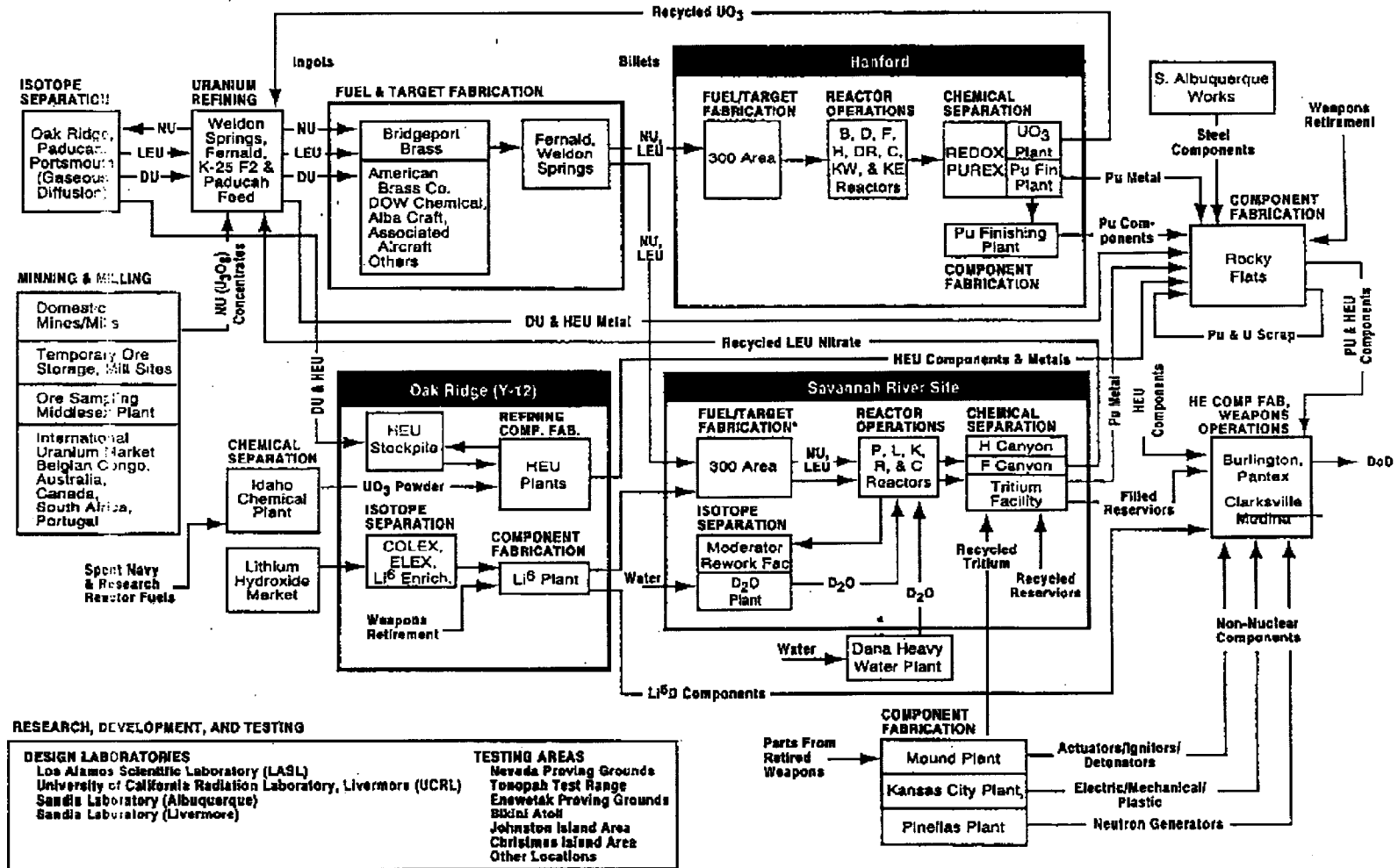


Figure 3-3C Material Flow – Atomic Energy Commission: mid 1950s – mid 1960s [DOE/EM-0319 1997]

# Section 3 Recycled Uranium

DOE/RL-2000-43

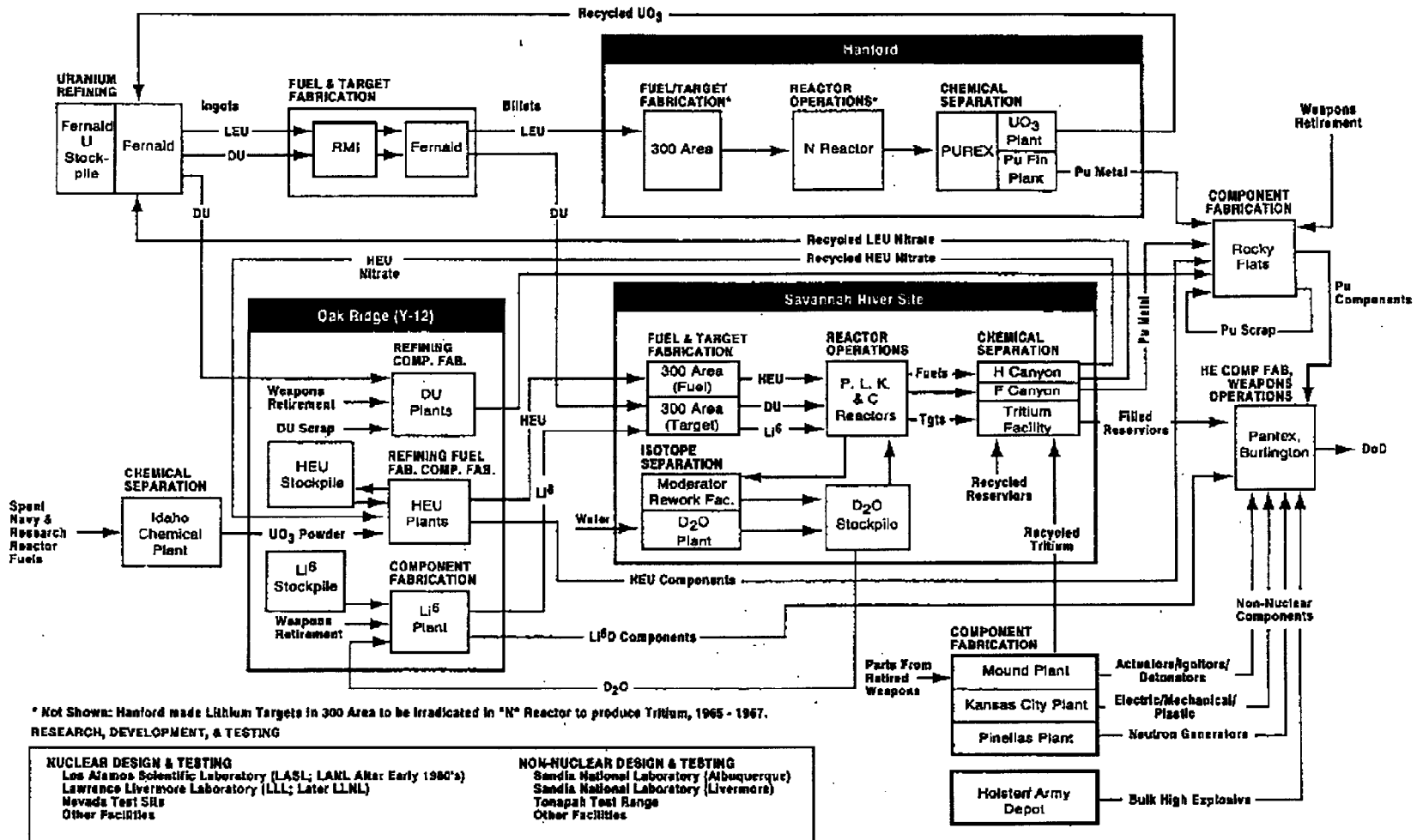


Figure 3-3D Material Flow – Atomic Energy Commission/Energy Research and Development Agency/Department of Energy: mid 1960s – late 1980s [DOE/EM-0319 1997]

## Section 3 Recycled Uranium

DOE/RL-2000-43

### 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 <sub>3</sub> 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 <sub>3</sub> LEU product to Oak Ridge K-25 (Production Channel)

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

Depleted Uranium:	July 1952	Hanford UO <sub>3</sub> 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

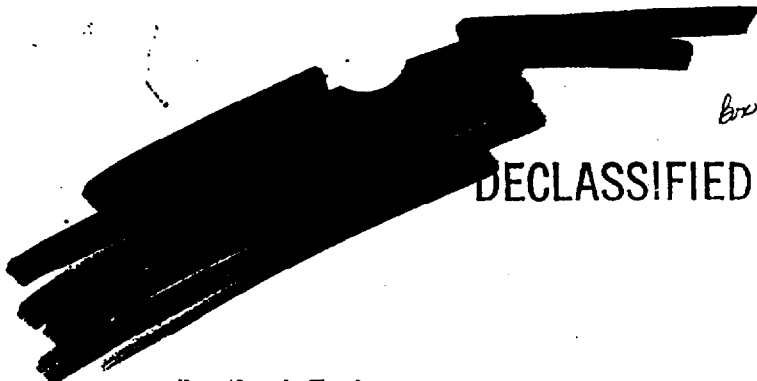
##### 3.1.2.2.1 Shipments

For UO<sub>3</sub> finished product from the Hanford production channel, the first lot of UO<sub>3</sub> 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<sub>3</sub> 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<sub>3</sub> 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<sub>3</sub> shipment is consistent with Hanford production history indicating UO<sub>3</sub> test runs in January 1952 and full operation in February 1952.

Section 3  
Recycled Uranium

DOE/RL-2000-43



EW-23738

*EW* ~~SECRET~~

DECLASSIFIED

March 11, 1952

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

This Document consists of  
...2...Pages No. 6...  
...19...Copies, Series...

Hanford  
43666

Dear Dr. Hurd:

UO<sub>3</sub> TRIAL PRODUCTION LOTS 007, 008, and 009

We are shipping by truck (United Motor Freight, GHL AT26971) Lots 007, 008, and 009 of UO<sub>3</sub> prepared from material processed through the Paducah 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, attn F. H. Anderson - J. W. Arendt. The average irradiation history of this uranium is considerably below the nominal 600 MWt/yr 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

**UNCLASSIFIED**

by Authority of RL0-CG-5

Section 2.7.3.1

by CARBON

Verified By WHS

11/14/94

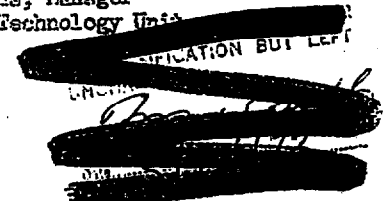
APPROVED FOR  
PUBLIC RELEASE  
CW 3-23-97

- 1 Dr. Frank Hurd, K-25
- 2 AF Huber, K-25
- 3 WB Eames, K-25
- 4 Sylvan Greager, K-25
- 5 Hanford Operations Office - Atomic Energy Commission -  
Attn: DG Sturges
- 6 AE Greninger - CH Greager
- 7 JE Maider - TW Hanff
- 8 RS Bell - VR Chapman
- 9 VD Donihue
- 10 JS
- 11 FW
- 12 RH
- 13 FW Albaugh - AH Easley
- 14 300 File
- 15 700 File
- 16 Pink
- 17 Yellow

Very truly yours,

*R.B. Richards*

R. B. Richards, Manager  
Separations Technology Unit



RIALS

DECLASSIFIED

Figure 3-4A First Hanford Shipment of UO<sub>3</sub>  
Containing Transuranics & Analytical Data  
[Richard 1952a]

# Section 3 Recycled Uranium

DOE/RL-2000-43

NW-0-107  
HAN-43666

Dr. Frank Eurd

- 2 -

March 11, 1952

<u>Component or Property</u>	<u>Reported as</u>	<u>Lot 007</u>	<u>Lot 008</u>	<u>Lot 009</u>
UO <sub>3</sub>	%	97.9	97.7	97.4
H <sub>2</sub> O	"	0.21	0.23	0.26
NO <sub>3</sub>	2HNO <sub>3</sub>	0.05	0.61	0.55
U <sub>3</sub> O <sub>8</sub>	%	0.12	0.1	0.11
Nz	ppm	3000	3000	2500
PO <sub>4</sub>	"	1500	1500	1500
Fe	"	700	950	550
Mn	"	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, <sup>β</sup>	*	< 5%	< 5%	< 10%
f.p. activity, <sup>γ</sup>	*	< 70%	< 100%	< 56%
U <sub>235</sub>	% of U	0.68	0.68	0.67

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

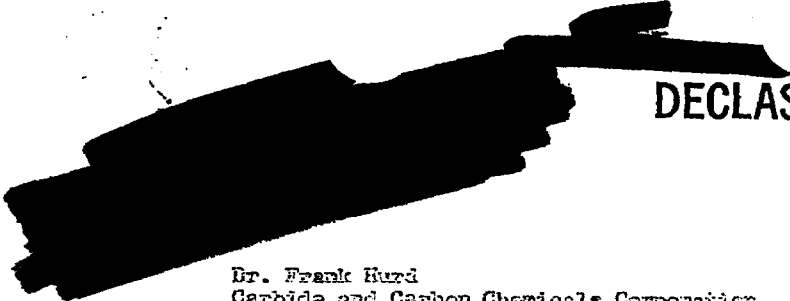
**Figure 3-4A (Continued) First Hanford Shipment Containing  
Transuranics and Analytical Data  
[Richards 1952a]**



Section 3  
Recycled Uranium

DOE/RL-2000-43

EM-23846



DECLASSIFIED

*Box A-23846 T.W.*  
130263  
1849

March 19, 1952

This Document consists of  
Pages No. of  
Copies, Series

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

Hanford  
43786

Dear Dr. Hurd:

UO<sub>3</sub> TRIAL PRODUCTION LOTS 010, 011, 012, and 013

We are shipping by rail (car Milwaukee 1014, CHL AT-26979) lots 010, 011, 012, and 013 of UO<sub>3</sub> 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

By C.A. Bowman-PNL

Verified By J. Briggs WAC-CO 11/14/94  
RBL:JEM:blp

Yours very truly,

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

By J. B. Work  
J. B. Work

- bcc: 1-2 Dr. Frank Hurd, K-25
- 3 AP Huber, K-25
- 4 MB Hines, K-25
- 5 Sylvan Cromer, K-25
- 6-7 Hanford Operations Office - Atomic Energy Commission - Att'n: EC Stanges
- 8 AB Greeninger - OH Greagor
- 9 JE Meider - TW Rauff
- 10 RS Bell - VR Chapman
- 11 VD Doubee
- 12 JB Work - RB Richards
- 13 FW Woodfield
- 14
- 15
- 16
- 17
- 18 Pink
- 19 Yellow

~~DECLASSIFICATION REVIEW FOR LEFT  
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Date: 4/73  
U.S. Division of Classification~~

APPROVED FOR  
RELEASE  
23-95

MATERIALS *W...*

DECLASSIFIED



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

# Section 3 Recycled Uranium

DOE/RL-2000-43

HS-23848

Dr. Frank Hurd

- 2 -

March 19, 1952

<u>Component or Property</u>	<u>Reported as</u>	<u>Lot 010</u>	<u>Lot 011</u>	<u>Lot 012</u>	<u>Lot 013</u>
UO <sub>3</sub>	%	97.3	97.6	98.0	98.1
H <sub>2</sub> O	"	0.27	0.24	0.24	0.23
NO <sub>3</sub>	<del>Σ</del> NO <sub>3</sub>	0.65	0.55	0.62	0.54
U <sub>3</sub> O <sub>8</sub>	%	0.24	0.46	0.35	0.45
Na	ppm	2500	2500	5000	2000
PO <sub>4</sub>	"	< 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	88.7
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 <sub>235</sub>	% of U	0.67	0.66	0.66	0.66

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

**Figure 3-4B (continued)  
Second Hanford Shipment of UO<sub>3</sub> - Analytical Results  
[Work 1952]**

# Section 3 Recycled Uranium

DOE/RL-2000-43

<p style="text-align: center;">(CLASSIFICATION)</p> <p>PROJECT</p> <p><b>Atlantic Richfield Hanford Company</b> Richland, Washington 99352</p>	<p style="text-align: center;">LITERATURE ACCESS CATEGORIES</p> <p style="text-align: center;">C-65 <b>DECLASSIFIED</b></p> <p style="text-align: center;"><i>Box</i> <i>103313</i></p>	<p style="text-align: center;">DOCUMENT NO.</p> <p style="text-align: center;">ARH-1720 JUN</p> <p style="text-align: center;">SERIES AND COPY NO.</p> <p style="text-align: center;">1 of 1</p> <p style="text-align: center;">DATE</p> <p style="text-align: center;">June 1, 1971</p>
<p style="text-align: center;">ISSUING FILE</p> <div style="border: 1px solid black; padding: 5px; width: fit-content; margin: 10px auto;"> <p style="text-align: center;">CIRCULATING COPY</p> <p style="text-align: center;">RECEIVED</p> <p style="text-align: center;">MAR 10 1971</p> <p style="text-align: center;">RECEIVED BY: JG DOCUMENT CONTROL 271-U Bldg., 200 West</p> </div>	<p style="text-align: center;">TITLE AND AUTHOR</p> <p style="text-align: center;">URANIUM OXIDE - SOURCE DATA - FY 1971</p> <p style="text-align: center;">June, 1971</p> <p style="text-align: center;"><i>Approved for Public Release</i> <i>9-12-95</i></p> <p style="text-align: center;">JG Murphy</p>	
<p><input type="checkbox"/> THIS DOCUMENT CONTAINS INFORMATION THE DISCLOSURE OF WHICH IN ANY MANNER TO AN UNAUTHORIZED PERSON IS PROHIBITED.</p> <p><input type="checkbox"/> OTHER OFFICIAL CLASSIFIED INFORMATION</p> <p>THIS MATERIAL CONTAINS INFORMATION AFFECTING THE NATIONAL DEFENSE OF THE UNITED STATES WITHIN THE MEANING OF THE ESPIONAGE LAWS, TITLE 18, U.S.C. SECS 793 AND 794, THE TRANSMISSION OR REVELATION OF WHICH IN ANY MANNER TO AN UNAUTHORIZED PERSON IS PROHIBITED BY LAW</p>	<p>THIS DOCUMENT MUST NOT BE LEFT UNATTENDED OR WHERE AN UNAUTHORIZED PERSON MAY HAVE ACCESS TO IT. WHEN NOT IN USE, IT MUST BE STORED IN AN APPROVED LOCKED REPOSITORY WITHIN AN APPROVED GUARDED AREA. WHILE IT IS IN YOUR POSSESSION AND UNTIL YOU HAVE RETURNED IT TO YOUR CLASSIFIED DOCUMENT RESPONSIBILITY STATION, IT IS YOUR RESPONSIBILITY TO PROTECT IT AND ITS CONTENTS WITHIN THE LIMITS OF THIS PROJECT FROM ANY UNAUTHORIZED PERSON. ITS TRANSMITTAL TO, AND STORAGE AT YOUR PLACE OF RESIDENCE IS PROHIBITED. IT MAY BE DUPLICATED ONLY IN ACCORDANCE WITH EXISTING SECURITY REGULATIONS. ALL PERSONS READING THIS DOCUMENT ARE REQUESTED TO SIGN IN THE SPACE BELOW.</p>	
<p>ROUTE TO:</p> <p>JG Murphy</p>	<p>FILES ROUTE:</p> <p>271-U Bldg.</p>	<p>SIGNATURE AND DATE:</p> <p><i>[Signature]</i> MAR 10 1971</p>
<p><b>RECORD COPY</b></p> <p><b>DECLASSIFIED</b></p> <p>RECORDS SCHEDULE DRS 14.6A</p>		
<p>54-6100-150 (8-67) REC'D, CD RICHLAND WASH</p> <p style="text-align: center;">(CLASSIFICATION)</p>		

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)

1. Name and Address of Shipper Atlantic Richfield Hanford Company Post Office Box 250 Richland, Washington 99352 Attention: G. B. Kuklinski		2. Name and Address of Receiver Union Carbide Corp.-Nuclear Division Paducah Gaseous Diffusion Plant P.O. Box 1110 Paducah, Kentucky 42002 Attention: B. T. Kraemer		5. Nature of Transaction Complete if Applicable (22) Transaction Type <input type="checkbox"/> Transaction Type <input type="checkbox"/> Transaction Type <input type="checkbox"/>		NO. Distribution of Copies 1 FVA EPA 2 FVA HAA 3 FVA HAA 4 HAA 5 FVA PAA 6 HAA 7 HVA TITLE 8 FVA COST-HOG 9 FVA TITLE 10	
11. Material and Description Depleted UO <sub>3</sub> Lot-1-5-7 (81.92 % U)		12. Transfer Authority—SNM Draft Number, Reference, or Order Number Letters: Ship UO <sub>3</sub> Dated 3/12/71 & O.J. Elgert/R.P. Corlew		10. Date of Transfer of Financial Responsibility Mo. (29-30) Day (31-32) Yr. (33)			

SHIPPER'S DATA

A. Date Shipped  
Mo. (70-71) 6 Day (72-73) 9 Yr. (74) 71

B. Form No. (75) 1

C. Signature of Authorized Official and Date Signed  
*G. B. Kuklinski* G. B. Kuklinski 6/12/71

Line No. (76-77)	AEC Project Number and Identification (22-31) NO.	Material Type (22-33) F	Material Description Code (22-34) G	Comptrol Code (24-26) H	Outer Code (27) I	LBS.		KGS. Element Weight (40-50) L	Weight % Isotope (51-54) M	KGS. Isotope Weight (55-65) N	Limits of Error	
						Gross Weight (J)	Net Weight (K)				Element (66-70) O	Isotope (71-75) P
Total-6 Hoppers												
	Lot-1-5-7 (81.92 % U)	10		401	G	84 208	72 901	27 088	0.658	178	+ 60	
	See page # 2 for detail					Cost Memo lbs.		59 720		372.96		
	June MSR											

RECEIVER'S DATA

A. Date Received  
Mo. (70-71) Day (72-73) Yr. (74)

B. Form No. (75)

C. Signature of Authorized Official and Date Signed  
*[Signature]*

Line No. (76-77)	AEC Project Number and Identification (22-31) E	Material Type (22-33) F	Material Description Code (22-34) G	Comptrol Code (24-26) H	Outer Code (27) I	LBS.		KGS. Element Weight (40-50) L	Weight % Isotope (51-54) M	KGS. Isotope Weight (55-65) N	Limits of Error	
						Gross Weight (J)	Net Weight (K)				Element (66-70) O	Isotope (71-75) P

18 U.S.C., SECTION 1031; ACT OF JUNE 25, 1949; 62 STAT. 749; MAKES IT A CRIMINAL OFFENSE TO MAKE A WILLFULLY FALSE STATEMENT OR REPRESENTATION TO ANY DEPARTMENT OR AGENCY OF THE UNITED STATES AS TO ANY MATTER WITHIN ITS JURISDICTION.

GPC 817  
6-11-71

Section 3  
Recycled Uranium


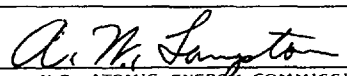
DOE/RL-2000-43

# Section 3 Recycled Uranium

DOE/RL-2000-43

[REDACTED]  
 (CLASSIFICATION)

UO<sub>3</sub> - 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 21 390 48 664 Lbs.
MATERIAL Depleted UO <sub>3</sub>	DATE SHIPPED 6-1-71
NO. OF CONTAINERS Lot-1-5-2 2 cont. Lot-1-5-3 4 cont.	NET SAMPLE WEIGHT 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:  <div style="text-align: center;">               G.B. Kuklinski              ATLANTIC RICHFIELD HANFORD COMPANY           </div>	DATE 6-2-71
ACCEPTED BY:  <div style="text-align: center;">               A. Mc Langston              U.S. ATOMIC ENERGY COMMISSION           </div>	DATE 6/7/71

Shipment Pending on Lot-1-5-3

[REDACTED]  
[REDACTED]  
[REDACTED]

[REDACTED]  
[REDACTED]

THIS DOCUMENT CONSISTS OF  
 1 PAGES, NO. 1 OF  
 2 COPIES. SERIES [REDACTED]

HANFORD CATEGORY C-65

**Figure 3-6 Example of Historical Product Acceptance Form  
Hanford Depleted UO<sub>3</sub> to Paducah (circa 1971)**

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In March 1959, General Electric was authorized by the AEC to begin routine shipments of low-enriched (0.94%  $^{235}\text{U}$  before irradiation)  $\text{UO}_3$  to the K-25 facilities in Oak Ridge [Gifford 1959]. Hanford LEU  $\text{UO}_3$  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%)  $\text{UO}_3$  to Oak Ridge. Although the K-25 facility was the first recipient of Hanford recycled uranium, the vast majority of the  $\text{UO}_3$  product was shipped to the Paducah site beginning in FY 1954 through FY 1972.

The third major recipient of Hanford recycled  $\text{UO}_3$  was the Fernald site, which began receiving research quantities of depleted  $\text{UO}_3$  in FY 1953. Although Fernald received small quantities of Hanford depleted  $\text{UO}_3$ , they were the major recipient of Hanford low-enriched recycled  $\text{UO}_3$  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  $\text{UO}_3$  which did not meet K-25 acceptance criteria for non-radioactive chemical purity were sent to Harshaw for purification. The majority of Hanford  $\text{UO}_3$  shipped from Hanford to the K-25 plant was later shipped from K-25 to Paducah.

### 3.1.2.2 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.

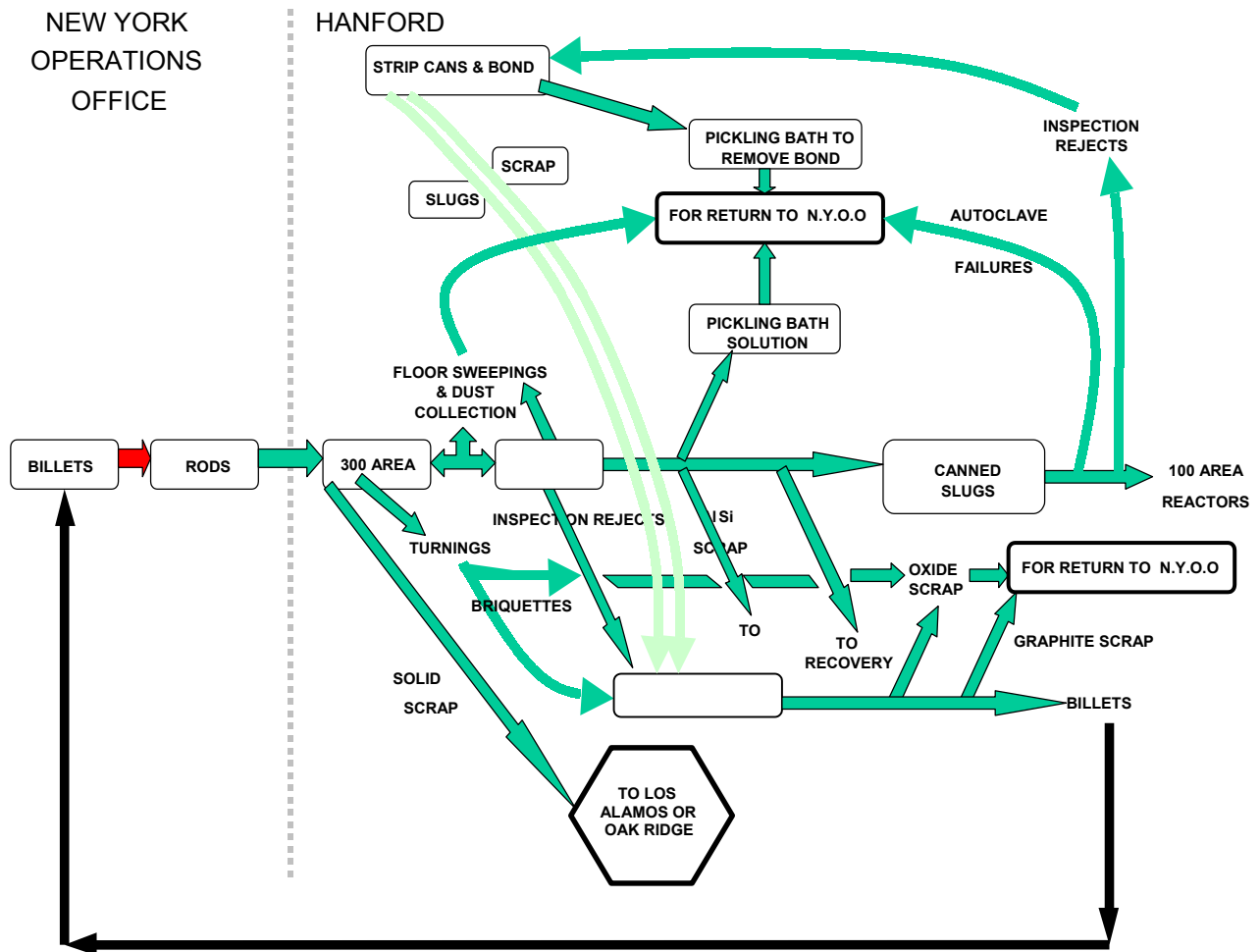
### 3.1.3 Out-of-Scope Uranium Transactions

#### 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

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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

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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:



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- 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

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- 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	<b><u>Fuel Fabrication &amp; Reactor Operation:</u></b> 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)
January 1966 - September 1967	<b><u>Chemical Separations, Processing &amp; Production</u></b> 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)
January 1965 - 1977	<b><u>Research &amp; Environmental Monitoring</u></b> Battelle Memorial Institute (BNWL) (became PNL)
1977 – Current	Pacific Northwest Laboratory (PNL)(became PNNL)

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- 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 <sub>3</sub> product was shipped (no fission products)
March 10, 1952:	First recorded shipment of UO <sub>3</sub> 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 <sub>3</sub> Plant [Gustafson 1957]
March-June, 1959:	First production and shipment of enriched UO <sub>3</sub> to K-25

#### 3.1.6.1 Beginning Shipment of Recycled Depleted Uranium Trioxide (UO<sub>3</sub>)

As previously noted, the first shipment of recycled UO<sub>3</sub> 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<sub>3</sub>)

The first shipments of low-enriched (0.8 -0.9% <sup>235</sup>U) UO<sub>3</sub> 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].

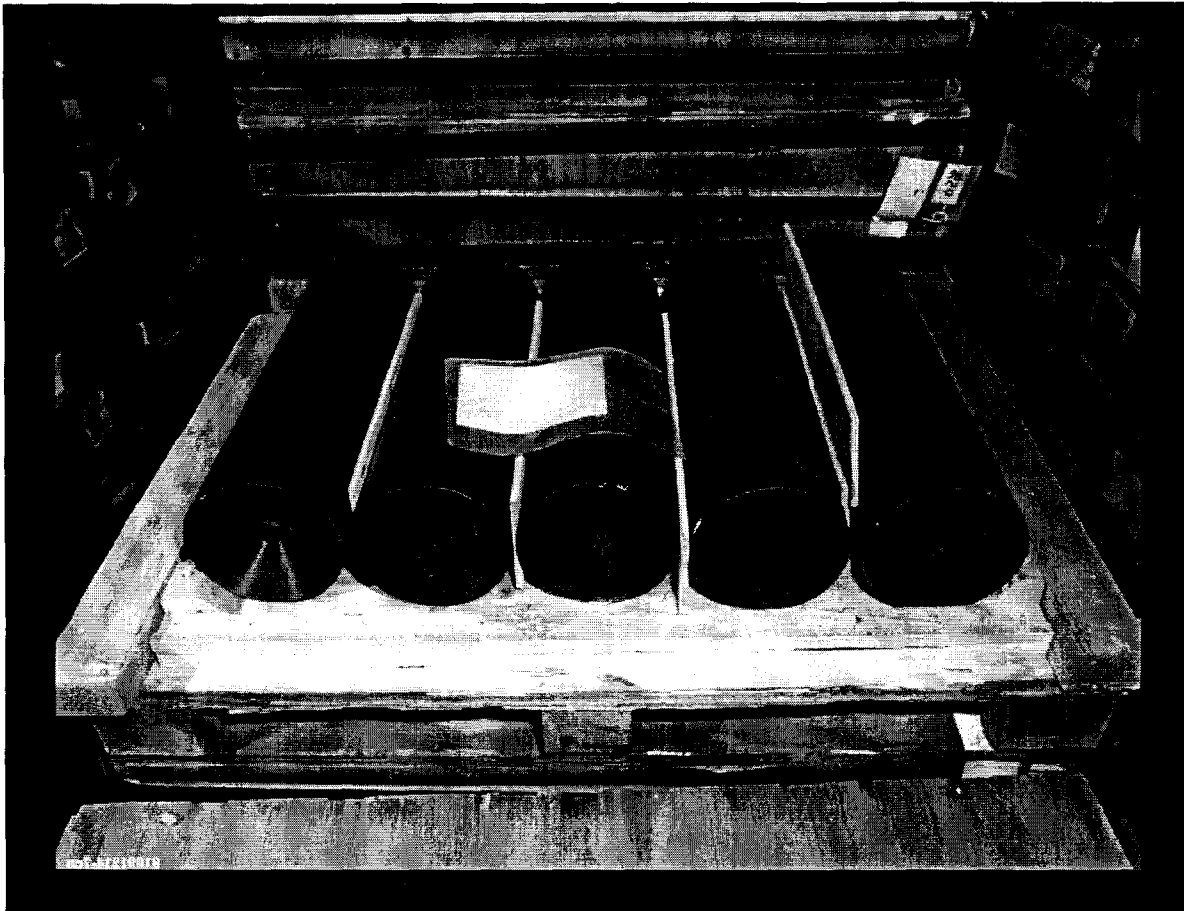
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### 3.2 Recycle Uranium Receipts

#### 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

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- 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  $^{236}\text{U}$  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  $\text{UO}_3$  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  $\text{UO}_3$  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

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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 3-1 below 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<sub>3</sub> 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<sub>3</sub> in returned shipping containers from Fernald. In 1983, incoming materials into the 300 Area were primarily 0.95% and 1.25% <sup>235</sup>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<sub>3</sub> 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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**Table 3-2 Hanford Receipts From Paducah**

(IN MTU)		Union Carbide of Kentucky									
		Management by Oak Ridge Operations CKY, FYA									
FY	Date		Into RIS	Hanford Contractor	Box #	Doc #	DU	NU	EU	MTU Total	
	From	To									
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	
<b>FY 1952 - FY 1965 Subtotal</b>							<b>22</b>	<b>0.1</b>	<b>2.4</b>	<b>24.5</b>	
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					
<b>Hanford Chem Processing Contractor subtotals</b>											
1966	1-Jul-65	30-Jun-66	HXA	Douglas United Nuc	38214	HAN 95171					
<b>Hanford FY 66 Aggregate subtotal</b>							<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	
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					
<b>Hanford Chem Processing Contractor subtotals</b>											
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					
<b>Hanford FY 67 Aggregate subtotal</b>							<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	
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					
<b>Hanford Chem Processing Contractor subtotals</b>											
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					
<b>Hanford FY 68 Aggregate subtotal</b>							<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	
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					
<b>Hanford Chem Processing Contractor subtotals</b>											
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					
<b>Hanford FY 69 Aggregate subtotal</b>								<b>0</b>	<b>0</b>	<b>0</b>	
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					
<b>Hanford Chem Processing Contractor subtotals</b>								<b>0</b>	<b>0</b>		
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					
<b>Hanford FY 70 Aggregate subtotal</b>							<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	
<b>FY 1966 - FY 1970 Subtotal</b>							<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	
<b>1952-June 30, 1970 MTU Subtotal</b>							<b>22</b>	<b>0.1</b>	<b>2.4</b>	<b>24.5</b>	
<b>July 1, 1970 - 3/31/99 Hanford MTU Subtotal</b>							<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	
<b>Hanford In-Scope MTU Grand Total</b>							<b>22</b>	<b>0.1</b>	<b>2.4</b>	<b>24.5</b>	

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**Table 3-3 Hanford Receipts From Fernald**

TOTAL URANIUM RECEIVED (IN MTUs)							NLO, FMPC, FEMP Fernald Ohio Managed by Oak Ridge Operations EVA, FVB, FVC			
FY	Date		Into RIS	Hanford Contractor	Box #	Doc #	MTU			Hanford MTU Total
	From	To					DU	NU	EU	
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
<b>FY 1953 - FY 1965 Subtotal</b>							<b>143.7</b>	<b>61,886.8</b>	<b>10,810.2</b>	<b>72,840.7</b>
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
<b>Hanford Chem Processing Contractor subtotals</b>							<b>0</b>	<b>1,126.5</b>	<b>1,202.6</b>	<b>2,329.1</b>
1966	1-Jul-65	30-Jun-66	HXA	Douglas United Nuc	38214	HAN 95171	0	1,992.8	1,282.8	3,275.6
<b>Hanford FY 66 Aggregate subtotal</b>							<b>0</b>	<b>3,119.3</b>	<b>2,485.4</b>	<b>5,604.7</b>
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
<b>Hanford Chem Processing Contractor subtotals</b>							<b>0</b>	<b>2.5</b>	<b>490.5</b>	<b>493</b>
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
<b>Hanford FY 67 Aggregate subtotal</b>							<b>94.3</b>	<b>3,200.1</b>	<b>1,762.9</b>	<b>5,057.3</b>
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
<b>Hanford Chem Processing Contractor subtotals</b>							<b>0</b>	<b>0.2</b>	<b>0.6</b>	<b>0.8</b>
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
<b>Hanford FY 68 Aggregate subtotal</b>							<b>0</b>	<b>1,253</b>	<b>2,168.8</b>	<b>3,421.8</b>
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
<b>Hanford Chem Processing Contractor subtotals</b>							<b>0</b>	<b>0</b>	<b>0.4</b>	<b>0.4</b>
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
<b>Hanford FY 69 Aggregate subtotal</b>							<b>0</b>	<b>138.6</b>	<b>2,443.3</b>	<b>2,581.9</b>
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
<b>Hanford Chem Processing Contractor subtotals</b>							<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>
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
<b>Hanford FY 70 Aggregate subtotal</b>							<b>0</b>	<b>1,782.1</b>	<b>661.8</b>	<b>2,443.9</b>
<b>FY 1966 - FY 1970 Subtotal</b>							<b>94</b>	<b>9,493</b>	<b>9,522</b>	<b>19,110</b>
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
<b>FY 71 thru March 31, 1999 Subtotal</b>							<b>6.6</b>	<b>399.1</b>	<b>368</b>	<b>773.7</b>
<b>Grand MTU Total FY 52 thru March 1999</b>							<b>244.6</b>	<b>71,778.</b>	<b>20,700.3</b>	<b>92,723.9</b>
<b>Grand MTU In-Scope Total FY 52-3/31/99</b>							<b>244.6</b>	<b>71,778.</b>	<b>20,700.3</b>	<b>92,723.9</b>



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**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		Into RIS	Hanford Contractor	Box #	Doc #	DU	NU	EU	Hanford MTU Total	
	From	To									
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	
<b>FY 1953 - FY 1965 Subtotal</b>							<b>0.4</b>	<b>0.1</b>	<b>4.4</b>	<b>4.9</b>	
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	
<b>Hanford Chem Processing Contractor subtotals</b>											
1966	1-Jul-65	30-Jun-66	HXA	Douglas United Nuc	38214	HAN 95171				0	
<b>Hanford FY 66 Aggregate subtotal</b>							<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	
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	
<b>Hanford Chem Processing Contractor subtotals</b>											
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	
<b>Hanford FY 67 Aggregate subtotal</b>							<b>0</b>	<b>0.034</b>	<b>0</b>	<b>0</b>	
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	
<b>Hanford Chem Processing Contractor subtotals</b>											
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	
<b>Hanford FY 68 Aggregate subtotal</b>							<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	
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	
<b>Hanford Chem Processing Contractor subtotals</b>											
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	
<b>Hanford FY 69 Aggregate subtotal</b>							<b>0</b>	<b>0.05</b>	<b>0</b>	<b>0.1</b>	
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	
<b>Hanford Chem Processing Contractor subtotals</b>											
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	
<b>Hanford FY 70 Aggregate subtotal</b>							<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	
<b>FY 1966 - FY 1970 Subtotal</b>							<b>0</b>	<b>0.084</b>	<b>0</b>	<b>0.084</b>	
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	
<b>FY 71 thru March 31, 1999 Subtotal</b>							<b>13.6</b>	<b>0</b>	<b>0.8</b>	<b>14.3</b>	
<b>Grand MTU Total 1947 thru March 1999</b>							<b>14</b>	<b>0.2</b>	<b>5.2</b>	<b>19.4</b>	
<b>MTU In-Scope Total FY 1953 thru March 1999</b>							<b>13.8</b>	<b>0.2</b>	<b>4.8</b>	<b>18.7</b>	

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fabrication activities in the 300 Areas. The other major stream was the UO<sub>3</sub> product produced at the UO<sub>3</sub> Plant in the 200 West Area.

Hanford UO<sub>3</sub> 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**

<b>Timeframe:</b>	<b>MTUs Shipped All Offsite Sites</b>	<b>MTUs Shipped Major Tier 1</b>	<b>MTUs Shipped Minor Tier 1</b>
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
<b>Recycle Total</b>	<b>109,792.4</b>	<b>104,146.2</b>	<b>5,646.2</b>

### 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<sub>3</sub> 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.

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**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
<b>FY 1952 - FY 1965 Subtotal</b>							<b>51,246.5</b>	<b>0</b>	<b>916</b>	<b>52,162.5</b>
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			
<b>Hanford Chem Processing Contractor subtotals</b>							<b>0</b>			
1966	1-Jul-65	30-Jun-66	HXA	Douglas United Nuc	38214	HAN 95171	0			
<b>Hanford FY 66 Aggregate subtotal</b>							<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>
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			
<b>Hanford Chem Processing Contractor subtotals</b>							<b>14,432.9</b>			
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			
<b>Hanford FY 67 Aggregate subtotal</b>							<b>14,432.9</b>	<b>0</b>	<b>0</b>	<b>14,433</b>
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			
<b>Hanford Chem Processing Contractor subtotals</b>							<b>0</b>			
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			
<b>Hanford FY 68 Aggregate subtotal</b>							<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>
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			
<b>Hanford Chem Processing Contractor subtotals</b>							<b>3,537.1</b>			
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			
<b>Hanford FY 69 Aggregate subtotal</b>							<b>3,537.1</b>	<b>0</b>	<b>0</b>	<b>3,537</b>
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			
<b>Hanford Chem Processing Contractor subtotals</b>							<b>0</b>	<b>0</b>	<b>0</b>	
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			
<b>Hanford FY 70 Aggregate subtotal</b>							<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>
<b>FY 1966 - FY 1970 Subtotal</b>							<b>17,970</b>	<b>0</b>	<b>0</b>	<b>17,970</b>
<b>1952-June 30, 70 MTU Subtotal</b>							<b>69,216.5</b>	<b>0</b>	<b>916</b>	<b>70,132.5</b>
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
<b>July 1, 1970 - Present MTU Subtotal</b>							<b>2,125</b>	<b>0</b>	<b>2,233.1</b>	<b>4,358.1</b>
<b>Hanford MTU Grand Total-All U Types</b>							<b>71,341.5</b>	<b>0</b>	<b>3,149.1</b>	<b>74,490.6</b>
<b>Hanford MTU In-Scope Grand Total-All U Types</b>							<b>71,341.5</b>	<b>0</b>	<b>3,149.1</b>	<b>74,490.6</b>

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**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 RIS	Hanford Contractor	Box #	Doc #	MTU			MTU All U Total
	From	To					DU	NU	EU	
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
<b>FY 52 thru FY 65 Subtotal</b>							<b>1.5</b>	<b>3,225.1</b>	<b>4,811</b>	<b>8,037.6</b>
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
<b>Hanford Chem Processing Contractor subtotals</b>							<b>0</b>	<b>122.2</b>	<b>2,023.7</b>	<b>2,146</b>
1966	01-Jul-65	30-Jun-66	HXA	Douglas United Nuc	38214	HAN 95171	0	82.4	14	96
<b>Hanford FY Aggregate subtotal</b>							<b>0</b>	<b>204.6</b>	<b>2,037.7</b>	<b>2,242</b>
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
<b>Hanford Chem Processing Contractor subtotals</b>							<b>0</b>	<b>3.9</b>	<b>1,459.5</b>	<b>1,463</b>
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
<b>Hanford FY Aggregate subtotal</b>							<b>0</b>	<b>76.5</b>	<b>1,484.7</b>	<b>1,561</b>
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
<b>Hanford Chem Processing Contractor subtotals</b>							<b>0</b>	<b>0</b>	<b>1,553.9</b>	<b>1,554</b>
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
<b>Hanford FY Aggregate subtotal</b>							<b>0</b>	<b>84.6</b>	<b>1,815.9</b>	<b>1,901</b>
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
<b>Hanford Chem Processing Contractor subtotals</b>							<b>0</b>	<b>0</b>	<b>1,870</b>	<b>1,870</b>
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
<b>Hanford FY Aggregate subtotal</b>							<b>0</b>	<b>73.6</b>	<b>2,065.2</b>	<b>2,139</b>
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
<b>Hanford Chem Processing Contractor subtotals</b>							<b>467.9</b>	<b>0</b>	<b>1,769</b>	<b>2,237</b>
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
<b>Hanford FY Aggregate subtotal</b>							<b>476.6</b>	<b>51.2</b>	<b>1,948.9</b>	<b>2,477</b>
<b>FY 1966 - FY 1970 Subtotal</b>							<b>476.6</b>	<b>490.5</b>	<b>9,352.4</b>	<b>10,319.5</b>
<b>FY 1971-3/1999 Shipments from Atlantic Richfield (HVA)</b>							<b>0</b>	<b>0.2</b>	<b>0.1</b>	<b>0.3</b>
<b>4/84-4/87 Shipments from Rockwell (HRA)</b>							<b>0</b>	<b>0</b>	<b>3,088.29</b>	<b>3,088.3</b>
<b>FY 1971-3/1999 Shipments from United Nuclear (HXA)</b>							<b>5.4</b>	<b>1,431.3</b>	<b>2,186.34</b>	<b>3,623</b>
<b>9/88-4/89 Shipments Westinghouse Han (HUD)</b>							<b>0</b>	<b>0</b>	<b>123.64</b>	<b>123.6</b>
<b>FY 1971-3/1999 Shipments from PNNL (HYA)</b>							<b>14.2</b>	<b>20.2</b>	<b>24.1</b>	<b>58.5</b>
<b>FY 71 thru March 31, 1999 Subtotal</b>							<b>19.6</b>	<b>1,451.7</b>	<b>5,422.5</b>	<b>6,893.8</b>
<b>Grand MTU Total FY 52 thru March 1999</b>							<b>497.7</b>	<b>5,167.3</b>	<b>19,585.9</b>	<b>25,250.9</b>
<b>Grand MTU In-Scope Total FY 52 thru March 1999</b>							<b>497.7</b>	<b>5,167.3</b>	<b>19,585.9</b>	<b>25,250.9</b>

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**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 RIS	Hanford Contractor	Box #	Doc #	MTU DU	MTU NU	MTU EU	MTU All J Total
	From	To								
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
<b>FY 52 thru FY 65 Subtotal</b>							<b>2,753.7</b>	<b>91.1</b>	<b>1,564.2</b>	<b>4,409</b>
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
<b>Hanford Chem Processing Contractor subtotals</b>							<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>
1966	01-Jul-65	30-Jun-66	HXA	Douglas United Nuc	38214	HAN 95171	0	0.1	0	0
<b>Hanford FY Aggregate subtotal</b>							<b>0</b>	<b>0.1</b>	<b>0</b>	<b>0.1</b>
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
<b>Hanford Chem Processing Contractor subtotals</b>							<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>
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
<b>Hanford FY Aggregate subtotal</b>							<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>
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
<b>Hanford Chem Processing Contractor subtotals</b>							<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>
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
<b>Hanford FY Aggregate subtotal</b>							<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>
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
<b>Hanford Chem Processing Contractor subtotals</b>							<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>
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
<b>Hanford FY Aggregate subtotal</b>							<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>
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
<b>Hanford Chem Processing Contractor subtotals</b>							<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>
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
<b>Hanford FY Aggregate subtotal</b>							<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>
<b>FY 1966 - FY 1970 Subtotal</b>							<b>0</b>	<b>0.1</b>	<b>0</b>	<b>0.1</b>
<b>FY 1971 -3/1999 Shipments from Atlantic Richfield (HVA)</b>							<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>
<b>4/84-4/87 Shipments from Rockwell (HRA)</b>							<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>
<b>FY 1971 -3/1999 Shipments from United Nuclear (HXA)</b>							<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>
<b>9/88 -3/99 Shipments Westinghouse (HUD) &amp; Fluor (HTA)</b>							<b>2.94</b>	<b>0</b>	<b>0.01</b>	<b>2.95</b>
<b>FY 1965 -3/1999 Shipments from PNNL (HYA)</b>							<b>6.58</b>	<b>0</b>	<b>2.09</b>	<b>8.67</b>
<b>FY 71 thru March 31, 1999 Subtotal</b>							<b>9.5</b>	<b>0</b>	<b>2.1</b>	<b>11.6</b>
<b>Grand MTU Total FY 52 thru March 1999</b>							<b>2,763.2</b>	<b>91.2</b>	<b>1,566.3</b>	<b>4,420.8</b>
<b>Grand MTU In-Scope Total FY 52 thru March 1999</b>							<b>2,763.2</b>	<b>75</b>	<b>1,566.3</b>	<b>4,404.6</b>

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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

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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  $\text{UO}_3$  shipment is consistent with Hanford production history indicating  $\text{UO}_3$  test runs in January 1952 and full operation in February 1952. The primary recipient of early 1950s Hanford  $\text{UO}_3$  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%  $^{235}\text{U}$  before irradiation)  $\text{UO}_3$  to the K-25 facilities in Oak Ridge [Gifford 1959]. Hanford LEU  $\text{UO}_3$  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  $\text{UO}_3$  [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  $\text{UO}_3$ .

### 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,  $\text{UO}_3$  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

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(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].



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In the 1980s, UO<sub>3</sub> process pipeline storage capacity was 45.6 tons of UO<sub>3</sub>. Yard storage of UO<sub>3</sub> 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<sub>3</sub> which were, in turn, determined by chemical analysis of composite samples with the <sup>235</sup>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<sub>3</sub> 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<sub>3</sub> 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<sub>3</sub> 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

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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<sub>3</sub> Plant Control Laboratory composited samples of each ten (10) drum lot for each carload of UO<sub>3</sub> 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<sub>3</sub> 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  $4.6 \times 10^{-9}$  lb/ft<sup>3</sup> in a total air volume of  $2.9 \times 10^9$  ft<sup>3</sup>.

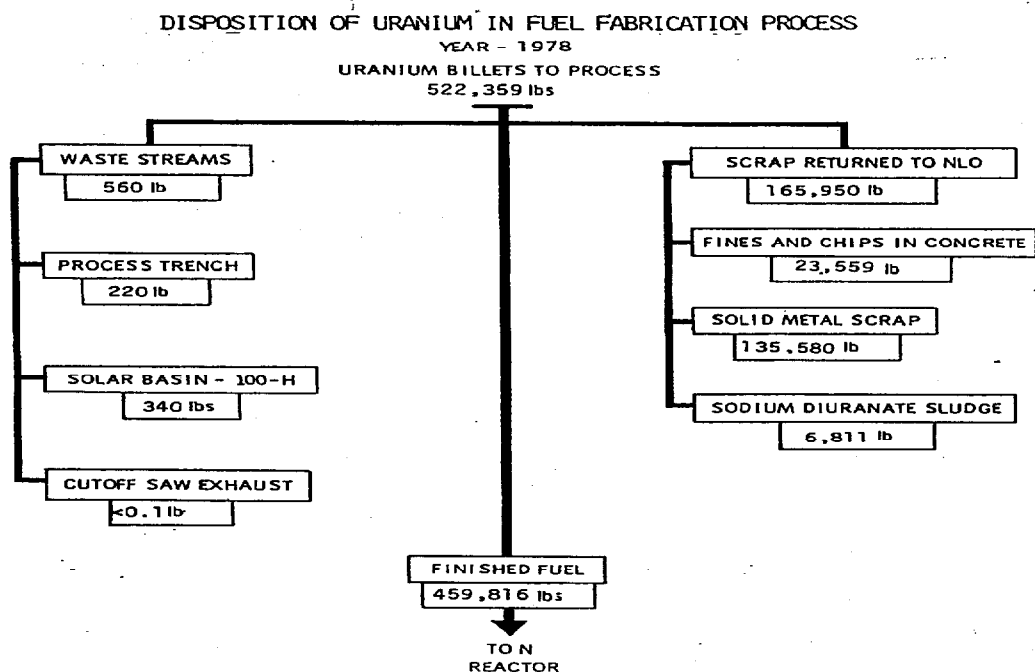
Solid uranium wastes, which included materials in failed and replaced equipment and normal line-generated process waste, were sent to Hanford burial grounds in the 300 and 600 Areas.

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.

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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.

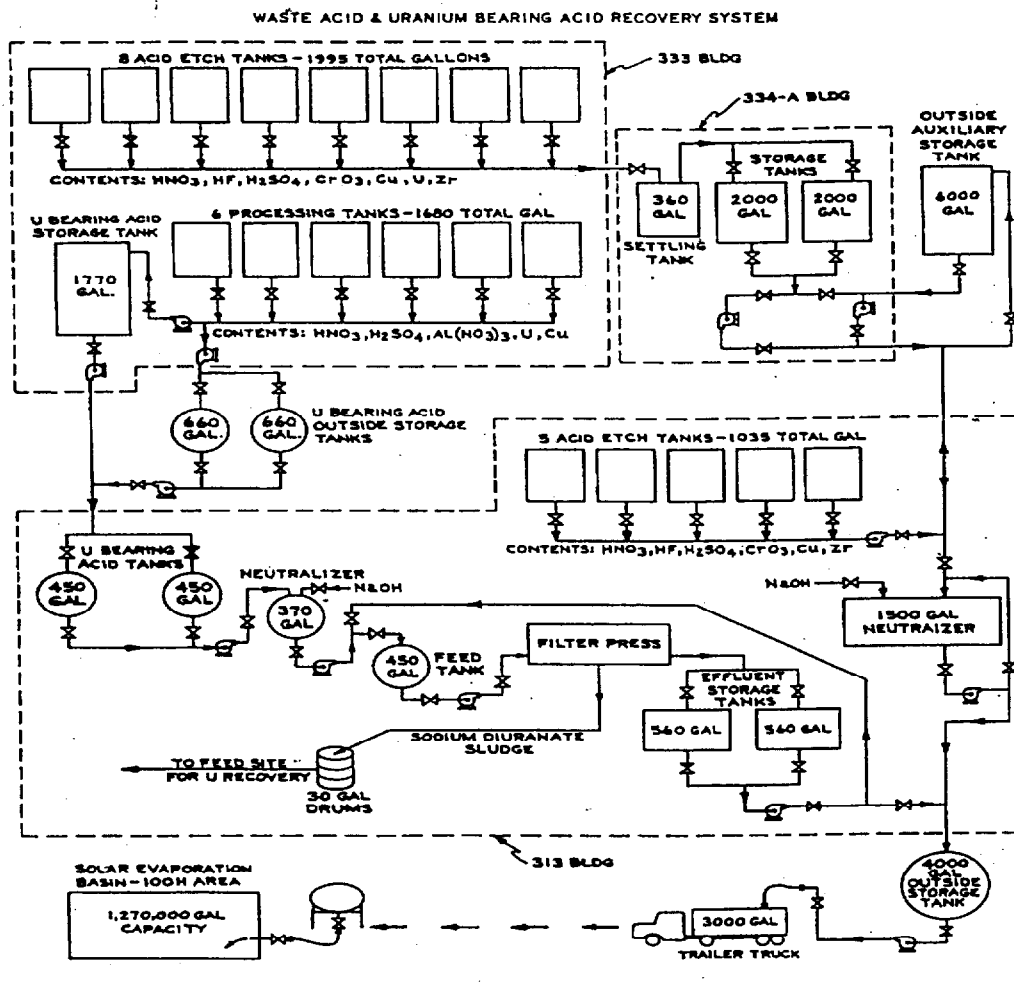
### 3.4.2.2 Liquid Effluent - Chemical Waste Containing Uranium

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.

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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.

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### 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<sub>3</sub>) Plant

The major unit operations performed at the UO<sub>3</sub> Plant were concentration of uranyl nitrate hexahydrate (UNH), calcination of UNH to UO<sub>3</sub>, packaging of the UO<sub>3</sub> 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<sub>3</sub> 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<sub>3</sub> content of the scrubber off-gas was negligible. The UO<sub>3</sub> product was conveyed to a cyclone separator where the UO<sub>3</sub> 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.

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### 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  $^{234}\text{U}$  and  $^{235}\text{U}$  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  $\text{BiPO}_4$  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



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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  $^{235}\text{U}$  in the uranium fuel to the reactors, and the percentage of  $^{235}\text{U}$  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  $^{238}\text{U}$ . Normal uranium (0.711 wt %  $^{235}\text{U}$ ) or low enriched uranium (0.94-1.25 wt %  $^{235}\text{U}$ ) was the feed to the reactors. The uranium recovered from processing was slightly depleted in  $^{235}\text{U}$ . 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  $^{235}\text{U}$  was fissioned in the reactors. If it is also assumed that 10% of the plutonium produced was also fissioned or transmuted, 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

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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. Secondly, 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 664.1 MTU 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 transmuted in the production reactors.

### Index Mapping for Summary Table 3-10:

Entry #	Table Reference (Receipts)	Entry #	Table Reference (Removals)
1.	Appendix B, Table 3.2.1	8.	Appendix B, Table 3.3.1
2.	Appendix B, Table 3.2.1	9.	Appendix B, Table 3.3.2
3.	Appendix B, Table 3.2.1	10.	Appendix B, Table 3.3.3
4.	Appendix B, Table 3.2.2	11.	Appendix B, Table 3.3.4
5.	Appendix B, Table 3.2.3		Appendix B, Table 3.3.5
6.	Appendix B, Table 3.2.4		Appendix B, Table 3.3.6
	Appendix B, Table 3.2.5		Appendix B, Table 3.3.7
	Appendix B, Table 3.2.6	12.	Appendix B, Table 3.3.8
	Appendix B, Table 3.2.7	13.	Section 5, Table 5.1.1
7.	Appendix B, Table 3.2.8	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**

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

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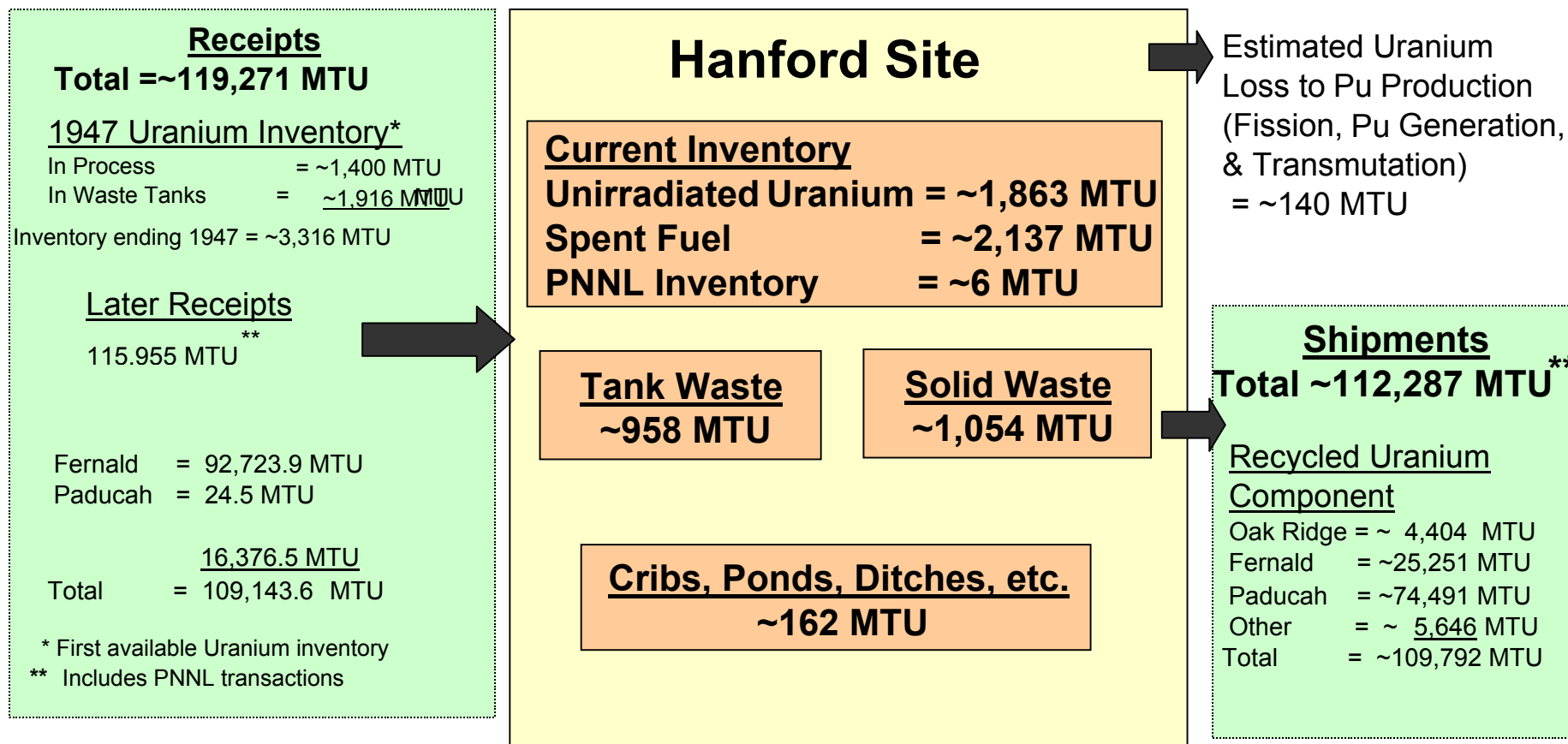
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**Figure 3-12 Hanford Uranium Mass Flow**

**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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### 4.0 Contaminants in Recycled Uranium

The earliest specifications on  $\text{UO}_3$  product for recycle required analyses to be performed for chemical and physical properties before it left the Hanford Site. Typical analyses included beta and gamma activity as a percent of aged natural uranium, metal impurities, density, particle size, plutonium, and sulfur. Prior to initiating the addition of sulfur, a chemical reactivity measurement was included to predict the effectiveness of the conversion of  $\text{UO}_3$  to  $\text{UF}_4$  in subsequent processing. Neptunium-237 analysis was not requested on the  $\text{UO}_3$  product until about 1978 and technetium-99 was not included in analysis requirements until 1985. Although specification threshold concentrations were proposed, neither isotope was included in the specifications. As a result, there is a wide variation in the quantity of data available for Pu,  $^{237}\text{Np}$ , and  $^{99}\text{Tc}$  contaminants in Hanford  $\text{UO}_3$ . This section focuses on the concentration of the three primary constituents of concern, Pu,  $^{237}\text{Np}$ , and  $^{99}\text{Tc}$ , although concentration data for other constituents are discussed.

#### 4.1 $\text{UO}_3$ Process Specifications

Processing specifications of the  $\text{UO}_3$  Plant interacted with those of the separations plants (U-Plant, REDOX, and PUREX) because the UNH product from the separations plants was the feed to  $\text{UO}_3$  Plant. The UNH did not leave the separations plant if chemical analyses showed the product to be outside the threshold concentrations in any constituent of concern unless the  $\text{UO}_3$  Plant manager granted prior approval. These threshold values were generally consistent through the years of  $\text{UO}_3$  operation and are described below.

##### 4.1.1 Feed Specifications

Feed specifications for the initial operation of the  $\text{UO}_3$  Plant are provided in the  $\text{UO}_3$  flowsheet included in Section 2.2.4.3. They indicate that the feed material from REDOX and U-Plants were tightly controlled, as the  $\text{UO}_3$  process provided no further purification of the uranium. The need for process control was recognized in the late 1940s and early 1950s, before the  $\text{UO}_3$  Plant came on line. Once decisions were made in the late 1940s to "enrich the depleted uranium back to normal concentrations" [Greenwalt 1947], questions were raised about "firm specifications for the final uranium product to be delivered from either the REDOX and the TBP Plants or an uranyl nitrate-oxide conversion plant at the Hanford works" [Greninger 1950]. The separation plants were originally designed on the basis that the recovered uranium would be sufficiently decontaminated with respect to Pu and gross beta and gamma activity to permit essentially direct physical handling of the final product in its last form at Hanford. It was also recognized at this early stage that subsequent processing at other plants might result in fractionation or concentration of either fission products or Pu and cause a need for more highly specific or greater decontamination than would be required at Hanford. A Pu concentration limit was defined in 1948 [Gamertsfelder 1948] based on the

## Contaminants in Recycled Uranium

tolerance level in breathing air. The conclusion was stated "that material with a purity limit of one part in 100 million parts uranium could be handled essentially as natural uranium." In a 1951 letter [Gamertsfelder 1951], the limit was again considered and it is stated that "reclaimed uranium should contain no more than one part plutonium in  $7.8 \times 10^6$  parts uranium" in order that the hazard due to breathing air contaminated with reclaimed uranium should be no more than 10% greater than for ordinary uranium. This value allowed a 10 ppb limit to be established and maintained throughout the history of the Hanford production era with greater than a ten fold conservatism factor built in.

### 4.1.2 Product Specifications

Threshold concentrations of constituents in UNH were included in technical manuals for both REDOX and U-Plants based on expected performance of the processes to purify the  $\text{UO}_3$  product. Both manuals set Pu concentration levels at 100 ppb [HW-18700 1951 and HW-19140 1951] but these threshold concentrations were not accepted by Oak Ridge, the Site responsible for setting standards for the  $\text{UO}_3$  Receiver Sites. Only product meeting the 10 ppb Pu specification were to be shipped. Negotiations continued between the sites into 1953 by which time the processes demonstrated the ability to meet a more stringent quality requirement.

Although firm specifications were reissued many times, (see Table 4-1) and changes were made in the beta, gamma, chemical reactivity, and metal impurities thresholds, the approved Pu specification value did not change. In 1951, Hanford proposed a Pu specification of 50 ppb but Oak Ridge held firm in maintaining the 10 ppb limit [Sapirie 1951]. Communications between Oak Ridge and Hanford continued into 1953 with adjustments to accept metal impurities up to 200 ppm with stipulations, but "in regards to the plutonium content, the specification of less than 10 ppb should not be exceeded and, if possible, the plutonium level should be even lower. Oxide received from Hanford has, in general, contained less than 5 parts per billion plutonium" [Sapirie 1953].

The product specifications for the  $\text{UO}_3$  Plant provided chemical and radiological requirements that had to be met. In 1953, based on operating experience, Hanford and Oak Ridge representatives agreed upon the properties of the Hanford  $\text{UO}_3$  to be included in a firm specification. These properties included fission product activity, Pu content, purity (uranium content), particle size, and volatile impurity content. "The maximum acceptable Pu concentration shall be ten parts of plutonium per billion parts of uranium. Plutonium shall be determined on each carload composite" [Smith 1953]. Table 4-1,  $\text{UO}_3$  Process Specifications, provides a list of the firm specification documents in place during the life of the  $\text{UO}_3$  Plant. The information in these documents show that the required Pu concentration specification remained unchanged.

### 4.1.3 Proposed Specifications

Product specifications for  $^{233}\text{U}$ ,  $^{232}\text{U}$ ,  $^{237}\text{Np}$ , and  $^{99}\text{Tc}$  were also discussed but not adopted. In 1962, it was proposed that the maximum concentration of  $^{233}\text{U}$  be set at 90 ppm on a  $^{235}\text{U}$  basis, and  $^{232}\text{U}$  be set at  $1.10\text{E}-2$  ppm on a  $^{235}\text{U}$  basis [Judson 1962]. In

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**Table 4-1 UO<sub>3</sub> Process Specifications**

Document Number	Title	Date	Pu Spec. Ppb	Laboratory Analysis Ref
HW-35938	UO <sub>3</sub> Product Specifications	1955	10	
HW-30654, Rev	Product Specifications Uranium Trioxide (Depleted) for Off-Site Shipment	1959	10	HW-24403 660.22
HW-59136	Product Specifications Uranium Trioxide (Depleted E Metal) for Off-Site Shipment	1959	10	HW-24403 660.22
HW-79219, Rev	Product Specifications Uranium Trioxide (Depleted E Metal) for Off-Site Shipment	1964	<10	HW-65402, Rev
Sloat 1964	Product Specifications Uranium Trioxide (Depleted) for On-Site Storage	1964	<10	HW-65402, Rev
HW-79219, Rev 2	Product Specifications Uranium Trioxide (Depleted E Metal) for Off-Site Shipment	1965	<10	HW-65402, Rev
ISO 528	Product Specifications Uranium Trioxide (Enriched to < 1% U <sup>235</sup> ) for Off-Site Shipment	1967	<10	HW-65402, Rev
ARH 896	Product Specifications Uranium Trioxide Depleted Normal (72) Metal	1969	<10	HW-65402, Rev
ARH 1396	Product Specifications Uranium Trioxide Depleted Normal (72) For Off-Site Shipment	1969	<10	ARH-85
ARH 1396, Rev	Product Specifications Uranium Trioxide Depleted Normal (72) For Off-Site Shipment	1970	<10	ARH-85
ARH 1493	Specification for PUREX UNH Product	1970	10	ARH-85
ARH 1763	Product Specifications Uranium Trioxide (Enriched to < 1% U <sup>235</sup> ) for Off-Site Shipment	1970	<10	ARH-85
AEC-2202	Product Specifications Hanford Uranium Trioxide	1971	<10	ARH-85
OSD-U-185-0001	Uranium Oxide Plant Operating Specifications	1983	<10	
OSD-U-185-0001	Uranium Oxide Plant Operating Specifications	1986	<10	
OSD-U-185-0002	Uranium Oxide Plant Operating Specifications	1992	<10	

1971, a <sup>237</sup>Np specification of <1 ppm for a lot composite and <0.3 on 10 lot composites [Corlew 1971] was discussed but not adopted. In 1982, a <sup>99</sup>Tc specification of 0.4 ppm was discussed [Miskho 1982, McClusky 1982]. It was implied that there was a 400 ppm limit for <sup>99</sup>Tc, but it has never been part of the Hanford product specifications for UO<sub>3</sub> product.

#### 4.1.4 Non-Radiological Contaminants

In addition to primary (radiological) contaminants of concern, the concentration of other constituents were also analyzed and determined to be below specification limits. Since these constituents were based on uranium concentration and the UO<sub>3</sub> process did not significantly reduce the concentration of impurities received in the UNH feed, the same specifications were applied to the separations plants. Infrequently, UNH was

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transferred from the separations plants to the UO<sub>3</sub> Plant with prior approval if the UO<sub>3</sub> Plant had material on hand that could be blended to bring the out-of-specification material to within specification concentration.

Figure 4-1, an example page from one of the specification documents, is included for completeness. It defines the threshold quantity of impurity that was allowed and the analytical method that was used to generate the result.

HW-59236	
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<u>Analysis</u>	<u>Method Ref.</u>
Sodium	1000.1, 769
Calcium	1000.1
Aluminum	1000.1
Iron	1000.1, 515.25
Chromium	1000.1, 341.1
Nickel	1000.1
Density, bulk	847.2
Density, packed	847.5
<b>3.22 Properties with Established Limits</b>	
<b>3.22.1 Gamma Activity</b>	
Gamma activity due to fission products shall be determined on each carload composite. For the purpose of setting the average acceptable gamma activity, shipments of uranium oxide will be considered in designated blocks of ten consecutive carloads. The average acceptable gamma activity due to fission products for a block shall not exceed 100 percent of the gamma activity for aged normal uranium. For the purpose of setting the maximum acceptable gamma activity specification, one carload shall be considered a unit. The maximum acceptable gamma activity for a unit, due to fission products, shall be 300 percent of the gamma activity of aged normal uranium.	
<b>3.22.2 Beta Activity</b>	
Beta activity due to fission products shall be determined on each carload composite. The maximum acceptable beta activity due to fission products shall be 100 percent of the beta activity of aged normal uranium.	
<b>3.22.3 Plutonium Content</b>	
Plutonium shall be determined on each carload composite. The maximum acceptable plutonium concentration shall be ten parts of plutonium per billion parts of uranium.	

**Figure 4-1 Example Page of Specifications for UO<sub>3</sub> Plant**

### 4.2 Recycle UO<sub>3</sub> Processing

Each of the separations processes (i.e. U-Plant, REDOX, PUREX) sampled the UNH product prior to sending it to a load-out tank for transfer to the UO<sub>3</sub> Plant. This internal transfer was not made until the analytical results were completed. If the UNH material was out of specifications in any respect, the material was recycled back to the partitioning cycle and reworked before being transferred to the UO<sub>3</sub> process [HW-25744 1952]. Weekly and monthly reports contain several examples of this rework being necessary during the early years of Hanford operations. In the REDOX process, this rework was most commonly necessary to reduce the fission product activity rather than



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for reducing the levels of the three primary constituents of concern. There was a final silica gel extraction for removal of zirconium/niobium-95 ( $^{95}\text{ZrNb}$ ), if those radionuclide concentrations were found to be high. This step was omitted if the UNH was found acceptable without employing this process step. Laboratory oriented, research and engineering flowsheet improvements were provided on a continuous basis through the operational life of each process. In addition, Process Engineering Support monitored and evaluated process operations on a daily basis. A few examples of these activities are recorded in the weekly and monthly reports and are included below to demonstrate the attention that was paid to UNH product quality in the separations plants and the  $\text{UO}_3$  product. In spite of this strict adherence to UNH specifications, five references have been found that document the shipment of  $\text{UO}_3$  product with Pu concentrations outside the 10 ppb limit. These citations are included in Section 4.2.1. Although Hanford documents indicate these shipments were made after approval was obtained from of the receiver site, copies of receiver site acknowledgement of these notifications have not been located.

### 4.2.1 Processing Issues

During processing at the separations operations (REDOX, PUREX, U-Plant), upsets occurred that caused the UNH product to be outside the acceptable specifications in one or more constituents. Provisions were made during the construction of these facilities for taking remedial actions without exacerbating the entire process. Provisions were made for storage and rework of the UNH prior to transfer to the final loadout tanks. The U-Plant process provided alternative decontamination of REDOX UNH from impurities prior to transfer to the  $\text{UO}_3$  process. There are also records that document the transfer of UNH produced in the U-Plant process to REDOX for decontamination of  $^{95}\text{ZrNb}$ . In PUREX, provisions were made for rework of the UNH prior to transfer to the staging tanks if the product was found to be outside the specification.

### 4.2.2 Typical Hanford Responses

The following items are presented to provide examples of the types of issues addressed by the Process Operations and the laboratory-oriented Research and Engineering organizations: (These items are not listed in chronological order and only items that pertain to UNH product quality have been included. All items found addressing Pu issues have been included.)

- Provisions were made to "ship all  $\text{UO}_3$  which fails to meet specifications for impurities, other than radioactive contaminants, to the Harshaw Chemical Company" [Shaw 1952]. A number of railcar shipments (numbers 77-87, 90, 93, 94, 96, 98) are recorded from July through September 1953) as being sent under this directive. Sodium contamination was a continuing problem in the UNH recovered from the waste tanks by the U-Plant. Iron concentrations above acceptable thresholds from corrosion were a recurring issue. These recurring non-conformance issues continued throughout the 1950s.

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- In 1953, a weekly report for REDOX [Christy 1953] states that six batches of UNH in excess of gamma specifications were sent to storage for decay of  $^{237}\text{U}$ .
- A firm specification was included in the REDOX and PUREX process operations that limited the concentration of plutonium allowed in the UNH product. Several references are recorded that indicate UNH transfers were held up awaiting analytical results on the process samples to verify that the product met the specification [HW-50584-DEL 1957].
- Several examples were encountered of  $\text{UO}_3$  produced from PUREX UNH that was outside the acceptable threshold for iron concentration [HW-48835-DEL 1957]. The excessive iron contamination in the final  $\text{UO}_3$  was found to originate in the  $\text{UO}_3$  Plant rather than in PUREX.
- An extensive investigation of analytical methods was initiated to resolve an apparent discrepancy of plutonium values in uranium as reported by REDOX and PUREX Laboratories. Subsequently, a real discrepancy was found to exist between results obtained by two different methods employed in the different laboratories. An analytical procedure was accepted that both laboratories subsequently used [HW-48835-DEL 1957].
- Conversion of UNH to  $\text{UO}_3$  was frequently hampered by foaming in the pot calciners. The identified source of this issue was the organic extractant, used in the U-Plant process, that contaminated the aqueous UNH feed. This issue was resolved when the continuous calciners were put into service.
- A shipment (carload #8) was made to Harshaw that contained 30 ppb Pu in 1952 [Richards 1952d].
- Three cars of continuous calciner powder were outside shipping specifications, however, they were accepted by the customer prior to shipment. The reason one car (UA-16) contained 16 ppb plutonium concentration was unexplained since the UNH feed was determined to be within the 10 ppb limit [HW-48835-DEL 1957]. An investigation was initiated that resulted in a modified procedure [HW-50584-DEL 1957] that eliminated the bias due to neptunium coextracting with the plutonium in the final uranium analyses. The quantity of powder represented is not given specifically but (at this time) the usual shipment contained 10 drums, each containing 900 pounds, which comprised one carload. These shipments were made prior to use of T-Hoppers which contained 4.5 metric ton of  $\text{UO}_3$ . The  $\text{UO}_3$  in one car exceeded the iron limit of 50 ppm and the third car exceeded the particle size specification of 98% passing a 40 mesh screen.
- In December 1953, a shipment of  $\text{UO}_3$  product was made to Paducah, after acceptance by Oak Ridge, with 19 ppb Pu [Christy 1954].

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- In January 1954 an additional two cars, numbers 148 and 149, of  $\text{UO}_3$  product were shipped to Paducah with 13 and 12 ppb Pu respectively. Lot 148 resulted from poor quality REDOX UNH and Lot 149 resulted from poor U-Plant UNH [Christy 1954a].
- A T-Hopper (T 58) was returned to the Hanford Site with residual material from the shipment of GDP tails from Paducah to Fernald. Typical quantities of residue in these containers is approximately two kilograms. Information from Fernald indicates that the ash heel in this T-Hopper was 900 grams, was 40.69 wt. % uranium, and contained ~7,760 ppb plutonium, and ~25,300 ppb neptunium on a uranium basis. T-Hopper T 58 was subsequently refilled with  $\text{UO}_3$  and is in storage at Hanford.

### 4.3 Analytical Laboratories

In the Hanford separations areas, buildings with the designation of "222" were laboratory facilities (222-B, -T, -S, and -U Labs) that supported the separations facility with the corresponding letter designation. As the only laboratory incorporated into its process building, the PUREX laboratory did not carry its own building designation. Analytical services for the  $\text{UO}_3$  Plant were provided by the 222-S Laboratory after the Metal Recovery and TBP processes were discontinued and the U-Plant laboratory was closed. These measurements continued in 222-S Laboratory until the  $\text{UO}_3$  process was put in standby in 1972. During restart of the  $\text{UO}_3$  process in 1983, the Plutonium Finishing Plant (PFP) Laboratory provided analyses for a short period until the testing could resume at the 222-S Laboratory. It continued there until the  $\text{UO}_3$  process was closed again in the late 1980s. The exception to this statement is that all uranium isotopic analyses and total metal impurities measured by emission spectroscopic analyses were performed at the PFP laboratory.

#### 4.3.1 $\text{UO}_3$ Product Sampling and Subsampling

Reliable analytical measurements were dependent on the adequacy of sampling and subsampling of the stream to be characterized. A new continuous sampler was designed for use when the continuous calciners were installed [Gustafson 1957]. This sampler was to replace a screw-type, continuous sampler used in the 224-UA unloading system to sample material produced in the pot calciners. A proportional sample was collected for analysis while each T-Hopper or pallet of four drums was being filled with  $\text{UO}_3$  product.

Continuous collection is generally recognized as an appropriate methodology for reliably sampling a stream that may have variability in composition. By collecting a portion of the bulk product as it is made or moved, variations in any constituent of concern will be sampled in relation to the extent that the constituent is present in the overall product.

When a sample arrived at the laboratory, it was placed on a tumbler-mixer and thoroughly homogenized before any aliquots were extracted for any purpose. After

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homogenization, a subsample was removed from each sample to build a composite representing a "lot" of material. A "lot" normally represented ten T-Hoppers or sixty drums of  $UO_3$  powder. This composite was again tumbled to effect thorough mixing before any subsampling was performed for either archive or analyses. In addition, a subsample of each sample was collected, sealed to exclude moisture, and stored separately for archive. Analytical measurements were then made of subsamples taken from the lot composite.

### 4.3.2 Analytical procedures

Procedures were developed for monitoring impurity levels and product quality through the separations processes while flowsheet testing of those processes was in progress. These procedures were transferred to the analytical laboratory supporting each process. Changes to these procedures were controlled and implemented only after closely controlled tests were conducted to verify performance. New methods of analysis were implemented to provide improved productivity or quality over the method being replaced. As higher resolution instrumentation became commercially available, especially for radionuclide characterization, these instruments were placed in use only after rigorous acceptance testing and approval of the change by the Process Engineering of the  $UO_3$  Plant. The original procedures to be used were collected in a procedure manual [McIntosh 1952]. That document replaced a preliminary manual, HW-12864, 1950. The Product Specifications documents identified the analytical procedures to be used for monitoring the product quality of  $UO_3$  shipped off-site, as shown in Table 4-1. The process control laboratories for REDOX, U-Plant, and PUREX were allowed to modify the procedures used on the UNH with technical justification but not without complex wide acceptance. Procedure differences were present between the laboratories and generally, the  $UO_3$  Laboratory procedures were the last to be changed because of the time required to obtain approvals.

Uranium concentrations were measured in UNH feed by density and nitric acid concentration. Because the UNH was very uniform, and had low impurity levels, the concentration was directly proportional to the density. This measurement method was very precise and accurate as long as the stream was within accepted impurity concentration thresholds. Other methods were used in the separations processes, such as X-ray photometer and spectrophotometry. These methods provided a more robust measurement in the event the uranium concentration did not meet the specifications or impurities were unexpectedly found by other analyses to be significant and affect the density methodology.

A gravimetric analysis was performed on the  $UO_3$  product in which the  $UO_3$  was converted to  $U_3O_8$ . This treatment eliminated contributions from water and corrections were made to account for the total metal impurities and sulfur associated with this compound.

The analysis methodology used for plutonium contamination was included in the original document [HW-12864 1950] although in 1960, this method was modified to improve the

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separation of plutonium from uranium and other alpha emitters [HW-65402 1960]. The formal mechanics of these methods are shown in a letter recommending substitution of an improved plutonium method from the previous accepted methodology [Harmon 1957]. This modification was included in the 1960 UO<sub>3</sub> process specification. Most (but not all procedures) of the established specification analyses were later documented in ARH-85 1970.

Plutonium was isolated from other alpha emitters and interferences by extracting it into thenoyl-trifluoro-acetone from a mildly acidic sample. The method is dependent on plutonium being in the extractable +4 oxidation state. The separation from uranium is effected by washing the extracted uranium from the organic phase with high concentration nitric acid. Alpha activity from <sup>237</sup>Np contributed to the plutonium alpha activity which was measured for determining the plutonium content. This resulted in a high-biased plutonium analysis. An estimate of the potential bias introduced can be calculated using the ratio of specific activities of <sup>239</sup>Pu (1.30E11) and <sup>237</sup>Np (1.56E9) and the relative concentrations of each (10 ppb and 500 ppb respectively). The Np could have introduced a high bias to the Pu result by as much as 30 percent if the Np came through the procedure quantitatively. If the Pu concentration was already near the 10 ppb limit, this contribution could be considered significant. A modification was made to the method in 1960 to improve separation of plutonium from neptunium. The modification included a reduction step that also reduced the oxidation state of neptunium and only the plutonium was reoxidized for extraction. The basic technology of the analytical method remained consistent throughout the rest of the history of the UO<sub>3</sub> process.

Prior to the mid-1950s, beta and gamma activity of UO<sub>3</sub> powder was determined using a Geiger-Mueller tube with a mica end window. During the gamma measurement, the beta activity was shielded out with an aluminum-lead-aluminum absorber. This provided a best estimate relationship of beta activity to gamma emissions. The Shonka instrument, a high-pressure ionization chamber, replaced the G-M tube. Absolute measurements were not possible on a control basis with the Shonka. Empirical controls and relationships to aged natural uranium were re-established to define relative changes in product quality. It was assumed at that time, based upon process knowledge, that product UO<sub>3</sub> would exceed the gamma activity threshold before reaching the beta threshold. Results from these instruments were likely biased high due to decay daughters of strontium-89 and strontium-90, if present, because of their high energy beta emission. In 1966, a modification was presented for measurement of beta and gamma activity with instrumentation that could attribute the gamma activity to specific fission products. Gamma scintillation counters replaced the Shonka after negotiations were concluded between Hanford and the recipients of the UO<sub>3</sub> product [Knights 1966]. In 1967, the UO<sub>3</sub> product specification established an upper limit of 15 uCi / lb. U for <sup>95</sup>ZrNb, 50 uCi /lb. for the combination of <sup>103</sup>Ru<sup>106</sup>RuRh, and 2 uCi /lb. for all other isotopes excluding <sup>99</sup>Tc. Ten lot average values were also established with the values for <sup>95</sup>ZrNb, <sup>103</sup>Ru, and <sup>106</sup>RuRh and others limited to 10, 25, and 0.5, respectively [Knights 1966].

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Introduction of the Beckman, Wide Beta II<sup>®</sup> Counter, provided the ability to measure beta activity directly rather than calculating the beta activity from the beta/gamma measurements. Since ruthenium isotopes produced the majority of beta activity, the beta specification threshold was eliminated as a routine measurement. Although the Wide Beta II<sup>®</sup> instruments exhibited superior sensitivity to the prior instruments, the beta measurements did not adequately represent the Tc concentration in the sample. Chemical separations were required to isolate the <sup>99</sup>Tc from all other beta emitters before quantitation. This was not requested until the restart of the UO<sub>3</sub> Plant in 1984. In later tables of this section, both the previous beta/gamma percent and specific radionuclide activities are presented.

Neptunium and technetium methods were not included in the original Hanford Works documents, nor are there single accepted methods for the measurements available today. For that reason, technologies developed at the on-site laboratories were applied after extensive testing and application to the UNH matrix. Reliable neptunium measurements were not made on UO<sub>3</sub> until 1969 and technetium analyses were not performed until 1985. Chemical standards with the isotope were included during the analyses to verify method performance.

An emission spectrograph provided the total metal impurities measurements on all UO<sub>3</sub> product. This methodology was originally procured for quantitation of Pu product in the PFP and when the need for analyses of UO<sub>3</sub> arose, aliquots were sent to PFP for analyses. The same logic was used for the uranium isotopic analyses that were also performed at PFP.

### 4.3.3 Analytical Methods and Errors

Each analytical method has an uncertainty associated with the measurement that can be attributed to either random or fixed errors. Both types must be considered and with appropriate data can be evaluated individually using statistical methods. The total uncertainty of a measurement is the combination of the two types. Fixed errors are those usually associated with the chemistry of the method such as extraction coefficients, volumes of vessels, and sampling. Random errors are those that are not repetitive such as degradation of chemicals used in the measurement and inadvertent use of incorrect supplies.

Combining both types of errors provides an error band that estimates the minimum and maximum concentration of a measured constituent that may be present in a sample. Certain of these parameters are easy to assess, but others are much more difficult to establish and monitor over time. During the development of a procedure, the fixed error contribution is defined and documented. The method is only put into service if it meets the measurement criteria established to support the use of the resulting data.

Early analyses of Pu were biased high from the effect of Np being coextracted during the separation of Pu from the sample matrix. This contribution was small when the UO<sub>3</sub> was not recycled and the <sup>237</sup>Np concentration was small compared to the concentration

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of Pu. As preparations were made to separate  $^{237}\text{Np}$  as a co-product, its contribution increased. The accuracy of the plutonium measurement was estimated to be  $100 \pm 20\%$  at the 99% confidence interval. Radioanalytical precision available at the time ranged from plus or minus 2 to 4% for gross beta, and plus or minus 0.2% to 10% for gross gamma depending on sample size [HW-19140 1951]. Emission spectrographic instrumentation provided data that was reliable within step ranges (20-50 ppm, 50-100 ppm), for each element. Unique quantitation values were not available on multi-element instrumentation until inductively coupled plasma atomic emission spectrometry became available in the late 1960s. Consequently, there are variations in early documented metal impurity data that may not be reproducible with current instrumentation.

### 4.3.4 Quality Assurance

Analytical procedures were written that implemented the standard methods documented in the manuals HW-12864, HW-24403, and HW-65402, cited earlier. Although laboratory-specific procedures were given different identification numbers, the technology remained the same. Details were modified to conform to specific instructions from the  $\text{UO}_3$  Process Engineering organization, implementation of new instrumentation, or to provide more specificity to the measurement.

#### 4.3.4.1 Quality Assurance Program

An extensive quality assurance program was developed for use by the laboratories performing specification analyses in support of the  $\text{UO}_3$  process. This program was primarily focused on the measurement of uranium, but included very limited standards data to monitor the performance of analytical methods for other constituents as well. The program consisted primarily of blind standards and in-house referee analyses. The percent average recovery and precision of the average (95CL) was reported and used by the nuclear material control organization to apply a bias correction to the uranium shipment data if necessary [Rochon 1972]. The uranium measurement threshold limit for percent average recovery was about  $100 \pm 0.5$  percent, but concern was raised if the result exceeded  $100 \pm 0.1$  percent. A chemist was assigned to oversee and approve all results generated by the laboratory technicians. This methodology was directly applicable to the UNH received by the  $\text{UO}_3$  Plant.

The measurement for uranium in  $\text{UO}_3$  was sufficiently reliable that it did not require monitoring. Temperature and laboratory balances used were routinely calibrated according to accepted standards of the time. However, in 1961-1962, there were shipper-receiver discrepancies recorded in the uranium analyses. Investigation of the discrepancy was resolved by finding that hygroscopic  $\text{UO}_3$  picked up water during shipment and storage before the measurement was made at the receiver site. These differences were less than one percent but resulted in a significant bias in uranium material balance.

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### 4.3.4.2 In-House Standards Program

An in-house standards program included synthetic UNH solutions (UNH from natural uranium) to which known quantities of the impurities of concern were added. These standard solutions were analyzed as a sample at a periodicity that would provide statistically significant quantities of data within the monitoring period, normally one month. During high production periods, these standard results were plentiful, however as the process was shut down for extended periods, data were not generated in sufficient numbers to be statistically evaluated for all constituents. Although sample preparation was performed in a laboratory room dedicated to uranium, analytical instruments were shared with other operations of the analytical laboratory. Standards results were not necessarily exclusive to the UNH or UO<sub>3</sub> product. The percent average recovery of the Pu measurements was maintained at  $100 \pm 10$  percent at the 95 percent confidence interval. Neptunium quantitation was held to  $95 \pm 15$  percent.

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) AEC-wide Measurements Program; 2) Fissionable Standards Samples Committee; and 3) Sample Exchange Program. These programs were supported by the AEC and its contractors and provided different emphasis. They continued until sufficient reliability was demonstrated that significant differences in analytical results would not be encountered.

Also in the early 1950s, Hanford continued to support quality assurance efforts to validate both the measurement techniques and product quality. Early correspondence between the New York Operations Office (NYOO) and Hanford indicates that UO<sub>3</sub> data between Oak Ridge and Hanford correlated very closely in that:

- For both labs, the precision of mass spectrometry was 0.006%.
- For both labs, the sampling was by aliquot and was nearly foolproof.
- Comparison between Hanford General Electric (HGE) and Carbide and Carbon Chemicals (CCC K-25 Oak Ridge) shipment analysis showed five cases of agreement at 0.64%; one case of agreement at 0.65%; and two cases of difference of 0.01%. Averaging the above shows that in eight cases there is a difference of 0.00250% between the two laboratories. This represented 9.48 pounds of <sup>235</sup>U out of 399,699.06 pounds of UO<sub>3</sub> shipped. The conclusion is that HGE analyses for Harshaw shipments are of the same reliability as above.

An independent referee program was continued throughout the uranium recycling effort to monitor the analytical processes at the participating sites. The program established that aliquots of each container and lot composites were prepared and sent to the Site receiving the lot shipment. Since analytical measurements were performed at the receiver's site on material from the same composite, this effected a double-blind



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external referee program. Shipper-receiver differences were tracked by the Nuclear Materials Accountability personnel. If there were significant differences, the event was investigated at both locations and the differences resolved. Limited data is available that shows some differences in concentrations of plutonium were present on individual lots as expected, but were probably within the combined (two site) error band of the measurement. This inter-site comparison has not been performed.

Agreement on the Pu concentration between Hanford and Oak Ridge was more problematic in the 1952-1953 time period [HW-27314 1953]. Hanford generated data was apparently significantly lower than the Oak Ridge analysis of the same  $\text{UO}_3$  powder. However, in one sample of four, the Pu concentration agreed. Documentation with resolution of this issue was not found.

### 4.4 $\text{UO}_3$ Analyses:

Production of  $\text{UO}_3$  product for recycle was continuous from inception in 1952 until the PUREX and  $\text{UO}_3$  Plant were placed in stand-down in 1972. By the time these processes were restarted in 1983, additional measurements were made that included  $^{237}\text{Np}$  and  $^{99}\text{Tc}$  although there was no threshold specification on the allowable concentration. Data is separated in the following sections only because of the discontinuity of operations. The sources of data used in the following subsections are gleaned from records as near to the final  $\text{UO}_3$  shipment report as possible. The only data sources available prior to 1984 for  $^{237}\text{Np}$  and  $^{99}\text{Tc}$  concentrations are the specifications imposed on the process facilities, REDOX or PUREX, and a few special analyses performed on UNH at the  $\text{UO}_3$  Plant.

#### 4.4.1 Impurity Concentrations in UNH

As described earlier, the  $\text{UO}_3$  process made no significant changes in the impurity concentrations of the incoming UNH. Sulfur was added to the UNH after the mid-1950s to improve the conversion of  $\text{UO}_3$  to  $\text{UF}_4$  at the receiving site. The concentration was varied from about 300 to as much as 3000 parts sulfur per million parts uranium according to the requests of the receivers. Radioisotopes and volatile compounds were present in the UNH feed to the  $\text{UO}_3$  Plant. Some minor concentrations of ruthenium and other volatile fission products were volatilized during the calcination process strictly due to their volatility. The conversion of UNH to  $\text{UO}_3$  evolved large quantities of nitrogen oxides. The majority of volatilized  $\text{NO}_x$  and some fission products were collected in the off-gas treatment system and returned to the PUREX Plant. Low concentrations of fission products were also included in wastewater discharged to the soil column. Constituents that were not volatilized remained in the  $\text{UO}_3$  product.

#### 4.4.2 Analyses Performed and Results

After conversion of UNH to  $\text{UO}_3$ , chemical analyses were performed on each lot, representative samples from which consisted of ten containers (when using T-Hoppers) or sixty drums. During heavy production, when both REDOX and PUREX were

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operating in the late 1950s through the mid-1960s, both slightly depleted and low enriched uranium was processed simultaneously in the UO<sub>3</sub> Plant.

### 4.4.3 Storage/Shipment of UO<sub>3</sub>

The UO<sub>3</sub> product was shipped as rapidly as possible when uranium fuel was in short supply nationally until 1964. Table 4-2 summarizes plutonium concentrations in uranium shipped in 1952 and low enriched uranium shipped from 1962 to 1972. Source documents have not been located to complete all time periods and therefore there are discontinuities in the car/lot numbers. The reason for this distinction is that after 1964, LEU UNH was separated from irradiated fuel in the REDOX process while depleted UNH was separated in the PUREX process. The segregation of data provides a measure of REDOX and PUREX capability to purify UNH independently. (Detailed information is shown in Appendix C, Tables 4-1 and 4-2.)

**Table 4-2 Summary of UO<sub>3</sub> Shipments In 1952 and LEU 1967 - 1972**

Car/Lot #	Month Shipped	Pu (ppb U)		References
		Minimum	Maximum	
007 to 009 <sup>(1)</sup>	Mar - 52	<5	<5	[Richards 1952]
010 to 013 <sup>(1)</sup>	Mar - 52	<1	<5	[Richards 1952a]
026 to 035	May - 52	<5	<5	[Richards 1952e]
036 to 045 *	Jun - 52	<5	<5	[Richards 1952b]
046 to 057 *	Jun - 52	<5	<5	[Richards 1952f]
77 to 88 (composite)	Aug - 52		9	[Richards 1952g]
197 to 200 *	Nov - 52	3	3	[Richards 1952c]
E-58 and E-59 *	May - 62	2	4	[Gifford 1964]
E-122 to E-221 and E-223	Jan - 65 to Aug - 67	<1	10	[Madeen 1967]
E1-8-1 to E1-8-12	Sep - 71 to Oct - 71	<1	9	Analytical Report
E1-9-1 to E1-9-15	Oct - 71 to Nov-71	<1	4	Analytical Report
E1-10-1 to E1-10-8	Nov - 71	<1	5	Analytical Report
E2-2-1 to E2-2-12	Feb - 72 to Mar - 72	2	4	Analytical Report

<sup>(1)</sup> Trial Lots

**\* Note:** Weekly/Monthly Reports available for the period 1952-1962 were examined and except for the five lots identified in Section 4.2.1, Process Issues, statements were made that the UO<sub>3</sub> product met the Pu specification. Reports for the years 1954 and 1958 have not been located.

Weekly Summary Reports for the period June 29, 1956 through August 31, 1956, reported plutonium concentrations in UNH produced in the U-Plant averaged 2.6 ppb

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with a maximum of 7.5 ppb and minimum of < 1 ppb. The average gamma percent for this UNH was 87 % of aged natural uranium. These are limited data, but they indicate the ability of the U-Plant Process to produce UNH that comfortably met the 10 ppb specification.

### 4.4.4 Storage of UO<sub>3</sub> at Hanford

Due to shutdown of facilities producing UF<sub>6</sub> at Paducah, Hanford-produced depleted UO<sub>3</sub> was stored at Hanford [Sloat 1964]. The enriched (nominal 0.8 wt% <sup>235</sup>U) was milled and packaged in T-Hoppers while the depleted (nominal 0.6 wt% <sup>235</sup>U) was packaged in 55 gallon drums for storage when the T-Hoppers were not available.

Plutonium and fission product concentrations on lots of depleted UO<sub>3</sub> packaged in drums and stored at Hanford are summarized in Table 4-3; more detailed reports are presented in the Appendix C, Table 4-3. A data package [ISO-877 1967] provided this product information for the time period from May 1964 through June 1967. The data covers 352 lots of drummed material that were processed during the 32-month period. The average plutonium concentration for the 352 lots was 2.2 ppb uranium with a low of <1 ppb and a high of 8 ppb. It should be noted that the plutonium concentration exceeded 5 ppb on only six lots out of the 352 and these were only 6, 6, 6, 7, 7 and 8 ppb. None exceeded the 10 ppb specification.

The data package includes concentrations of specific radioisotopes, and gross beta and gamma radiation levels during periods when the measurements were made. The average beta radiation for 317 lots for which data is available was 6.53% of the beta radiation level of aged natural uranium and ranged from a low of 0.31% to a maximum of 36.5%. The average gamma radiation level was 78.2% that of aged natural uranium and ranged from a low of 3.9% to a maximum of 212%.

The gross beta and gamma data were not included for the last 35 lots; however, activity levels for specific isotopes (<sup>95</sup>ZrNb, <sup>103</sup>Ru and <sup>106</sup>RuRh) were documented for the last 52 lots in the data package. The average <sup>95</sup>ZrNb activity was 4.58 μCi/lb of uranium with a range of 1.23 to 38.76 μCi/lb. It should be noted that the data is fairly consistent except for two entries that appear to be calculation errors that are off by a factor of ten. If these two entries (38.76 and 20.18) are corrected, the average activity becomes 3.56 μCi/lb of uranium and the range is 1.23 to 7.04 μCi/lb. The average <sup>103</sup>Ru activity was 0.29 μCi/lb and the range was from unmeasurable to 2.79 μCi/lb. For <sup>106</sup>RuRh, the average activity was 0.44 μCi/lb of uranium and the range was from unmeasurable to 1.78 μCi/lb.

This material whose analytical results are presented in Table 4-3 and some LEU was shipped by truck and rail to Paducah between 1969 to 1971. Gamma isotopic data (where available) are presented in this table in addition to the beta and gamma percentages (although a direct correlation can not be drawn without the calculations used to report the beta and gamma percent of aged natural uranium). UO<sub>3</sub> produced

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from low enriched UNH continued to be shipped to the National Lead Company of Ohio, Fernald Plant, for blending and recycling, according to specifications presented by HW-79219 Rev. 1964.

**Table 4-3 Summary of Drummed UO<sub>3</sub> Product**

Date Lot No.	Pu Conc. Low/High (ppb)	Beta % Low/High	Gamma % Low/High	<sup>103</sup> Ru	<sup>106</sup> RuRh	<sup>95</sup> ZrNb
May 1964 45-1 – 45-15	1 / 5	3 / 5	26 / 42			
Jun 1964 46-1 – 46-16	2 / 8	4 / 6	40 / 69			
Jul 1964 47-1 – 47-5	3 / 5	6	44 / 49			
Aug 1964 48-1 – 49-15	2 / 5	4 / 6	39 / 54			
Sep 1964 49-1 – 49-16	2 / 4	5 / 8	45 / 91			
Oct 1964 410-1 – 410-15	1 / 5	5 / 9	61 / 106			
Nov 1964 411-1 – 411-12	1 / 6	5 / 10	58 / 115			
Dec 1964 412-1 – 412-12	1 / 2	9 / 11	107 / 136			
Jan 1965 51-1	2	9	99			
Feb 1965 52-1 – 52-2	2	12 / 13	176 / 183			
Mar 1965 53-1 – 53-13	1 / 3	10 / 12	30 / 168			
Apr 1965 54-1 – 54-19	1 / 3	9 / 36	111 / 163			
May 1965 55-1 – 55-20	1 / 2	10 / 13	116 / 166			
Jun 1965 56-1 – 56-17	1 / 5	5 / 19	64 / 212			
Jul 1965 57-1 – 57-6	1 / 2	7 / 10	74 / 90			
Aug 1965 58-1 – 58-11	1 / 2	7 / 12	67 / 158			
Sep 1965 59-1 – 59-12	1 / 4	5 / 7	63 / 80			
Oct 1965 510-1 – 510-10	1 / 4	3 / 7	25 / 86			
Nov 1965 511-1 – 511-4	1 / 2	8 / 12	98 / 149			
Dec 1965 512-1 – 512-6	1 / 2	8 / 9	101 / 124			

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**Table 4-3 (Cont'd) Summary of Drummed UO<sub>3</sub> Product**

Lot No.	Pu Conc. Low/High (ppb)	Beta % Low/High	Gamma % Low/High	<sup>103</sup> Ru UCI/lb U Low/High	<sup>106</sup> RuRh Uci/lb U Low/High	<sup>95</sup> ZrNb UCI / lb U Low/High
Jan 1966 61-1 – 61-12	1 / 3	5 / 11	67 / 121			
Feb 1966 62-1 – 62-6	1 / 4	4 / 6	52 / 81			
Mar 1966 63-1 – 63-7	1 / 2	2 / 4	23 / 52			
Apr 1966 64-1 – 64-8	1 / 2	2 / 3	23 / 45			
Sep 1966 69-1 – 69-11	1 / 3	0.3 / 2	4 / 24			
Oct 1966 610-1 – 610-15	1 / 6	2 / 4	21 / 55			
Nov 1966 611-1 – 611-15	1 / 3	3 / 4	34 / 69			
Jan 1967 71-1 – 71-11	1 / 7	2 / 3	33 / 44	0.02 / 0.7	0.3 / 1.8	3 / 4
Feb 1967 72-1 – 72-10	2 / 3	2	31 / 41	0.04 / 0.7	0.03 / 2	3 / 4
Apr 1967 74-1 – 74-16	2 / 4			1E-3 / 0.4	0.05 / 0.6	2 / 39
May 1967 75-1 – 75-12	1 / 5			0.09 / 0.4	1E-3 / 1	1 / 7
Jun 1967 76-1 – 76-2	2			0.08 / 0.4	0.2 / 0.6	6 / 8
5/71 – 7/71 15-1 - 15-13	<1 / <9					
Aug 1971 16-13 - 16-15	<1 / <3					
8/71 – 10/71 17-1 - 17-12	<1 / 6					
8/71 – 10/71 18-1 - 18-12	<1 / 2 (lot 18-8=9)					
10/71 – 11/71 19-1 – 19-11	<1 / 1					
2/72 – 3/72 22-1 – 22-11 Inclusive	2 / 4					
Apr 72 23-1 – 23-2	3 / 4					
4/72 – 6/72 24-1 – 24-8	2					

Analytical data has not yet been located on UO<sub>3</sub> that was produced between 1952 and 1964. It appears that since the maximum plutonium concentration did not change in the specifications and that no evidence was found that any shipments were made without

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prior approval from the receiving site, very few if any of the lots with unrecovered data exceeded the 10 ppb threshold. Using the LEU data from 1962 through 1967, when only REDOX was processing LEU spent fuel, it is obvious that the REDOX process was well able to produce the UNH within the specification limit. Likewise using the analyses of depleted fuel from 1964 forward, PUREX was also capable of meeting the UNH plutonium specification. Consequently, there is a basis for predicting with assurance that nearly all shipments of  $\text{UO}_3$  met the plutonium specification.

### 4.4.5 $\text{UO}_3$ Processed In/After 1984 Restart of PUREX/ $\text{UO}_3$ Plants

When the PUREX and  $\text{UO}_3$  operations resumed in 1983, after about 10 years of stand-down, the  $\text{UO}_3$  process support analyses were performed for the three impurities Pu,  $^{237}\text{Np}$ , and  $^{99}\text{Tc}$  and results of these analyses are summarized in Table 4-4. There is less consistency in these data because the measurement systems were inactive for the extended down period from the previous operating period. These data were also generated by two different laboratories on site. Data that has been found is included in Table 4-4 in its entirety. Data recorded in Table 4-5 is a special processing of 177 drums of  $\text{UO}_3$  that is atypical in the  $^{235}\text{U}$  content, but is included for completeness.

## 4.5 Neptunium-237

### 4.5.1 Neptunium Concentration in Recycled Uranium

From the earliest records of uranium production at the  $\text{UO}_3$  facility, plutonium analyses were required, however the same was not true for neptunium. Production of  $^{237}\text{Np}$  in the Hanford reactors was modeled based on reactor power levels and uranium isotopic data.

### 4.5.2 Neptunium-237 Formation

$^{237}\text{Np}$  was formed in the Hanford production reactors by several possible neutron capture reactions in uranium. In natural uranium, the formation of  $^{237}\text{Np}$  was due to two distinct reactions:

1.  $^{238}\text{U} (n,2n) \rightarrow ^{237}\text{U} (\beta) \rightarrow ^{237}\text{Np}$
2.  $^{235}\text{U} (n, \gamma) \rightarrow ^{236}\text{U} (n, \gamma) \rightarrow ^{237}\text{U} (\beta) \rightarrow ^{237}\text{Np}$

The generation of  $^{236}\text{U}$  in uranium recovered for recycle, materially added to the production of  $^{237}\text{Np}$ . The  $^{236}\text{U}$  reaction [Nilson 1961, Gestson 1967] was:

3.  $^{236}\text{U} (n, \gamma) \rightarrow ^{237}\text{U} (\beta) \rightarrow ^{237}\text{Np}$

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Table 4-4 Analyses of UO<sub>3</sub> Produced In/After 1984 at Hanford

Lot No.	Date	Pu ppb	Np * ppb	Tc ppm	<sup>103</sup> Ru + <sup>106</sup> RuRh uCi/lb U	<sup>95</sup> ZrNb uCi/lb U	<sup>234</sup> Th/Pa uCi/lb U	<sup>234</sup> U wt %	<sup>235</sup> U wt %	<sup>236</sup> U wt%	<sup>238</sup> U wt %
84-08	6/11/84	2	N/A	N/A	<5	<3	<10	0.008	0.884	0.060	99.088
85-11	6/21/85	<0.5			<8	<6	<10	0.008	0.845	0.065	99.082
85-12	6/25/85	<5			<6	<8	<10	0.010	0.849	0.068	99.073
85-13	6/26/85	<5			<6	<8	<10	0.011	0.852	0.070	99.067
85-14	7/16/85	<5			<6	<8	<10	0.009	0.846	0.068	99.077
85-15	7/16/85	<5			<6	<8	<10	0.009	0.849	0.071	99.071
85-16	7/19/85	<5			<4	<6	<10	0.008	0.848	0.066	99.078
85-17	7/19/85	<5			<4	<6	<10	0.009	0.848	0.067	99.076
85-18	9/30/85	<5	<1000	7	<8	<6	<1	0.009	0.924	0.076	98.991
85-19	9/30/85	<5	<1000	7	<8	<6	<1	0.010	0.942	0.074	98.974
85-20	9/30/85	<5	<1000	7	<8	<6	<2	0.010	0.940	0.072	98.978
86-05	5/6/86	<2	490	12	<6	<4	<31	0.011	0.807	0.080	99.102
86-16	9/22/86	1	400	10	<6	<4	6	0.010	0.873	0.073	99.044
86-23	11/17/86	1	300	8	<6	<4	6	0.011	0.957	0.075	98.957
88-1	3/17/88	2	40	4	<6	<4	9	0.008	0.819	0.074	99.099
88-2	3/17/88	2	120	4	<6	<4	8	0.008	0.950	0.074	99.068
88-3	3/17/88	<1	160	3	<6	<4	10	0.009	0.818	0.073	99.100

Data retrieved from Analytical Data Sheets

\* Limited additional <sup>237</sup>Np data preceding 1985 are provided in Section 4.5.4, 4.5.5, and Table 4-7.

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**Table 4-5 Special Process Batch**

Lot No.	Date	Pu ppb	<sup>237</sup> Np ppb	<sup>99</sup> Tc ppm	<sup>235</sup> U wt %
93-1	8/30/85	<50 *	8	8	0.298
93-2	8/30/85	<50*	140	8	0.267
93-3	8/30/85	<50*	140	8	0.276

### 4.5.3 Predicted vs. Actual <sup>237</sup>Np Production

The early reports predicted that the <sup>236</sup>U would build-up in recycled uranium at a rate of 80-180 ppm per cycle for the single pass reactors and 400 ppm for N Reactor depending on the enrichment level of the blend material. The actual <sup>237</sup>Np production was a function of the type of uranium (natural or enriched), the per cent <sup>240</sup>Pu in the irradiated fuel and the concentration of <sup>236</sup>U in the feed [Schneller 1968]. The predicted <sup>237</sup>Np production (starting with fuel of 100 ppm <sup>236</sup>U in N Reactor) per ton of uranium is: 2.15 g for 0.947% enriched <sup>235</sup>U and 2.88 g for 1.25% enriched <sup>235</sup>U. For the reactors with 0.947% enriched <sup>235</sup>U, the production is 0.5 g. The relationship of parameters is summarized in Table 4-6 [Schneller 1968].

**Table 4-6, Calculated Production of Neptunium in Hanford Reactors**

Fuel Enrichment	% <sup>240</sup> Pu	<sup>236</sup> U ppm	g <sup>237</sup> Np/MTU
0.71	6	0	1.9
0.71	12	0	6.1
0.94	6	260-340	4.9- 5.4
.94- 1.25	9	60	9.5
.94- 1.25	12	60	18.9
.94- 1.25	20	60	47
2.10	6	-	16.4

### 4.5.4 Enhancing Production of Neptunium

Enhancing the production of <sup>237</sup>Np became of interest because it is the primary precursor for the production of <sup>238</sup>Pu, an important isotopic heat source. Therefore, there were efforts to enhance the separation of <sup>237</sup>Np from the uranium stream in the REDOX and PUREX processes. Neptunium was isolated in REDOX starting on November 30, 1959 [Weekly Report 1959] and on a semi-continuous basis in PUREX in January 1963.

In PUREX, the inventory of <sup>237</sup>Np was allowed to accumulate by reflux between the Backcycle Waste System, the First Decontamination and Partition, and the Final Uranium Cycles. During scheduled plant shutdowns, the <sup>237</sup>Np was recovered on a campaign basis [Schmittroh 1995]. In 1959, modifications were made to the PUREX flowsheet to improve the efficiency of the Np recovery operation [Weekly Report February 1959]. In 1963, <sup>237</sup>Np was recovered on a semi-continuous basis with the



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installation of the Neptunium Recovery System and the Neptunium Purification System. During this cyclical operations mode, the  $^{237}\text{Np}$  concentration in the recovered uranium varied by as much as an order of magnitude. Data presented in Table 4-4 shows this variability with concentrations ranging from 20 to 490 ppb.

The  $^{237}\text{Np}$  is separated from the uranium by taking advantage of the relatively large differences in extractability of the two elements. The separation is further enhanced by deliberately saturating the organic solvent with uranium and maintaining a controlled uranium "loss" to the aqueous waste corresponding to about five percent of the input to the system. The organic uranium product stream normally contains less than five parts of plutonium and 100 parts of  $^{237}\text{Np}$  per billion parts of uranium [Matheison 1968].

Analytical measurements of  $^{237}\text{Np}$  in UNH were not routinely performed at the  $\text{UO}_3$  Plant prior to 1969. Initial analyses were performed on the REDOX and PUREX UNH before shipment to the  $\text{UO}_3$  for conversion of the UNH to  $\text{UO}_3$ . Neptunium concentrations in the  $\text{UO}_3$  powder shipped offsite were not routinely reported until the mid-1980s.

At the Paducah GDP, measurements were made after FY 1957 on monthly composite samples of received  $\text{UO}_3$  [Smith 1984]. The average concentration of  $^{237}\text{Np}$  in uranium oxide received from Hanford and Savannah River prior to FY 1967 was 240 ppb with a range of 10 to 600 ppb. For Hanford material after FY 1967 the average concentration of  $^{237}\text{Np}$  was 120 ppb with a range of 50 to 270 ppb. The concentration of  $^{237}\text{Np}$  in recovered low enriched  $\text{UO}_3$  from Hanford was slightly lower, 50 ppb with a range of 10 to 110 ppb.

In 1978, the  $\text{UO}_3$  chemical flowsheet included a proposed threshold for the neptunium content of incoming UNH to the  $\text{UO}_3$  Plant. The value is given in grams/gallon and includes a minimum uranium threshold of 2.12 M. By calculation, the allowed concentration is 210 parts  $^{237}\text{Np}$  per billion parts uranium. Table 4-7 lists available neptunium concentrations measured in the incoming UNH from PUREX to the receiver tank at  $\text{UO}_3$  Plant in 1969 and 1970. These values agree with the limited data generated and reported at Hanford on  $\text{UO}_3$  product produced in 1985-1986.

Available data [Smith 1984] suggests that  $^{237}\text{Np}$  concentrations in  $\text{UO}_3$  remained within the same wide range of values before and after recovery of  $^{237}\text{Np}$  was initiated in 1959 as a co-product. Recovery of the  $^{237}\text{Np}$  occurred within approximately the same time period that the  $^{236}\text{U}$  concentration in reactor fuels was enhanced. There was therefore little net effect on the quality of  $\text{UO}_3$  product.

In addition, analyses were reported from Paducah [Ritter K/ETO-30 (no issue date)] reports average Np receipts by year. The estimated Np received at Paducah with  $\text{UO}_3$  was 18.4 Kg from 1953-1976 (no receipts shown for the years 1965-1968 and 1971). The annual quantity for the years 1953-1956 was estimated rather than measured but from 1956-1976 the quantity was measured. Assuming the quantity of reactor tails received is reported in English tons, the average Np concentration from 1953-1964 is 239 ppb  $\pm$ 1ppb. From 1969-1976 the average Np concentration varies from 11 ppb to

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89 ppb. These values all fall within the limited measurement data available from Hanford and Fernald. These data also cover the period that all three uranium recovery processes at Hanford operated.

**Table 4-7 Neptunium Analyses on UNH**

Reference Date	Date of Transfer (1)	Neptunium Gram/gallon	Calculated (2) Neptunium (ppb)	
McIntosh 1969	6/3/69 – 7/31/69	<4.50E-5 – 1.78E-4	<20 – 90	
McIntosh 1969a	8/1/69 – 8/25/69	3.01E-5 – 5.18E-4	20 – 270	3 samples 5.17E-4
McIntosh 1969b	10/2/69 – 10/25/69	4.81E-5 – 2.71E-4	20 – 140	
McIntosh 1970	12/5/69 – 12/31/69	3.3E-5 – 1.6E-4	20 – 80	
McIntosh 1970a	1/5/70 – 1/30/70	4.2E-5 – 8.15E-4	20 – 430	
McIntosh 1970b	2/3/70 – 2/11/70	6.51E-5 – 3.02E-4	30 – 160	
McIntosh 1970c	4/15/70 – 5/1/70	4.11E-5 – 5.56E-4	20 – 290	

- (1) It is recognized that these values are all from near the end of production operations at Hanford. (Concentrations of neptunium measured in the product UO<sub>3</sub> were given in Table 4-4)
- (2) Uranium concentration assumed to be 504 g/L, based upon the minimum U concentration defined in the UNH specification for the PUREX Plant.

### 4.6 Technetium-99

#### 4.6.1 Technetium-99 Concentration in Recycled Uranium

Technetium-99 was produced in Hanford reactors during the production of plutonium from the fission of <sup>235</sup>U. <sup>99</sup>Tc is formed at the rate of 30.0 mg <sup>99</sup>Tc per gram <sup>235</sup>U fissioned. Most recent ORIGEN2 calculations representing the production history of all the single-pass reactors and N-reactor indicate that 1960 kg <sup>99</sup>Tc were produced at the Hanford Site [Watrous 1997]. While the uncertainties of the ORIGEN2 results vary for different nuclides, for <sup>99</sup>Tc the uncertainties are expected to be less than 10%. The quantity of <sup>99</sup>Tc co-processed with the recovered UO<sub>3</sub> is a function of the solvent extraction process used to recover uranium and the distribution coefficients (organic/aqueous phases) for <sup>99</sup>Tc. Based on analyses and reported distributions coefficients, between 20% to 30% of the <sup>99</sup>Tc was co-processed with the UO<sub>3</sub> and shipped offsite [Roberts 1971, Schmitroth 1995].

#### 4.6.2 Hanford Technetium Measurements

Analytical measurements for <sup>99</sup>Tc in the UO<sub>3</sub> product were not routinely performed prior to 1985 at Hanford. Most of the uranium shipped in the 1980s was from N-Reactor weapons-grade production. The measured <sup>99</sup>Tc concentrations in UO<sub>3</sub> recovered from PUREX were in the range of 7-8 ppm (Table 4-4). These values are well below the 400

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ppm implied specification but above the proposed specification of 0.4 ppm. Special studies were performed in 1964 in which  $^{99}\text{Tc}$  concentrations were found to be  $1.74\text{E}5$  d/m/gram in PUREX-produced UNH and  $2.9\text{E}4$  d/m/gram in REDOX UNH. This calculates to 450 ppb in PUREX and 760 ppb in REDOX UNH [Christy 1964]. The range of  $^{99}\text{Tc}$  concentrations in the  $\text{UO}_3$  in T-Hoppers currently stored at Hanford is between 2.3 to 12.4 ppm. In a review of the radiological effects of a  $\text{UO}_3$  release scenario in the interim safety basis [Goldberg 1998], it was noted that  $^{99}\text{Tc}$  was not included in the original source term calculations. A concentration of 0.001 weight percent  $^{99}\text{Tc}$  "supplied by the customer" was ascribed to the stored  $\text{UO}_3$ , consistent with the measured values.

### 4.6.3 Paducah Measurements of Technetium-99 in Recycled Uranium from Hanford

Measurements on "depleted reactor tails" received from Hanford were made at Paducah from 1959 onward [Smith 1984]. The  $^{99}\text{Tc}$  data clustered in the range of 4 to 10 ppm on a uranium basis. The  $^{99}\text{Tc}$  average was 7 ppm +/-30%. The few analyses reported for recovered enriched uranium showed an average  $^{99}\text{Tc}$  concentration of 16 ppm with a range of 11-27 ppm.

### 4.6.4 Fernald Measurements of Technetium-99 in Recycled Uranium from Hanford

Measurements at Fernald on  $\text{UO}_3$  lots from Hanford shipped in the 1980s are consistent with measurements at Hanford and Paducah and are in the range of 3 to 12 ppm [Lower 1995].

## 4.7 Uranium Isotopic Composition

### 4.7.1 Natural Uranium

Natural uranium contains three isotopes  $^{238}\text{U}$ ,  $^{234}\text{U}$ , and  $^{235}\text{U}$  which are present in the weight percentages 99.28 %, 0.005 % and 0.711% respectively. Irradiation of uranium in the Hanford reactors resulted in the generation of other uranium isotopes, in particular  $^{236}\text{U}$  and  $^{232}\text{U}$ . The preponderance of the uranium irradiated in the Hanford reactors was natural or normal and the remainder was low enriched uranium (LEU) primarily 0.94 wt% or 1.25 wt%  $^{235}\text{U}$ . In the context of this document, natural uranium is uranium that has not been irradiated. "Normal" uranium is uranium that has been through a nuclear reactor and recovered from the spent fuel, but contains approximately the same concentration  $^{235}\text{U}$  as occurs in nature. This  $^{235}\text{U}$  concentration is attained either by blending uranium of different isotopic compositions or by processing in a GDP. Until normal U entered the metal fabrication process, reactor generated fission products would not be present in the fuel fabrication operations. It is believed that "normal" uranium was not received at Hanford for fuel fabrication before the start up of National Lead of Ohio. One year after  $\text{UO}_3$  shipments from Hanford, the cascade feed at K-25 was composed almost entirely of reactor depleted uranium and therefore the quantities of normal uranium hereinafter will almost surely vary from theoretical isotopic ratio of 0.711%  $^{235}\text{U}$ . In a letter [Gifford 1963], a statement is made that "...the next billets to be

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received from the feed material sites for NPR fuel elements will be recycle material.” These billets were being produced at NLO.

### 4.7.2 Normal Uranium

Normal uranium received for reactor fuel tended to have a low concentration of  $^{236}\text{U}$ , the  $^{235}\text{U}$  concentration was depleted to only around 0.64 wt% due to the short irradiation time. The  $^{236}\text{U}$  isotope and concentration did not build up very rapidly. In the gaseous diffusion process, the  $^{235}\text{U}$  isotope is partially separated from other U isotopes and blended to produce the desired product isotopic composition.

### 4.7.3 Low Enriched Uranium (LEU)

LEU shipped to Hanford for fabrication into fuel elements was recycled uranium. The recycled uranium contained varying amounts of  $^{236}\text{U}$  depending on the number of times it had been recycled through the reactors and the exposure time in the reactor. From 1975 through 1979, the 0.94% enriched fuel contained  $^{236}\text{U}$  mostly in the range of 400 to 500 ppm and the 1.25 % enriched fuel contained between 350 to 400 ppm. From 1981 through 1986 the  $^{236}\text{U}$  was mostly between 500 and 600 ppm for 0.947 enriched fuel and 500 to 800 ppm for 1.25% enriched fuel [Schmitroth 1995].

### 4.7.4 Typical Recovered LEU Uranium Oxide

The approximate isotopic content of LEU uranium oxide from N-Reactor operations contained 79 -154 ppb  $^{232}\text{U}$ , 0.009 wt%  $^{234}\text{U}$ , 0.88 wt%  $^{235}\text{U}$ , and 0.07 wt%  $^{236}\text{U}$  [Millward 1993]. Based on analytical measurements taken between 1972 and 1988, the recovered LEU contained an average of 0.0093 wt%  $^{234}\text{U}$  with a range of 0.008 to 0.011 wt %  $^{234}\text{U}$ , 0.860 wt%  $^{235}\text{U}$  with a range of 0.748 to 0.957 wt%  $^{235}\text{U}$ , and 0.071 wt %  $^{236}\text{U}$  with a range of 0.06 to 0.08 wt%  $^{236}\text{U}$ . Table 4-8 presents typical uranium isotopic distributions of LEU  $\text{UO}_3$  product.

Table 4-9 shows a significant decrease in the  $^{236}\text{U}$  concentration in depleted uranium in the  $^{235}\text{U}$  concentration. These three lots are much different in isotopic content and would have been classified as depleted by the GDPs. They are atypical of normal production at Hanford. These three lots represent 177 fifty-five gallon drums that were in the Hanford Site Inventory in 1992 but have since been buried [Salley 1992].

Measurements of the uranium isotopic content of the recovered  $\text{UO}_3$  produced at the  $\text{UO}_3$  Plant were made on every lot of material shipped from Hanford. As shown in Table 4-10, the average  $^{235}\text{U}$  concentration of the depleted  $\text{UO}_3$  over the time period of 1952 through 1971 was 0.645 wt%, with a range of 0.62 to 0.68 wt% based on currently available data.

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**Table 4-8 Typical Uranium Isotopic Ratio of LEU Produced In/After 1970**

Lot	Year	<sup>234</sup> U wt %	<sup>235</sup> U wt %	<sup>236</sup> U wt %
329A - C	May 1970		0.813	
330A - C	June 1970		0.806	
331A - C	June 1970		0.808	
332A -C	June 1970		0.813	
333A & B	June 1970		0.817	
E - 335	1971		0.865	
E - 336	1971		0.865	
18-1 - 18-12	1971		0.846	
19-1 - 19-16	1971		0.847	
110-1 - 110-8	1971		0.844	
22-1 - 22-12	1972		0.748	
84-08	1984	0.008	0.884	0.06
84-1 to 84-21	1984		0.85	0.06
85-11	1985	0.008	0.845	0.065
85-012	1985	0.01	0.849	0.068
85-13	1985	0.011	0.852	0.07
85-014	1985	0.009	0.846	0.068
85-015	1985	0.009	0.849	0.071
85-016	1985	0.008	0.848	0.066
85-017	1985	0.009	0.848	0.067
85-018	1985	0.009	0.924	0.076
85-019	1985	0.01	0.924	0.074
85-020	1985	0.01	0.94	0.072
86-05	1986	0.011	0.807	0.08
86-16	1986	0.01	0.873	0.073
86-23	1986	0.011	0.957	0.075
88-1	1988	0.008	0.819	0.074
88-2	1988	0.008	0.85	0.074
88-3	1988	0.009	0.818	0.073
<b>Average</b>		<b>0.009</b>	<b>0.86</b>	<b>0.071</b>

**Table 4-9 Deeply Depleted UO<sub>3</sub> Isotopic Data**

Lot	Year	Wt % of <sup>234</sup> U	Wt % of <sup>235</sup> U	Wt % of <sup>236</sup> U
93-1	1985	0.004	0.298	0.016
93-2	1985	0.002	0.267	0.015
93-3	1985	0.004	0.276	0.017
<b>Average</b>		<b>0.003</b>	<b>0.280</b>	<b>0.016</b>

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**Table 4-10 <sup>235</sup>U Isotopic Data of Pre-1972 Product or Depleted UO<sub>3</sub>**

Lot*	Year	<sup>235</sup> U wt %	Lot *	Year	<sup>235</sup> U wt %
7	1952	0.68	56-1 to 56-17	1965	0.650
8	1952	0.68	57-1 to 57-6	1965	0.647
9	1952	0.67	58-1 to 58-11	1965	0.638
036 to 045	1952	0.64	59-1 to 59-12	1965	0.652
007 to 009	1952	0.68	510-1 to 510-10	1965	0.65
010 to 013	1952	0.66	511-1 to 51-4	1965	0.654
197-200	1952	0.64	512-1 to 512-6	1965	0.63
9T	1952	0.64	Adjustments	1966	0.647
45-1	1964	0.63	Adjustments	1966	0.638
45-2	1964	0.632	Adjustments	1966	0.651
45-3	1964	0.633	Adjustments	1966	0.65
45-4	1964	0.636	Adjustments	1966	0.654
45-5	1964	0.635	Adjustments	1966	0.633
45-6	1964	0.634	Adjustments	1966	0.63
45-7	1964	0.641	Adjustments	1966	0.648
45-8	1964	0.637	Adjustments	1966	0.644
45-9	1964	0.644	Adjustments	1966	0.647
45-10	1964	0.642	Adjustments	1966	0.65
45-11 to 45-15	1964	0.644	Adjustments	1966	0.622
46-1 to 46-16	1964	0.646	61-1 to 61-12	1966	0.63
47-1 to 47-5	1964	0.620	62-1 to 62-6	1966	0.648
48-1 to 48-15	1964	0.634	63-1 to 63-7	1966	0.644
49-1 to 49-16	1964	0.640	64-1 to 64-8	1966	0.647
410-1 to 410-15	1964	0.636	69-1 to 69-11	1966	0.65
411-1 to 411-12	1964	0.642	610-1 to 610-15	1966	0.643
412-1 to 412-12	1964	0.640	75-1 to 72-12	1967	0.633
Adjustments	1965	0.648	76-1	1967	0.633
Adjustments	1965	0.647	71-1 to 71-11	1967	0.654
Adjustments	1965	0.642	72-1 to 72-7	1967	0.658
Adjustments	1965	0.650	72-8 to 72-10	1967	0.653
51-1	1965	0.644	74-2 to 74-16	1967	0.629
52-1 to 52-2	1965	0.644	1-5-2 & 1-5-7	1971	0.658
53-1 to -53-13	1965	0.648	1-5-1 - 1-5-10 & 1-5-13	5/25/71 - 7/26/71	0.651
54-1 to 54-19	1965	0.647	1-6-2 - 1-6-15	7/1/71 - 8/3/71	0.651
55-1 to 55-20	1965	0.645	1-7-2 - 1-7-12	9/7/71 - 10/12/71	0.66 est.
			<b>Average</b>		<b>0.644</b>

\* Data collected from Uranium Oxide – Source Data – Revised by Month [Murphy 1971]

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### 4.8 Contaminants in Uranium Metal

Uranium metal was received at the Hanford Site in the form of bare rods or ingots for use as fuel for the reactors. The fabrication operations in the 300 Area processed this metal into fuel elements or "slugs" suitable for use in Hanford reactors. There were several steps in this process including dipping the metal in a tin, lead, or chromium solution; extruding or pressing into aluminum or later zircaloy tubes; and cutting these elements to length and welding end caps to form a complete seal. These operations were labor intensive and required extensive exacting physical and reactivity tests to be met. Prior to the mid-1960 time period, the desired  $^{235}\text{U}$  content of uranium metal for fuel was attained by using natural U or processing recycle  $\text{UO}_3$  through a GDP. This process reduced the concentration of fission product radionuclides before the metal ingot production. Analyses performed by the supplier on the metal were accepted at Hanford after an initial test program demonstrated the reliability of the measurement system. Products of uranium decay were expected to be present and fuel fabrication operations at Hanford were tailored to be consistent with the guidelines established at that time.

#### 4.8.1 Non-radiological Composition

Incoming uranium metal was shipped from NLO after being shown to meet specifications of chemical impurities with maximum concentrations given for the elements in Table 4-11 [Gill 1963].

**Table 4-11 Chemical Specifications for Uranium Metal Billets**

Element	Min / Max Concentration (ppm)	Element	Max Concentration (ppm)
Be	/ 6	Mg	15
B	/ 0.25	Mn	20
Cd	/ 0.2	Ni	90
C	300 / 650	N	50
Cr	/ 20	Si	50
Cu	/ 65	Zr	75
H	/ 2.0	U	99.81% (Minimum)
Fe	115 / 200		

By 1985, aluminum was added to the "routine" N-Reactor fuel specification when FEDC Alloys were processed for irradiation. In addition, uranium ingots were to be analyzed periodically for 20 "incidental" non-radiological impurities [WHC-SP-0056 1987].

These specifications are rather recent updates, but appear to be consistent with earlier requirements in which the importance of maintaining the quality of the incoming uranium metal was recognized. In 1952, chemical analyses were being improved in the 300

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Area Spectrographic Laboratory from those included in the methods compendium HW-24403 and in reports of the development documents [Daniel 1952]. This method development improved the measurement detection limits of three elements and added six elements that could be detected. It should be noted that the elements of concern were for those non-radioactive constituents that might perturb the nuclear reactivity of the fuel in the reactor, the physical characteristics of the fuel during fabrication operations, or form impurity inclusions in the fuel.

The importance of adhering to these critical specifications is apparent from the extensive "round robin" acceptance test program implemented in May 1951. This program was recommended by the Chief, Metal Branch, Production Division, NYOO, to the Hanford Operations Office (HO) in Richland [Morgan 1951]. These verification tests included selection, by the St. Louis Area Office, of two consecutive production lots (16 heats) each week. Samples from each of the 16 heats were to be sent to New Brunswick Laboratory (NBL), an AEC operated referee laboratory, where complete and precise analysis for all elements of concern was to be performed. The NYOO would collect the sample identification and coordinate shipment of the samples to Hanford where they would be analyzed. Data from both sites (NBL and HO) were to be collected and evaluated by the NYOO. "When sufficient information has been obtained to enable a reliable correlation to be made of the results, chemical analyses, and bare slug tests, an acceptance plan based on functional testing will be devised" [Morgan 1951].

Several letters issued in 1953 have been reviewed (between C. L. Karl and others) that address uranium metal specifications and uniformity of metal composition. Blending of feed materials (scrap, virgin derbies, and briquettes) into the metal appeared to have value rather than relying on one feed source alone. Although routine sampling and testing protocols were established with assistance from the Hanford Research Division during this period, the Hanford Site accepted the shipper's data for impurities. No records have been found that indicate that routine impurity analyses were performed after the uranium metal was received at Hanford for fabrication as fuel.

### 4.8.2 Metallographic Testing

Extensive micrographic examinations were performed on the uranium metal after fabrication into fuel elements to evaluate heating, rolling, and quenching effects on the grain size and orientation. These metallographic examinations of uranium metal and uranium compounds were performed in the onsite laboratory facilities during the 1950s [Bach 1950, Hartcorn 1954, Gardner 1956].

### 4.8.3 Radiological Contaminants

Prior to 1952, no uranium oxide was recycled and as a result, Pu,  $^{237}\text{Np}$ ,  $^{99}\text{Tc}$  and fission product contamination were not present in the metal received for fuel fabrication. Between 1952 and 1962,  $\text{UO}_3$  was processed through the gaseous diffusion plants, which significantly reduced the concentration of Pu and  $^{237}\text{Np}$  in the enriched product to



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levels reported to be in the parts per trillion. Special test measurements performed at Oak Ridge in 1973 estimated that approximately 85 % of  $^{99}\text{Tc}$  received with recycle  $\text{UO}_3$  is vaporized to the gaseous diffusion cascade. Measurements of the cascade tails suggests that essentially all  $^{99}\text{Tc}$  entered the cascade. In 1963, a trap was installed to reduce the  $^{99}\text{Tc}$  concentration in the cascade product, and the concentration was reduced in the enriched U fraction from an average of 3.2 ppm to an average of 0.15 ppm. Routine  $^{99}\text{Tc}$  measurements were not initiated at Paducah until fiscal year 1972. In fiscal year 1974 the average  $^{99}\text{Tc}$  concentration peaked at about six ppm and in 1982 the Paducah GDP product averaged below the detectable level of 0.01 ppm [Smith 1984].

It can be assumed that the  $^{99}\text{Tc}$  concentration in U metal received at Hanford between 1953 and 1963 varied proportionally with the content of  $^{99}\text{Tc}$  in the recycled  $\text{UO}_3$ . After 1963, the  $^{99}\text{Tc}$  content of the U metal would have been lower, but dependent on the effectiveness of the trap installed to remove  $^{99}\text{Tc}$  in the GDP cascade.

### 4.8.4 Direct Blending

In 1962, the Fernald Plant proposed blending LEU oxide from Hanford with oxide containing 1.2%  $^{235}\text{U}$  produced from  $\text{UF}_6$  from Paducah to produce metal for reactor fuel [Keller 1962]. This process was to supercede generating the desired  $^{235}\text{U}$  content within the GDPs. This direct blending of  $\text{UO}_3$  containing the recycled radioisotopes would be expected to increase the radionuclide content of metal returned to Hanford from that produced only from GDP product. Since metal was produced by blending GDP enriched U and recycled  $\text{UO}_3$ , the radionuclide content of metal could not exceed the radionuclide content in the  $\text{UO}_3$ , since there were no concentration processes in the metal production.

The metal production site, Fernald, maintained a maximum acceptable concentration of 10 ppb for Pu, even though this was not included in the Hanford metal specifications. Concentrations of the Pu,  $^{237}\text{Np}$ , and  $^{99}\text{Tc}$  were not routinely monitored at Hanford on the received metal. One set of data (Transuranic Analyses for 0.95%  $^{235}\text{U}$  Enriched Ingot Composites) is presented in Table 4-11. These data reflect composites of metal in the Hanford inventory after Hanford reactor operations ceased.

Although these data are incomplete, they indicate that U metal, even when produced by direct blending, remains below the 10 ppb in Pu content and the Np content is within the range of concentrations documented on the  $\text{UO}_3$  product. The  $^{99}\text{Tc}$  concentrations appear to be lower than the accepted concentrations values on the limited  $\text{UO}_3$  data available.

Metal produced from natural uranium or normal uranium which has been processed through a GDP could be expected to have much lower concentrations of Pu and  $^{237}\text{Np}$ . During the 10 year period 1972 through 1982, Smith [Smith 1984] reports average values of  $^{99}\text{Tc}$  in Paducah GDP product from <0.01 to 6.1 ppm. That document also

## Contaminants in Recycled Uranium

indicates traces of  $^{237}\text{Np}$  entered the product stream, but no evidence was found for the presence of Pu to have been carried over into the product.

**Table 4-12 Transuranic Content in Ingot Composites**

Composite No.	Pu (ppb)	$^{237}\text{Np}$ (ppb)	$^{99}\text{Tc}$ (ppm)
85-1	3.0	155	3.2
85-3	2.7	211	3.2
85-8	3.5	179	3.7
85-9	2.4	243	4.0
85-19	2.7	185	5.5
85-25	2.2	192	3.2
85-26	2.0	198	5.8
85-33	2.9	185	4.2
85-42	7.0	204	1.8
85-43	4.3	166	2.9
85-52	8.1	192	2.3
85-53	2.2	134	3.4
85-59	4.3	185	0.7
85-60	5.2	179	0.9
85-61	3.0	153	0.8

In a personal communication with Fernald personnel [J. Neyer and C.W. Lower April 6, 2000], the following information was verified:

1. No specification was present for radionuclides in uranium metal prior to 1986. At that time, a 10 ppb upper threshold for Pu was listed.
2. Prior to 1962, Fernald only made metal using U processed through a GDP. Limited data indicated this material contained approximately 30 parts plutonium per trillion parts uranium. Np was usually in the same order of magnitude.
3. Direct blending of recycle uranium with GDP enriched uranium began in 1962 and the first shipment of metal produced from this blend occurred in 1963. Because of dilution in the process, the Pu averaged about 1 ppb.
4. Uranium metal received at Hanford from 1963 to the end of receipts (1980s) had bounding levels of Pu about 1 ppb for 0.95%  $^{235}\text{U}$  and 6 – 7 ppb in 1.25% U. During 1985, GDP tails were blended with the metal products fabricated and the values listed incorporate those tails. The weighted average of Pu in all  $\text{UO}_3$  used for direct blending was about 2.6 ppb.
5. The Np concentration is bounded during the same time period at a high of about 211 ppb. They recognized the wide variation in the neptunium concentrations.
6.  $^{99}\text{Tc}$  concentrations in metal during the 1980s ranged from 8 to 15 ppm.

**Contaminants in Recycled Uranium**

Hanford did not routinely measure the uranium metal receipts for the amounts of Pu, Np, and Tc constituents. Since Hanford has very little data on the constituent concentration in the uranium metal received for fuel fabrication, it was necessary to estimate concentration ranges of Pu, Np, and Tc in the received metal for this historical review, based upon data presented in Table 4-12, the Smith 1984 document, and communication with Fernald personnel during the course of this review. For the purpose of providing a rough estimate of the amount of constituents in the metal received at Hanford for fuel fabrication, the following ranges of constituents were used: Pu range of 0.01 - 6 ppb, with a mean of 3 ppb; Np range of 3 - 10 ppb, with a mean of 6.5 ppb; Tc range of 0.01 - 6 ppm, with a mean of 3 ppm. It is recognized that the selected range will have a significant impact on the amounts of constituents received, however refinement of these ranges would require a more thorough analysis of historical Hanford data in conjunction with an analysis of available analytical data from those sites who shipped uranium to Hanford. The ranges listed above were utilized in Tables I-12, I-13, and I-14 to estimate potential quantities of constituents in recycled uranium received at Hanford.

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## Section 5 Current Inventory of Recycled Uranium

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### 5.0 Current Inventory of Recycled Uranium (as of March 30, 1999)

#### 5.1 Current Project Hanford Management Contractor (PHMC) Inventory of Recycled Uranium

The remaining inventory of in-scope uranium at Hanford is approximately 1,863 metric tons of depleted, normal, and low-enriched material. The inventory consists of metal billets, unfinished and finished fuel,  $UO_3$  powder, and scrap. As shown in Figure 5-1, the inventory, managed by the Hanford contractor, represents about 47% of the approximate 4,000 MTU total uranium inventory. Of this in-scope total, ~669 MTU is legacy  $UO_3$  powder and the remaining ~1,194 MTU is metal as billets, unfinished fuel, and finished fuel.

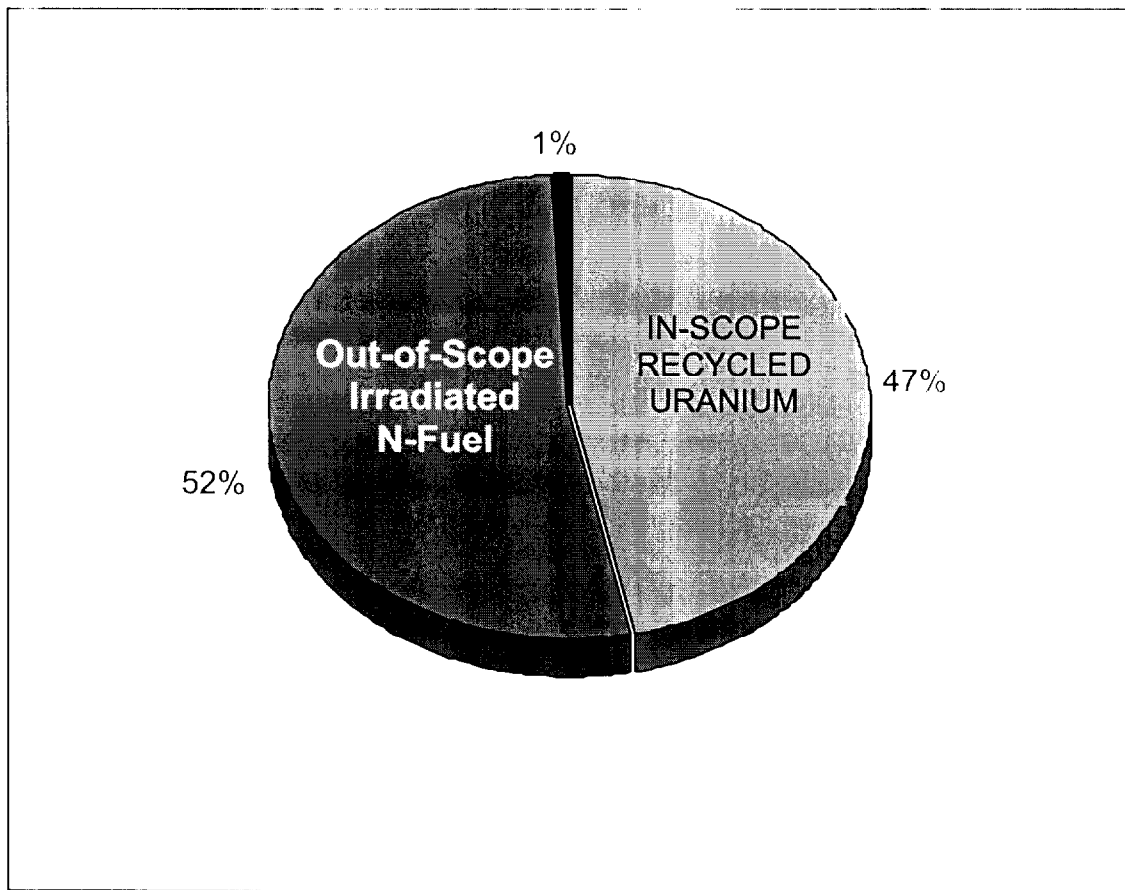


Figure 5-1 Hanford Total PHMC Uranium Inventory

The vast majority of the out-of-scope uranium inventory is the irradiated legacy N-fuel stored in the Hanford K-Basins currently awaiting transfer to the Canister Storage Building. The remaining 1% out-of-scope contains miscellaneous spent fuel (PWR Core II, etc.) and Pu/U (MOX) oxides and scrap. Appendix D, Table 5.1.1 provides a detailed listing of this inventory sorted by physical location and Composition of Ending Inventory

## Current Inventory of Recycled Uranium

(COEI) descriptors. As the table indicates the recycled uranium is stored at the 300 Area Fuel Fabrication complex and the UO<sub>3</sub> Plant.

### 5.2 Pacific Northwest National Laboratory Current Inventory of Recycled Uranium

Battelle Memorial Institute (BMI), assumed management of the Pacific Northwest National Laboratory (PNL) research and development activities for Hanford in 1965. PNL later received national recognition and became the Pacific Northwest National Laboratory (PNNL). One of the significant projects of the 1960s was PNL's design of the Fast Flux Test Facility (FFTF) in support of the Atomic Energy Commission's commercial nuclear power program. This project utilized uranium in the fabrication of mixed oxide fuel (MOX) containing uranium and fuel grade plutonium. The role of the PNNL in support of Defense missions has been significantly reduced from the 1960s. The narrative below provides a brief overview of the main PNNL project utilizing recycled uranium. The approximate 6.4 metric ton PNNL inventory is shown in Appendix D, Table 5.1.2. The receipts and shipments relating PNNL recycled uranium transactions with the three Major Tier 1 sites are shown in Section 3.2 and 3.3 tables.

The Kinetic Energy Projectile Project (KEPP) project is an ongoing project that started in 1974. This was an extension of work for others through Picatinny Arsenal, which supported other munitions prior to the depleted uranium (DU) phase. In 1974, the uranium used for PNNL research activities was DOE material. This feedstock started as green salt from Paducah, which was delivered to National Lead of Ohio (NLO/Fernald) for processing into the ingot stage. The ingots were then sent to Rocky Flats (RFETS) for alloying with titanium and processed into billet form. The billets were then shipped to PNNL for final processing and machining. Essentially all of the uranium involved in the project was and is DU alloyed with a small amount of titanium. This alloy is used because of its density and mechanical properties that provide strength to survive extreme launch conditions. After the research penetrators showed great promise for defeating current armor threats, production facilities had to be established. This led to facilities such as National Laboratory of Albany and NLO to produce production quantities. Continuing success led to the private sector getting involved through systems contractors such as Honeywell, etc. The initial private uranium producers were Nuclear Metals Inc and Aerojet Ordnance Company. Both private companies are involved in recycling of the penetrator alloy. The March 31, 1999 DU inventory at 306W building is approximately 4.9 metric tons with a storage limit in the 300 Area limited to 10 MTU. (In the past this limit has been 30 MTU.)

The receipts and shipments of normal, and enriched uranium into and out of PNNL were primarily for experimental fuel development of MOX fuel in support of the Liquid Metal Fast Breeder Reactor (Fast Flux Test Facility (FFTF)) program. The uranium itself was mainly supplied to Nuclear Energy (NE), via the DOE allotment process, from Defense Programs recycled production channels. As such, the entire PNNL uranium inventory, including DU, is considered in-scope.

## Section 6

# Discussion and Conclusions

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### 6.0 Discussion and Conclusions

Based on the review of the documents located, the RL Team concludes the following:

#### 6.1 Recycled Uranium Shipped and Received

##### 6.1.1 Operating History

Uranium recovery from irradiated fuel began at Hanford in 1952 using the REDOX process located in the 202-S Plant. Shortly thereafter, the U-Plant also began supplying uranyl nitrate hexahydrate (UNH) containing uranium recovered from the waste tanks. In 1956, the PUREX Plant came on line and also recovered uranium, as UNH, from irradiated fuel for calcination and recycle. The UNH product was piped from REDOX Plant and U-Plant and trucked from PUREX to the UO<sub>3</sub> Plant. At the UO<sub>3</sub> Plant the UNH was converted by calcination to UO<sub>3</sub> powder. The powder was sampled and packaged into either drums or specially designed "T-Hoppers" for shipment.

##### 6.1.2 Recycled Uranium Specifications

Hanford received recycled uranium metal billets for reactor fuel rod manufacture starting about mid-1952; however, the recycled uranium used to produce these billets had been processed through the gaseous diffusion plants (GDPs) and was reported to contain approximately 30 parts plutonium per trillion parts uranium. After about 1963, as a result of a process change at Fernald involving blending, their metal billet plutonium specification rose to a not to exceed 10 parts plutonium per billion parts of uranium level. Hanford did not routinely perform a radionuclide analysis on the incoming billets, but relied on the shipper.

##### 6.1.3 Recycled Uranium Shipments and Receipts

In all, Hanford shipped approximately **109,792** metric tons (MTU) of recovered (recycled) uranium. Of this, **74,491** MTU were shipped (as UO<sub>3</sub>) to the Paducah GDP, **4,404** MTU were shipped to the K-25 GDP and Y-12 Plant, and **25,251** MTU were shipped to Fernald. Metal turnings and scrap produced during fuel rod manufacture were returned to Fernald for recovery into new fuel rod billets. Lesser quantities of recycled uranium were sent to Harshaw Chemical Co. and Mallinckrodt Chemical Works for further refining to remove non-radioactive contaminants. Additional recovered uranium, in minor quantities, was sent to over 100 other destinations to support various DOE missions.

Hanford received and processed approximately **109,144 MT** of recycled uranium, with approximately 85% (92,767 MT) being received from Paducah, Fernald and Oak Ridge. Uranium metal received for fuel fabrication before 1952 was made from natural uranium and is out of scope for this report. With the exception of the material remaining at Hanford, the majority of this material was used for fuel, irradiated in the Hanford

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reactors, processed in the separations facilities to recover the plutonium and uranium, and the recovered uranium shipped offsite for use or recycle.

### 6.1.4 Current Inventory

Excluding uranium in solid and liquid waste and releases to the cribs, Hanford currently has approximately **4,006** MTU remaining in various forms including metal received for fabricating fuel, unused fuel, irradiated fuel, unirradiated uranium in mixed oxide fuel at the Fast Flux Test Facility and at the Plutonium Finishing Plant, and recovered uranium as  $\text{UO}_3$  stored in T-Hoppers awaiting final disposition. The recycled uranium in the irradiated fuel (2,137 MTU) is outside the scope of this study.

~**958** MTU is mixed with fission products and other chemical wastes in high-level waste storage tanks. ~**1,054** MTU is buried solid waste, and ~**162** MTU was released to the environment through various cribs, ponds, and ditches.

### 6.1.5 Shipper/Receiver Differences

During and after the May 17, 2000 Uranium Mass Balance Project workshop at Oak Ridge, TN, the RL team worked with other site representatives to compare shipping and receiving quantities of recycled uranium. For the Hanford shipments to Paducah, the percent variance between 1952 through March 30, 1999, was approximately 0.02% of the approximate 74,491 MT total. Percentage variances for shipments from Hanford to Fernald were approximately 0.7%. Percentage variances for Hanford receipts from Fernald were approximately 0.2%. Comparison between Hanford and Oak Ridge for shipments and receipts to the Oak Ridge aggregate of K-25 and the Y-12 will not be completed until the Y-12 transactions are prepared. The percentage variance for Hanford shipments to Savannah River (DuPont) were approximately 0.3%.

### 6.1.6 Inventory Difference

Hanford uranium shipments, receipts, and material in storage, and waste records indicate a small material difference of about **0.5 wt%** of the uranium received remains unexplained based upon the reviewed records. The calculation of this material difference includes an estimate that ~**140** MTU was consumed during reactor operations and the generation of plutonium. The material difference resides largely in the uncertainties associated with quantities of uranium in liquid and solid wastes in the waste tanks, and in the estimate of uranium fissioned and transmuted to operate the reactors and generate plutonium.

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### 6.2 Typical Impurities and Isotopic Composition

#### 6.2.1 Plutonium

Hanford participated in development of the recycled  $\text{UO}_3$  product specification starting in about 1950. By 1952, before commencement of uranium recovery operations, a preliminary specification requirement of less than 10 parts Pu per billion parts uranium was established. This limit was firmly established in 1953 and remained in place for the entire  $\text{UO}_3$  production period. The bulk of Hanford's shipments of recycled  $\text{UO}_3$  powder to the GDPs contained only trace amounts (<10 ppb) of Pu. Based on the limited amount of historical documentation located, it still appears the preponderance of Hanford recycled  $\text{UO}_3$  powder contained  $\leq 5$  ppb. Six shipments were identified in Hanford documents as containing about 12, 13, 16, 19, 22, and 30 ppb average, respectively; however, records indicate receiver sites were typically notified of these out-of-specification conditions and accepted these materials prior to their shipment from Hanford. These shipments represented ~193 MTU containing ~3.4 g Pu. Information from Oak Ridge indicates that their site received four shipments from Hanford for which their analyses indicated Pu concentrations of 13, 17, 17, and 28 ppb. These shipments are in addition to the shipment containing 22 ppb mentioned above. Hanford analyses on these four shipments indicate the Pu concentrations were all <10 ppb. Available documentation indicates that Hanford and Oak Ridge both acknowledged this discrepancy. This is further discussed in Section 6.4.3. These four shipments totaled ~123 MTU and contained ~2.3 gPu. The limited analytical data located is insufficient for RL to determine the total quantity of plutonium shipped to the various GDPs; however, it appears that approximately 110 to 550 grams of plutonium were shipped with the 109,792 MTU, based upon an assumed average plutonium concentration range of one to five ppb. The mean of this range of Pu concentrations is 330 grams of Pu.

Hanford did not routinely analyze the incoming uranium metal for radioactive constituents, but relied on the shipper's guidelines for the metal product. It appears, based on the information available, that metal received prior to 1963 had been processed through the Paducah GDP and contained on the order of 10 parts or less plutonium per trillion parts uranium. Metal that was received in 1963 and beyond had been directly blended at Fernald and contained <10 ppb Pu.

#### 6.2.2 Neptunium and Technetium

Hanford did not routinely analyze the  $\text{UO}_3$  product for neptunium or technetium before 1980, as there were no related product specification requirements. For Hanford recycled  $\text{UO}_3$  powder, technetium and neptunium limits were not considered required. Until 1967, Hanford analyzed the recycled  $\text{UO}_3$  powder for total beta and gamma activity and conformed to the required specification levels of less than 100% of the beta activity of aged natural uranium and less than 300% of the gamma activity of aged natural uranium, respectively. In 1967, the beta and gamma measurements were dropped in favor of specific isotopic measurements ( $^{95}\text{Zr/Nb}$ ,  $^{103}\text{Ru}$ , and  $^{106}\text{RuRh}$ ) as



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discussed in Section 4.3.2. Information provided by Fernald indicates that metal produced from recycled uranium contained  $^{99}\text{Tc}$  ranging from 3 - 12 ppm and  $^{237}\text{Np}$  with an upper bound of 500 ppb.

No uranium processing activities at Hanford have been identified that would increase the plutonium component of the recycled uranium after it was separated in the reprocessing plants. In the course of this study, no documentation has been found that reports concentration of constituents in areas accessed during maintenance activities. However, time has not been available to perform a detailed assessment of all uranium processing steps utilized at Hanford to assure that impurities in uranium were never concentrated. The  $\text{UO}_3$  Plant calciners, which converted the recovered UNH to  $\text{UO}_3$  powder did operate at elevated temperatures in an oxidizing environment. It is reasonable to believe that any volatile fission products which may have been present in the recycled uranium could have been released through the off-gas system, plated out on equipment surfaces, accumulated in off-gas scrubber solutions, or have been released to the environment. Documentation has been found to indicate that some of the ruthenium volatilized during UNH calcination, with decontamination factors (DF) ranging from <1 to 6 (see Appendix G, Section G.5). No operations in the fuel fabrication processes have been identified which would be expected to have further concentrated the constituents, other than the burning of metal fines to uranium trioxide.

### 6.3 Activity Assessment and Occupational Potential Exposure

The DOE-HQ mass balance project is a Department-wide effort to review each site that was involved with recycled uranium to provide an estimate of specific activities involving recycled uranium, and to develop a preliminary estimate of the approximate number of employees whose work subjected them to potential exposure from the constituents in the recycled uranium. The estimate of occupational potential exposure (OPE) is based on guidance developed during a workshop meeting held at the ORNL in May, 2000. This OPE criteria is listed at the bottom of Table 6-1. The recycled uranium activity and OPE assessment for Hanford is provided below.

The operations, maintenance and waste handling operations of the facilities described in Section 2 contributed to some personnel exposure and environmental releases. However, distinguishing any such personnel exposures to trace quantities of transuranics and fission products in recycled uranium from those associated with other Hanford operations which involved the handling and processing of significant quantities of irradiated fuel, high-level waste, and plutonium, would be very difficult. Assessment of personnel uranium exposure is further complicated by the practice of transferring personnel between facilities to meet ongoing work needs. The facilities at Hanford that had the highest potential for uranium exposure were the fuel fabrication facilities where large amounts of uranium metal and scrap were handled, and the  $\text{UO}_3$  Plant, which handled large quantities of dry  $\text{UO}_3$  powder. Other facilities involved with the handling of separated recycled uranium (as UNH) and of any waste from recycled uranium processing also had the potential for contributing to some exposure.

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**Table 6-1 Assessment of Activities at Hanford Where Workers Were Most Likely to Contact Recycled Uranium**

Location	Interval (s)	Processing Steps/Work Performed	Constituents of Interest <sup>5</sup>	Constituent Levels <sup>(1)</sup>	Airborne Potential <sup>(2)</sup>	Exposure Duration <sup>(3)</sup>	OPE <sup>(4)</sup>	
U Plant	1952-1958	<b>Reference – Hanford Mass Balance Report Figure 2-4, beginning at "Uranium Stripping column.</b>						
		• Concentrator operation	Typically Pu = 1-5 ppb Np = 20-500 ppb Tc = 3-12 ppm ↓	1	0	3	0	
		• Acid handling		1	1	2	2	
		• Sampling		1	1	2	2	
		• Maintenance in uranium-handling areas		1	1	2	2	
		• All assays and waste handling and disposition		1	1	2	2	
		• UNH transfer to UO <sub>3</sub> Plant (pumping)		1	2	1	2	
		• UNH transport to 321 Bldg. (truck)		1	1	1	1	
		• Recycle and rework off-spec material.		1	1	1	1	
REDOX	1952-1967	<b>Reference-Hanford Mass Balance Report Figure 2-9. Beginning at "U-Stripping column.</b>						
		• Concentrator operation	Typically Pu = 1-5 ppb Np = 20-500 ppb Tc = 3-12 ppm ↓	1	0	3	0	
		• Acid handling		1	1	2	2	
		• Sampling		1	1	1	1	
		• Maintenance in uranium-handling areas		1	1	2	2	
		• All assays and waste handling and disposition		1	1	2	2	
		• UNH transfer to UO <sub>3</sub> Plant (pumping)		1	1	2	2	
		• Recycle and rework off-spec material.		1	1	1	1	
		• Acid Receipt and handling.		1	1	1	1	
PUREX	1952-1972 1982-1990	<b>Reference-Hanford Mass Balance Report Figure 2-10 beginning at final uranium cycle</b>						
		• Extraction column operation	Typically Pu = 1-5 ppb Np = 20-500 ppb Tc = 3-12 ppm ↓	1	0	3	0	
		• Concentrator operation		1	0	3	0	
		• Sampling and assay		1	1	1	1	
		• Maintenance in uranium-handling areas		1	1	2	2	
		• Waste handling and disposition		1	1	2	2	
		• UNH transport (truck) to UO <sub>3</sub> Plant		1	2	2	4	
		• Recycle and rework off-spec material		1	1	1	1	
		• Receipt and off-load of reclaimed nitric acid		1	1	2	2	
UO <sub>3</sub> Plant	1952-1972 1984-1994 (Intermittent)	<b>Reference-Hanford Mass Balance Report Figures 2-5 and 2-6. All processing and handling activities including:</b>						
		• UNH receipt (truck and pipeline)	Typically Pu = 1-5 ppb Np = 20-500 ppb Tc = 3-12 ppm ↓	1	2	2	4	
		• Concentration		1	1	3	3	
		• Calcination (batch & continuous)		1	3	3	9	
		• Product handling, size reduction, & loadout		1	3	3	9	
		• Product storage and shipping		1	1	3	3	
		• Acid recovery, storage, shipping (rail)		1	1	2	2	
		• Sampling and assay		1	2	2	4	
		• Waste collection, handling, disposition		1	2	2	4	
		• Recycle, blending of off-spec materials		1	2	1	2	
		• All equipment and facility repairs		1	3	2	6	
• Development of continuous calciners	1	3		3	9			

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**Table 6-1 Assessment of Activities at Hanford Where Workers Were Most Likely to Contact Recycled Uranium (Cont.)**

Location	Interval (s)	Processing Steps/Work Performed	Constituents of Interest	Constituent Levels <sup>(1)</sup>	Airborne Potential <sup>(2)</sup>	Exposure Duration <sup>(3)</sup>	OPE <sup>(4)</sup>
<b>Reference-Hanford Mass Balance Report Figure 2-13.</b>							
Fuel Fab 313-314 Building	1952- 1971	• Metal melting, pickling, and acid etch	Typically* Pu = 0.01- 6 ppb Np = 3 - 10 ppb Tc = 0.01 - 6 ppm	0	3	3	0
		• Foundry and metal forming		0	3	3	0
		• Cladding application		0	2	3	0
		• Scrap		0	3	2	0
		• Waste handling and disposal		0	1	2	0
<b>Reference-Hanford Mass Balance Report Figure 2-14.</b>							
Fuel Fab (N Fuel) 333 Building	1963- 1987	• Metal pickling, and acid etch	Typically* Pu = 0.01- 6 ppb Np = 3 - 10 ppb Tc = 0.01 - 6 ppm	0	3	2	0
		• Metal forming, machining, and welding		0	3	3	0
		• Cladding application		0	2	3	0
		• Scrap		0	3	2	0
		• Waste handling and disposal		0	1	2	0
Solar Pond 183-H Basin	1975- 1985	• Solar Pond receipt of waste from 300 Area; evaporation of those liquids	↓	0	1	1	0
		• Removal of residues and interment at Environmental Restoration Disposal Facility.	↓	0	2	2	0
<b>Numbers of people at "No Significant Exposure Potential"</b>			<b>Numbers of people at "Moderate Occupational Exposure Potential"</b>				
300 Area AL-CLAD Fuel			350	U-Plant			12
300 Area ZR-Clad Fuel			300	REDOX			36
183-H Solar Basin			20	PUREX			64
<hr/>			<hr/>	UO <sub>3</sub> Plant			<hr/>
670						344	<hr/>
						<b>456</b>	

(See Figure 6-1 for staffing estimate assumptions)

### Criteria for Occupational Potential Exposure (Potential exposure criteria developed during Uranium Mass Balance Workshop, 5/2000)

#### Factors

- 1) **Constituent Level** – Typical constituent concentrations in material being handled
  - 0 – Sum of constituents clearly below de minimis levels (clearly less than 10% added dose)
  - 1 – Sum of constituents likely to cause up to 20% total dose
  - 2 – Sum of constituents likely to cause more than 20% but less than 50% total dose
  - 3 – Sum of constituents likely to cause 50% >more of total dose
- 2) **Airborne Potential** – Likelihood to be airborne or Potential concentration in air
  - 0 – No likelihood of being airborne
  - 1 – Low airborne potential
  - 2 – Moderate airborne potential
  - 3 – High airborne potential

\*See Section 4.8.4

- 3) **Exposure Duration** – Time of worker exposure on job
  - 1 – 50 hours / year or less
  - 2 – More than 50 hrs / year but less than 500 hours
  - 3 – 500 or more hours per year

- 4) **Occupational Potential Exposure (OPE) =**  
**Constituent Level X Airborne Potential X Exposure Duration**
  - 0 – No significant Occupational Exposure Potential
  - 1 – Low Occupational Exposure Potential
  - 2 – 2-9 = Moderate Occupational Exposure Potential
  - 3 – >10 = High Occupational Exposure Potential

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Time was insufficient to complete an in-depth activity and potential worker exposure assessment. However, a cursory estimate, utilizing assumptions of direct labor and maintenance staffing at the facilities of interest, was completed to provide an overview of recycled uranium work activities in these facilities and an OPE estimate.

The facilities that were identified to have involved the handling of recycled uranium included: (1) the 313-314 Building complex in the 300 Area which was primarily involved with the fabrication of aluminum-clad reactor fuels, (2) the 333 Building complex in the 300 Area which was involved in the fabrication of zirconium-clad reactor fuels, (3) the REDOX Chemical Separations Plant in the 200 West area where reactor fuels were dissolved for plutonium and uranium recovery (including transfer of the UNH to the UO<sub>3</sub> Plant for calcination), (4) the U-Plant in the 200 West area where pre-1952 tank wastes were processed for uranium recovery, (5) the UO<sub>3</sub> Plant in the 200 West area where uranium recovered as UNH was received, concentrated, calcined, and packaged for shipment and recycle, (6) the PUREX Plant in the 200 East area where irradiated fuels were dissolved for separation of plutonium and uranium (with the UNH being shipped by truck to the UO<sub>3</sub> Plant for calcination), and (7) the 183-H solar basin in the 100-H area that was used for a ten-year interval to evaporate dilute liquid wastes generated at the 300 area fuel fabrication plants.

The interval of operation for each of these facilities is illustrated in Figure 6-1, along with an estimate of probable direct labor staffing support. The staffing calculations were based upon estimates of the number of operators and craft personnel per shift, the number of shifts per week, and an estimate of the average length of time that an employee would work at the facility. This information was used to estimate the total number of people who worked at each facility during its operating lifetime. These staffing totals, by facility, were then used as inputs to Table 6-1 to allow an estimate of the number of people likely to have been exposed to various levels of constituents of recycled uranium. Below is a typical staffing estimate calculation for Figure 6-1:

As an example, consider the 313-314 Building complex which had a PQ operations shift schedule and operated for 25 Years. It is estimated that the following operational information would apply to these facilities:

25 Operators/Shift; 10 Crafts/Shift; and an average Employee Time at Facility of ~5 years.

Thus, the number of workers on any given shift that may have been in contact with uranium would be 25 fuel fabrication operators plus 10 maintenance craftsmen for a total of 35. The "PQ" shift arrangement provided for Monday through Friday coverage of the 8AM to 4PM shift and the 4PM to Midnight shift. If the average worker remained at the job for 5 years then,

$$(35 \text{ workers/shift}) \times (2 \text{ shifts/day}) \times \frac{25 \text{ years facility operation}}{5 \text{ years at that facility for a typical worker}}$$

= 350 involved employees at that facility over the lifetime of the facility.

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Facility	1940's	1950's	1960's	1970's	1980's	1990's
<b>313-314 Building (1)</b>						
<b>333 Building (2)</b>						
<b>REDOX (3)</b>						
<b>U-Plant (4)</b>						
<b>UO<sub>3</sub> (5)</b>						
<b>PUREX (6)</b>						
<b>Solar Pond 183-H Basin (7)</b>						
1) <b>313-314 Building</b> PQ shift 25 years operation 25 operators/shift 10 crafts/shift average time at facility - 5 years $(25 + 10) \times 2 \times 25/5 = 350$ personnel				5) <b>UO<sub>3</sub> Plant</b> ABCD shift – 20 years operation 12 operators/shift 8 crafts/shift average time at facility - 5 years $(12 + 8) \times 4 \times 20/5 = 320$ personnel Calciner Development ABCD shift – 1 year operation 4 techs/shift 2 crafts/shift average time at facility – 1 year $(4 + 2) \times 4 = 24$ personnel		
2) <b>333 Building</b> PQ shift – 25 years operation 20 operators/shift 10 crafts/shift average time at facility – 5 years $(20 + 10) \times 2 \times 25/5 = 300$ personnel				6) <b>PUREX</b> ABCD shift – 20 years operation Assume 4 employees/shift worked with recycled uranium average time at facility - 5 years $4 \times 4 \times 20/5 = 64$ personnel		
3) <b>REDOX</b> ABCD shift – 15 years operation Assume 3 employees/shift worked with recycled uranium average time at facility – 5 years $3 \times 4 \times 15/5 = 36$ personnel				7) <b>183-H Basin</b> ABCD shift – 10 years operation Assume 1 employee/shift worked this task average time at facility – 2 years $1 \times 4 \times 10/2 = 20$ personnel		
4) <b>U Plant</b> ABCD shift – 4 years operation Assume 3 employees/shift worked with recycled uranium average time at facility – 4 years $3 \times 4 \times 4/4 = 12$ personnel						
<b>Note:</b> Shift definitions = ABCD is three 8 hour shifts/day, 7 days/week PQ is two 8 hour shifts/day, 5 days/week						

**Figure 6-1 Estimate of Personnel Having Work Potentially Involving Exposure to Recycled Uranium at Specific Facilities**

Specific recycled uranium activities where worker contact with recycled uranium may have occurred were identified from plant description and process flow information which has been provided in Section 2 of this report. Estimated ranges of constituent concentrations in the recycled uranium were identified for each facility, based upon analytical information provided in Section 4. Criteria for estimating the OPE for each activity were then used to assess the exposure potential for each activity. The summary assessments for each activity in the facilities were then applied to the staffing estimates

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shown in Figure 6-1 to arrive at an estimate of the number of personnel who could have had some level of OPE. All of this information is presented in Table 6-1.

The data summarized in Table 6-1 indicates that a total of about **1,126** people are estimated to have worked in areas directly involving recycle uranium during the operational time of the Hanford Site. Using the given OPE assessment criteria, of the **~1,126** staff personnel, it is estimated that **~670** had "no significant exposure potential" while **~456** had "moderate occupational exposure potential." It should be noted that this is only a rough estimate based upon limited data, engineering judgements and assumptions, and the application of some broad general OPE criteria which were established specifically for the mass balance project.

Since 1946, Hanford has had formal personnel monitoring programs in place which are designed to identify uptake of radioactive materials by personnel. Any employee who was assigned to a work location where contact with radioactive materials was judged to be possible was required to participate in the bioassay program. Each decision/request for bioassay evaluation on an individual or group of people represented a rather conservative contemporary judgement for protection of employees from radioactivity. Not all of those who were placed on the uranium bioassay program were expected to have direct contact with the radioactive material. It is therefore reasonable to suggest that the number of employees sampled on the uranium-specific bioassay program represents a conservative and upper bounding estimate of the number of individual workers potentially exposed to recycled uranium at Hanford.

Site records show that more than 50,000 employees were hired at Hanford over the operating period of the installation. In contrast, since the sampling program was established in 1946, only ~4,200 Hanford employees have been subjected to uranium-specific bioassay sampling and evaluation. A preliminary review of the records of that program was conducted. Those records (which included estimates for the constituents of interest) identified no significant doses associated with the recycled uranium for any of the Hanford Uranium Bioassay program participants. Due to the eligibility criteria applied, it is considered highly improbable that any substantial number of un-assayed site employees could have had any significant uranium uptake. For this study on recycled uranium traffic at Hanford, the very brief and somewhat empirical staffing and timing models for the facilities that handled large quantities of recycled uranium suggests that ~1,126 of the 4,200 employees did in fact perform substantial duty in the facilities that included opportunities for rather close contact with recycled uranium. Of that number, perhaps ~456 individuals had "moderate occupation exposure potential" as assessed and defined in the criteria that was given.

For a more specific analysis of worker contact with recycled uranium at Hanford than that contained in this report, an examination of Hanford's uranium bioassay records, a more detailed review of plant-by-plant operations, abnormal events, maintenance, and facility upgrades, overlaid by staffing models and production intervals would be required. Corroboration of such an analysis by examination of various records and

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interviews of retired employees would be necessary, in order to validate the OPE estimates.

### 6.4 Data Validation

#### 6.4.1 Recycled Uranium Shipped from Hanford

External validation of Hanford shipment and receipt quantities of recycled uranium were performed, to the extent possible, during and after the May 17, 2000 workshop previously described in Section 6.1.5. For those sites identified as Major Tier 1 sites (Paducah, Fernald, and Oak Ridge) in which comparison was possible, the percentage variances between Hanford and other site data was below 1% (0.02-0.7%) for transaction categories detailed in Section 6.1.5.

#### 6.4.2 Impurities Shipped with UO<sub>3</sub> from Hanford

As shown in Section 4, fairly complete analytical data for Pu contained in shipments of UO<sub>3</sub> have been located for the years from 1963 to 1988. Data on shipments prior to 1963 are limited for the constituents of concern including Pu, <sup>237</sup>Np, or <sup>99</sup>Tc. Hanford data for the <sup>237</sup>Np and <sup>99</sup>Tc were not available on a routine basis until 1984. In an attempt to reconstruct the quantity of constituents that were present in Hanford produced UO<sub>3</sub>, source documents from other sites were used to make the estimates, i.e. Smith 1984 and Ritter K/ETO-30 and draft U Mass Balance reports of receipts from the Major Tier 1 receiver sites. The Smith and Ritter documents report the result of special studies performed at Paducah using Hanford UO<sub>3</sub> as a starting material. Analyses were completed at these sites on hundreds of samples between 1959 to 1973 for Pu, <sup>237</sup>Np, and <sup>99</sup>Tc.

Engineering estimates of the quantities of constituents (Pu, Np, and Tc) which were present in recycled uranium received, shipped, contained in waste, released to the environment, or contained in the current recycled uranium inventory at Hanford have been made. The detailed results of these estimates are provided in Appendix I of this report. Analytical data on the concentration of Np and Tc in Hanford recycled uranium is minimal, since there were no specification requirements for these elements. Reasonable analytical data has been identified which indicates that recycled uranium shipped from Hanford typically contained Pu in the range of 1 to 5 ppb, and limited analytical data indicate Np ranged from 20 to 500 ppb, and Tc ranged from 3 to 12 ppm.

Since it is not possible to provide a complete historical assessment of the constituent levels in all recycled uranium Hanford, rough estimates of annual quantities of constituents in recycled uranium shipped each year were developed by assuming that the constituent levels during the years when analytical data is not available were the same as those for the years when analytical data is available. The annual estimates provided were based upon the low, mean, and high values for the constituent ranges mentioned above. Summaries of the total amount of constituents sent to Paducah,

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Fernald, and Oak Ridge sites are shown in Figures 6-2, 6-3, and 6-4. The ~110,000 MT of recycled uranium shipped from Hanford is estimated to have contained from ~110 to ~550 g Pu, ~2.2 to ~28 Kg Np, and ~330 to ~1,318 Kg of Tc. In general, these estimated constituent quantities appear to be consistent with data from sites receiving Hanford recycled uranium.

### 6.4.3 Discussion of Pu Data Differences Between K-25 and Hanford

In the K-25 Uranium Mass Balance Preliminary Site Report, analytical data are presented that indicate the Pu concentrations of  $UO_3$  reported by K-25 between January and April 1953 are significantly outside the 10 ppb specification threshold. Hanford and Oak Ridge agree that data generated before and after the January to April 1953 time period are generally well within the 10 ppb threshold. Analysis of source documents are not available from Hanford for shipment composites or lots during this time period. However, monthly and weekly reports for this time period do not indicate that  $UO_3$  shipments to Oak Ridge or Harshaw were made of out-of-specification  $UO_3$  material in the Pu constituent. A reference [Schmidt 1953] recognizes that there was some discrepancy in the plutonium analytical results between Oak Ridge and Hanford. This reference also indicates other constituent data are in agreement. Communications were ongoing at that time to resolve the differences, specifically on shipments 18, 19, and 20. This reference states that Hanford reported less than 10 ppb and Oak Ridge reported concentrations in the range of 15 to 20 ppb on those three shipments. Both laboratories reported 22 ppb on the shipment composite number 43.

In 1952, Hanford was analyzing each lot of material but reduced the analytical workload in November 1952 by only analyzing the carload composite for Pu. The K-25 report apparently includes measurements of each lot. A lot represented eight drums, each drum contained about 300 Kg of  $UO_3$ , and a car shipment included 11 or 12 lots (about 31-32 MTU) but ranged from 5 to 12 lots. Hanford transfer records show 411 MTU of  $UO_3$  and metal scrap were shipped to Oak Ridge during the January to June 1953 time period. On the graphic in the K-25 draft report, approximately 45 –50 data points are shown during the January to April 1953 time frame. Assuming each point represents the results of one lot reported, this indicates four shipments were made and would have contained about 120 to 150 MTU. This is consistent with the weekly and monthly reports for the time period. This represents about three percent of the uranium sent to Oak Ridge. During the same time period Hanford shipped approximately four times more material to Harshaw Chemical Co. than to Oak Ridge. The Harshaw product was shipped on to Oak Ridge after processing to remove non-radionuclide constituents. The Oak Ridge report indicates the Harshaw material met the Pu specification.

The reference, cited above, indicates that Oak Ridge was using an analytical procedure that was not included in the authorized procedure manual of that time. They added an aluminum nitrate "salting agent" that could enhance the extraction of Pu into the organic extractant. Hanford was using the procedure in the manual and this could account for the discrepancy in the constituent concentration. It is evident that the Hanford results



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Plutonium Contained In 110,000 MT Recycled Uranium  
From 1952- March 1999 As Trace Impurity, Typically 1 - 5 ppb

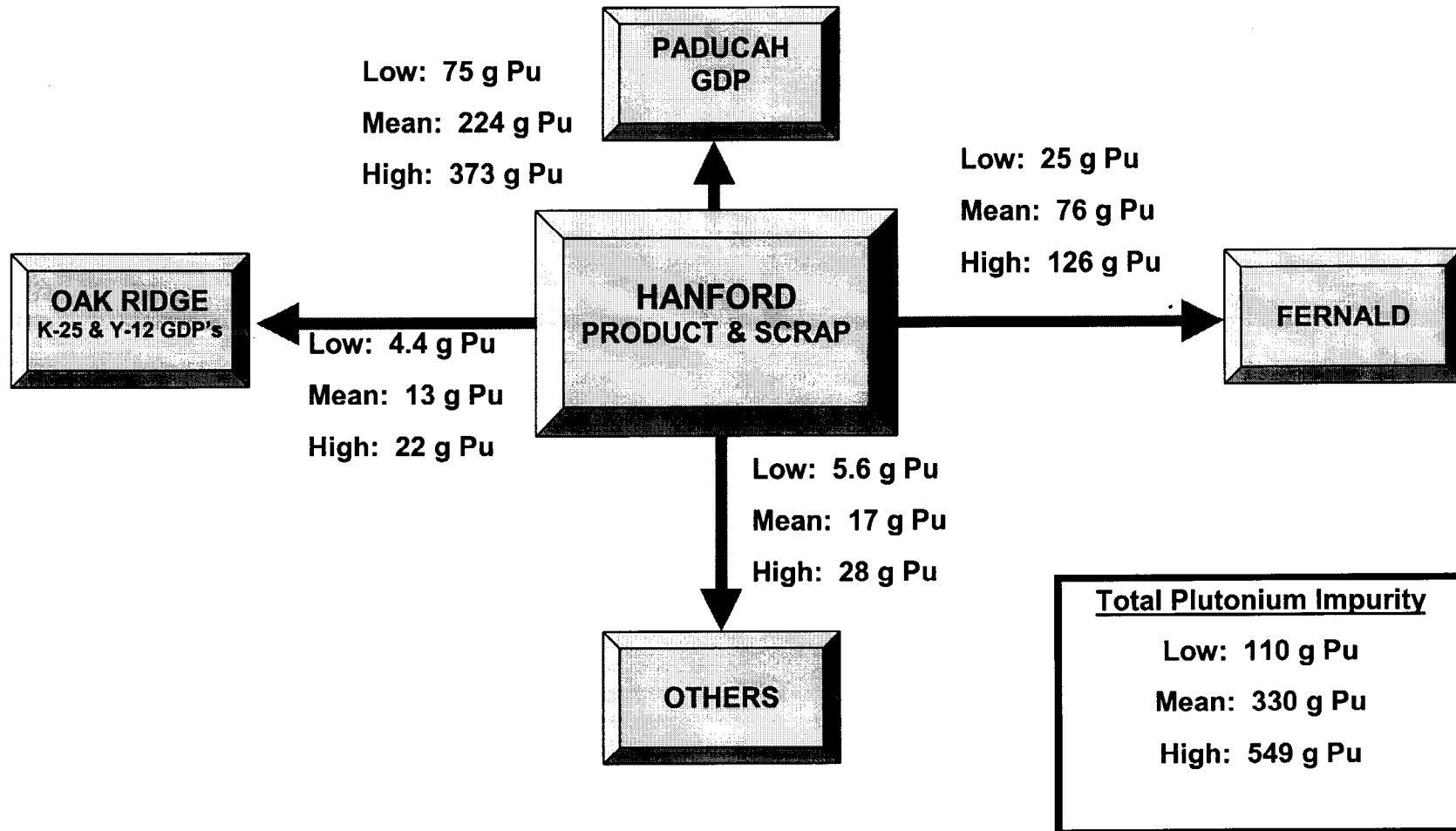


Figure 6-2 Plutonium Contained in Recycled Uranium Shipped From Hanford

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Neptunium Contained In 110,000 MT Recycled Uranium  
From 1952- March 1999 As Trace Impurity, Typically 20 - 500 ppb

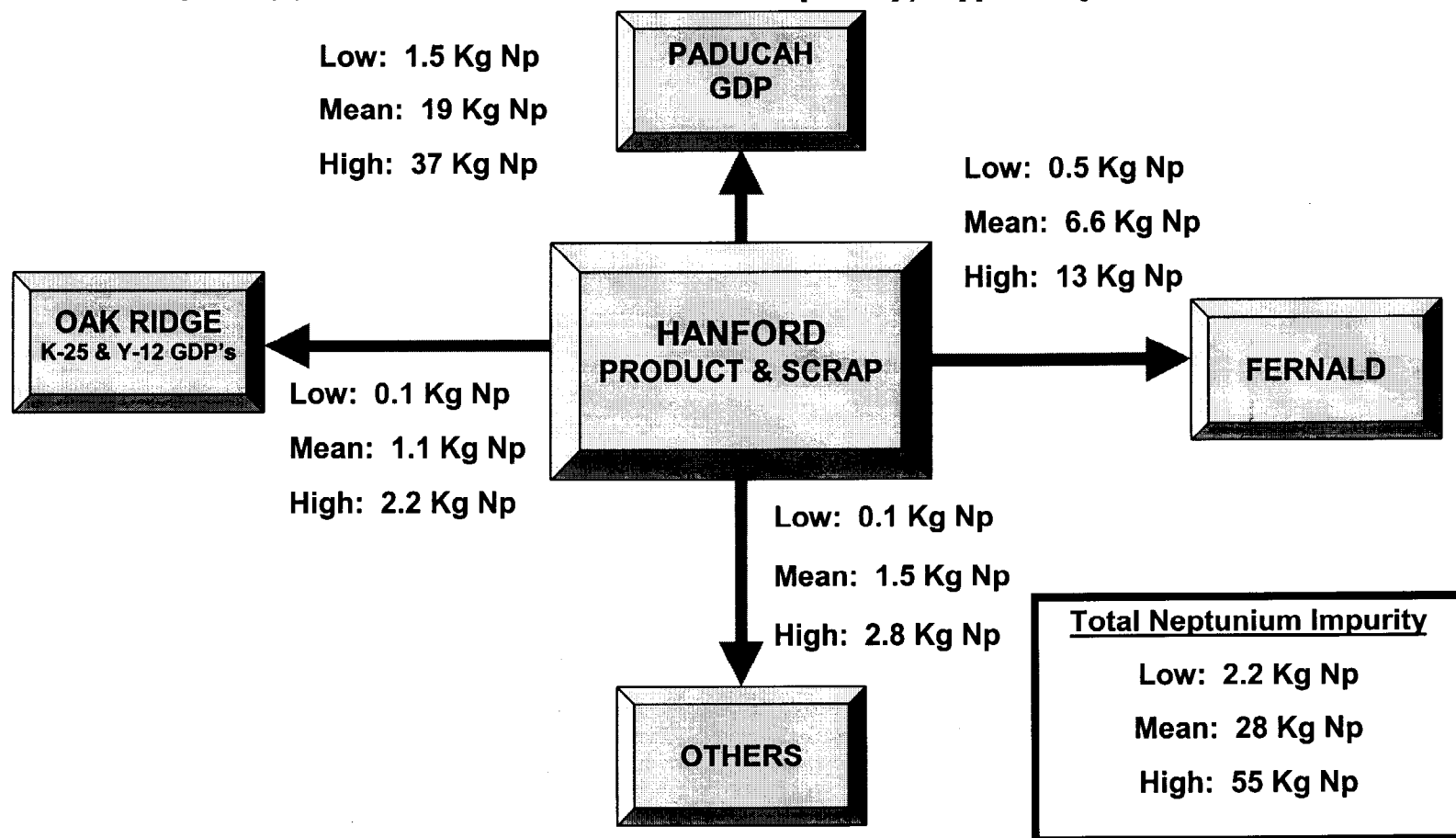


Figure 6-3 Neptunium Contained in Recycled Uranium Shipped From Hanford

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**Technetium Contained In 110,000 MT Recycled Uranium  
From 1952- March 1999 As Trace Impurity, Typically 3 - 12 ppm**

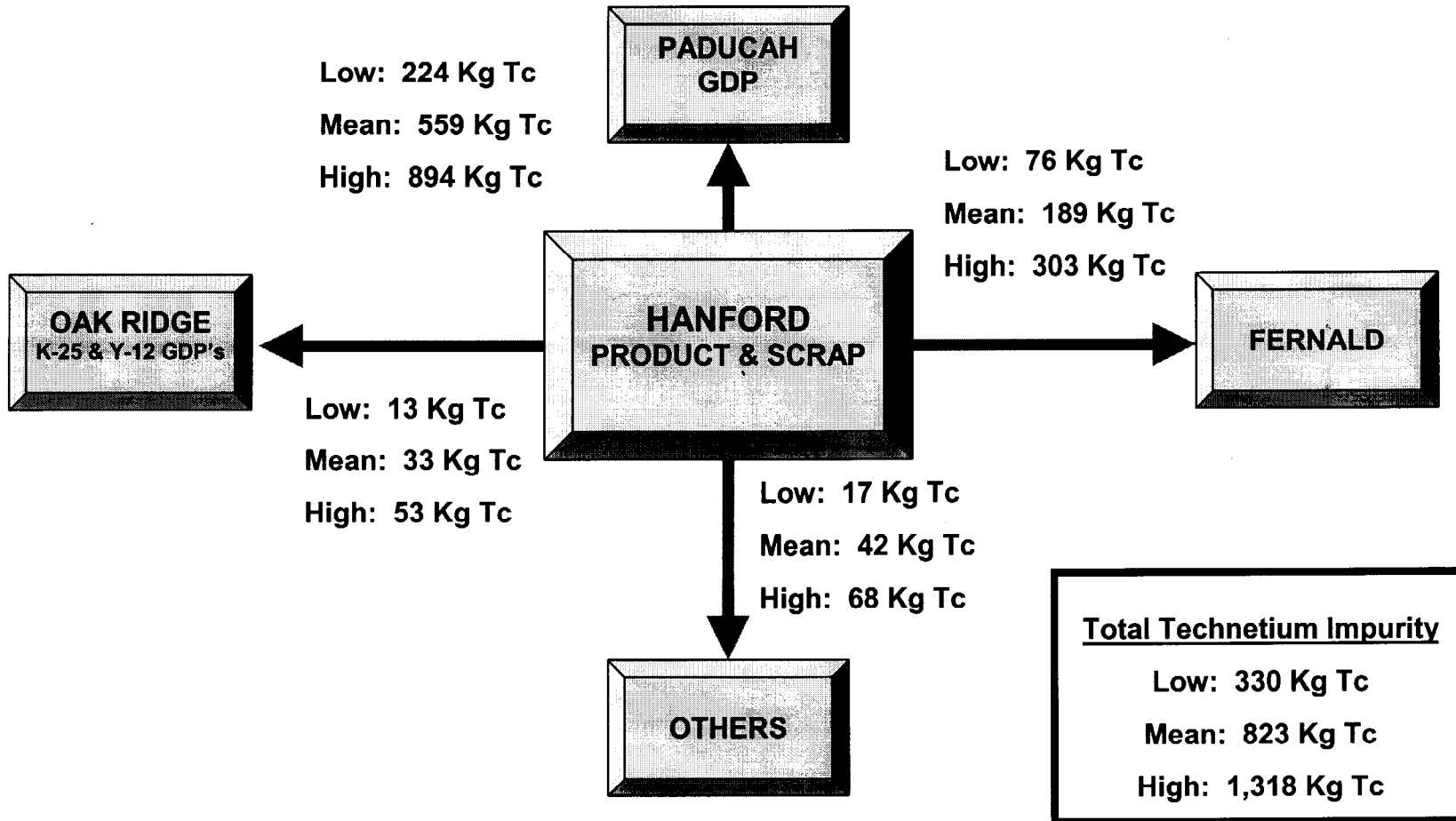


Figure 6-4 Technetium Contained in Recycled Uranium Shipped From Hanford

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are biased low compared to the K-25 results. It is interesting to note that during the same time period that Oak Ridge reported receiving high Pu concentrations from Hanford, they also reported receiving slightly higher Pu levels from Harshaw than in preceding or succeeding periods. It seems that there would be a delay of a month or more in the receipt at Oak Ridge of Hanford produced  $UO_3$  while processing was performed at Harshaw. The potential of the Harshaw process to reduce the Pu concentration in  $UO_3$  product from Hanford is not known.

If Hanford data (less than 10 ppb for all shipments except shipment number 43 which Hanford reported as being 22 ppb) are used, about 4.5 grams of Pu would have been included with the  $UO_3$  shipped during the January – April 1953 time period. If Oak Ridge's example data are extrapolated to the material shipped during this period and the average is 22 ppb, the Pu included with the  $UO_3$  is 9 grams. This represents a difference of 4.5 grams of Pu in approximately **120 to 150** MTU of uranium.

In 1948 and again in 1951 the concentration of Pu allowable in recycled  $UO_3$  was established to limit the increase in potential hazard to personnel to no more than 10 percent of the hazard present from handling aged natural uranium in equilibrium with its decay daughters [Gamertsfelder 1948 and 1951]. The threshold established for Pu was 10 ppb and included a large conservatism factor. In 1985, a task force re-evaluated the 10 ppb limit against the then current air concentration guides and concluded that the 10 ppb value represented 3.5 percent of the concentration guide [DOE/OR-859 1985]. Therefore, with respect to personnel hazards from Pu impurities in recycled uranium, even the Hanford shipments which were above the specification of 10 ppb were well within the concentration guidance as established both in 1951 and again when the guidance was re-evaluated in 1985.

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### References:

DOE/OR-859 1985

DOE/OR-859, *The Report of the Joint Task Force on Uranium Recycle Materials Processing*, Task Force Members Dick Egli et. al., September 1985

Gamertsfelder 1948

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# **Appendix A**

## **Glossary of Acronyms and Terms**

# APPENDIX A

## Acronyms and Glossary of Terms

DOE/RL-2000-43

### Acronyms

200E	200 East Area of the Hanford Site
200W	200 West Area of the Hanford Site
300 Area	300 Area of the Hanford Site
AEC	U.S. Atomic Energy Commission
AOC	Abnormal operating conditions
ANU	Aged natural uranium, a standard nomenclature for natural uranium that has undergone no separations for 2 years
ARH	Atlantic Richfield Hanford Company
BMI	Battelle Memorial Institute, Columbus, Ohio
CCC	Carbide and Carbon Corp., Operated the Paducah, Ky and Oak Ridge Operations for the AEC
COEI	Composition of ending inventory
DOE	U.S. Department of Energy
DOE-RL	U.S. Department of Energy-Richland Operations Office
DOE-HQ	U. S. Department of Energy-Headquarters
DU	Depleted uranium ( $^{235}\text{U}$ component less than 0.711 wt %)
ERDA	Energy Research and Development Administration
ERDF	Environmental Restoration Disposal Facility
EU	Enriched Uranium (>0.7% $^{235}\text{U}$ <20%)
FFTF	Fast Flux Test Facility
FMPC	Feed Materials Processing Center, Fernald, Ohio
GDP	Gaseous diffusion plant – an enrichment process of the $^{235}\text{U}$ component

# APPENDIX A

## Acronyms and Glossary of Terms

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### Acronyms

GE	General Electric Company
HAN	Hanford document number prefix
HE or HEU	High enriched uranium ( $^{235}\text{U}$ content >20%)
HEPA	High efficiency particulate air (filter)
HVAC	Heating, ventilation, and air conditioning
HW	Hanford Works (entire-plant area including laboratory facility) (Also used as document number prefix)
I & E	A type of reactor fuel element
ISO	Document prefix number used by ISOCHEM at Hanford
LEU	Low enriched uranium (uranium with the $^{235}\text{U}$ content from 0.71 wt % to less than 20 wt %)
LMFBR	Liquid Metal Fast Breeder Reactor
Lot(s)	10 T-Hoppers or 60 drums of $\text{UO}_3$ powder
MED	Manhattan Engineer District
MOX	Mixed Pu-U oxide reactor fuel
MT	Metric ton (s)
MTU	Metric ton (s) uranium
NBL	New Brunswick Laboratory – operated as an independent laboratory for the AEC and successor agencies
NE	Office of Nuclear Energy, U.S. Department of Energy
NLO	National Lead Company of Ohio
NPH	Normal paraffin hydrocarbon



# APPENDIX A

## Acronyms and Glossary of Terms

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### Acronyms

NYOO	New York Operations Office, AEC
ORIGEN2	Oak Ridge Isotope Generation Program, Version II (A model predicting isotopes produced as a result of nuclear fission of uranium.)
OSD	Operational specification document
PHMC	Project Hanford Management Contractor
PFPP	Plutonium Finishing Plant
PNL	Pacific Northwest Laboratories (to 1995)
PNNL	Pacific Northwest National Laboratory (after 1995)
PUREX	Plutonium Uranium Extraction (process or facility)
PWR	Pressured water reactor
R&E	Research and Engineering
REDOX	Reduction-Oxidation (process or facility)
Ref	Reference
Rev	Revision
RFETS	Rocky Flats Environmental Technology Site
RHO	Rockwell Hanford Operations
RL	Richland Operations Office
SK	Sketch
TBP	Tributyl phosphate
TIG	Tungsten inert gas (welding)
TK	Tank
TRU	Transuranic (having an atomic number greater than 92)

**APPENDIX A**  
**Acronyms and Glossary of Terms**

DOE/RL-2000-43

**Acronyms**

U	Uranium-any form and all isotopes
UNH	Uranyl nitrate hexahydrate
WHC	Westinghouse Hanford Company

**APPENDIX A**  
**Acronyms and Glossary of Terms**

DOE/RL-2000-43

**Glossary of Terms**

94 Metal	Uranium enriched to 0.94 percent of uranium 235
125 Metal	Uranium enriched to 1.25 percent uranium 235
Aged Natural Uranium Aliquot	Natural uranium which has not been subjected to any radiological separation processes for at least 2 years A small part of the larger sample
B	Boron
Be	Beryllium
C	Carbon
CCl <sub>4</sub>	Carbon tetrachloride
Cd	Cadmium
Ci	Curie, 3.73E10 disintegrations per second
Cr	Chromium
<sup>137</sup> Cs	Cesium 137, the 137 isotope of Cesium
Cu	Copper
DF	Decontamination Factor
Derby	Uranium metal button
Detrex™	Trichloroethylene, a solvent degreaser
duPont	E. I. DuPont de Nemours and Company
E Metal	Uranium metal enriched in <sup>235</sup> U content above 0.711 wt%
Fe	Iron
Fractionation	Separating one component from another such as separating the Pu from U stream
g	Gram(s)

**APPENDIX A**  
**Acronyms and Glossary of Terms**

DOE/RL-2000-43

**Glossary of Terms**

Green Salt	Uranium Tetrafluoride, UF <sub>4</sub> , radioactive, green crystals
H	Hydrogen
Hexone	Methyl isobutyl ketone
Homogenization	Mixing thoroughly without purposely changing particle size
Ingot	Uranium metal bar used as the source material for reactor fuel fabrication
K-25	K-25 site at Oak Ridge, Tennessee
Legacy	Materials or other assets remaining in inventory which have no identified current or future programmatic use and require dispositioning
Mg	Magnesium
μCi/lb	Micro-curies per pound
Mn	Manganese
MWD/t	Megawatt Days/thermal (fuel burnup)
N	Nitrogen
Natural uranium	As-mined uranium that has not been irradiated or isotopically separated
Normal uranium	Uranium with a ratio of <sup>235</sup> U to total U similar to natural U. (The ratio may be artificially regenerated)
Ni	Nickel
NOx	Nitrogenoxide; oxides of nitrogen
N-Reactor	New Production Reactor
<sup>237</sup> Np	Neptunium - 237
One lot of uranium	Traditionally 10 T-Hoppers or 60 drums of UO <sub>3</sub> product

**APPENDIX A**  
**Acronyms and Glossary of Terms**

DOE/RL-2000-43

**Glossary of Terms**

Paducah	Paducah Gaseous Diffusion Plant, Operated by Carbide and Carbon Corp. for the AEC at Paducah, Kentucky
Pot Calciner	Heated, stirred vessel to convert UNH to UO <sub>3</sub> in UO <sub>3</sub> -Plant
ppb	Parts per billion
ppm	Parts per million
Pu	Plutonium
Round robin	A process of exchanging samples between testing labs and comparing results to identify, understand, and rationalize/minimize differences
<sup>106</sup> RuRh	Ruthenium-Rhodium-106 decay chain
<sup>103</sup> Ru	Ruthenium isotope 103
<sup>90</sup> Sr	Strontium isotope 90
Subsampling	Removing a portion of a larger sample to a separate container
<sup>99</sup> Tc	Technetium - 99
T-Hoppers	Specially designed containers used to ship UO <sub>3</sub> on rail cars
U	Uranium-any form and all isotopes
U <sub>3</sub> O <sub>8</sub>	Uranous-uranic oxide
<sup>232</sup> U, <sup>233</sup> U, <sup>235</sup> U, <sup>236</sup> U, <sup>237</sup> U, <sup>238</sup> U, <sup>240</sup> U	Isotopes of uranium. Unless specified otherwise in the text, "U" includes all isotopes of uranium
μCi/gm	Micro-curies per gram
UF <sub>4</sub>	Uranium tetrafluoride
UF <sub>6</sub>	Uranium hexafluoride
UO <sub>2</sub>	Uranium dioxide

**APPENDIX A**  
**Acronyms and Glossary of Terms**

DOE/RL-2000-43

**Glossary of Terms**

UO <sub>3</sub>	Uranium trioxide - the product shipped from Hanford
UPb	Uranium mono-lead
UPb <sub>3</sub>	Uranium tri-lead
Virgin Uranium	Uranium which has never been irradiated
<sup>95</sup> ZrNb	Zirconium Niobium 95 decay chain

## **Appendix B**

### **Section 3 - Supplemental Information**

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## Appendix B

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### Section 3 – Supplemental Information

Table 3.2.1 Out-of-Scope Hanford Receipts (as reference)

December 1947 thru December 1949 Hanford (GE Company) Uranium Receipts

(ALL RECEIPTS ARE OUT OF SCOPE)						GE- Hanford Works Beginning Inventory			Mallinckrodt Chem Works (St. Louis) NY Ops (later under ORO Ops)				
						IN MELT PLANT BEG. INV. Kg NU	PILES & BASIN IN PROCESS Kg NU	IN 200 WASTE STORAGE Kg DU	Kg DU	Kg NU	Gm EU	Kg All U	CY
Time Frame	Date		REC RIS	Box #	Doc #								
	From	To											
1947	31-Dec-47	BEG. INV.	HGE	38213	HW-15-701	577,901.2	822,428	1,915,708					
1947	31-Dec-47	31-Dec-48	HGE	38213	HW-15-701					14,106.5	0	14,106.5	47
1948	31-Dec-48	31-Dec-49	HGE	38213	FTS-668					12,782	0	12,782	48
<b>KILOGRAM TOTALS 47-12/31/49</b>												<b>26,888.5</b>	
<b>MTU TOTALS 47-12/31/49</b>						<b>577.9012</b>	<b>822.428</b>	<b>1,915.708</b>				<b>26.8885</b>	

(ALL RECEIPTS ARE OUT OF SCOPE)						Simonds Saw & Steel Co. NY Ops				Electro Metallurgical Chem Wks NY Ops			
						Kg DU	Kg NU	Gm EU	Kg All U	Kg DU	Kg NU	Gm EU	Kg All U
Time Frame	Date		REC RIS	Box #	Doc #								
	From	To											
1947	31-Dec-47	BEG. INV.	HGE	38213	HW-15-701								
1947	31-Dec-47	31-Dec-48	HGE	38213	HW-15-701		400,522.8	0	400,522.8		16,836.6	0	16,836.6
1948	31-Dec-48	31-Dec-49	HGE	38213	FTS-668	121	1,325,590	0	1,325,711		5,350	0	5,350
<b>KILOGRAM TOTALS 47-12/31/49</b>									<b>1,726,233.8</b>				<b>22,186.6</b>
<b>MTU TOTALS 47-12/31/49</b>									<b>1,726.2338</b>				<b>22.1866</b>

**Appendix B**  
**Section 3 – Supplemental Information**

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**Table 3.2.1 (Cont.) Out-of-Scope Hanford Receipts (as reference)**  
**December 1947 thru December 1949 Hanford (GE Company) Uranium Receipts**

<b>(ALL RECEIPTS ARE OUT OF SCOPE)</b>						<b>Metal Hydrides Inc. NY Ops</b>					<b>Vulcan Crucible Steel NY Ops Aliquippa, Pa. (sent billets to Hanford)</b>			
<b>Time Frame</b>	<b>Date</b>		<b>REC RIS</b>	<b>Box #</b>	<b>Doc #</b>	<b>Kg DU</b>	<b>Kg NU</b>	<b>Gm EU</b>	<b>Kg All U</b>	<b>CY</b>	<b>Kg DU</b>	<b>Kg NU</b>	<b>Gm EU</b>	<b>Kg All U</b>
	<b>From</b>	<b>To</b>												
1947	31-Dec-47	BEG. INV.	HGE	38213	HW-15-701									
1947	31-Dec-47	31-Dec-48	HGE	38213	HW-15-701		27,766.3	0	27,766.3	47		256,481.4	0	<b>256,481.4</b>
1948	31-Dec-48	31-Dec-49	HGE	38213	FTS-668				0	48		221,775	0	<b>221,775</b>
<b>KILOGRAM TOTALS 47-12/31/49</b>						<b>27,766.3</b>					<b>478,256.4</b>			
<b>MTU TOTALS 47-12/31/49</b>						<b>27.7663</b>					<b>478.2564</b>			

<b>(ALL RECEIPTS ARE OUT OF SCOPE)</b>						<b>Chicago Operations Office Argonne National Lab</b>					<b>Chicago Operations Office Battelle Memorial Institute</b>				
<b>Time Frame</b>	<b>Date</b>		<b>REC RIS</b>	<b>Box #</b>	<b>Doc #</b>	<b>Kg DU</b>	<b>Kg NU</b>	<b>Gm EU</b>	<b>Kg All U</b>	<b>CY</b>	<b>Kg DU</b>	<b>Kg NU</b>	<b>Gm EU</b>	<b>Kg All U</b>	<b>CY</b>
	<b>From</b>	<b>To</b>													
1947	31-Dec-47	BEG. INV.	HGE	38213	HW-15-701										
1947	31-Dec-47	31-Dec-48	HGE	38213	HW-15-701	5.7	152		157.7	47		232.3	0	232.3	47
1948	31-Dec-48	31-Dec-49	HGE	38213	FTS-668			48.60	0.05	48		130	0	130	48
<b>KILOGRAM TOTALS 47-12/31/49</b>						<b>157.75</b>					<b>362.3</b>				
<b>MTU TOTALS 47-12/31/49</b>						<b>0.1575</b>					<b>0.363</b>				

**Appendix B**  
**Section 3 – Supplemental Information**

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**Table 3.2.1 (Cont.) Out-of-Scope Hanford Receipts (as reference)**  
**December 1947 thru December 1949 Hanford (GE Company) Uranium Receipts**

(ALL RECEIPTS ARE OUT OF SCOPE)						New York Ops Office NY Ops					Towanda Sub-Office TOA			
Time Frame	Date		REC RIS	Box #	Doc #	Kg DU	Kg NU	Gm EU	Kg All U	CY	Kg DU	Kg NU	Gm EU	Kg All U
	From	To												
1947	31-Dec-47	BEG. INV.	HGE	38213	HW-15-701									
1947	31-Dec-47	31-Dec-48	HGE	38213	HW-15-701		1,008.9	0	1,008.9	47		463,680.7	0	<b>463,680.7</b>
1948	31-Dec-48	31-Dec-49	HGE	38213	FTS-668			0	0	48			0	0
<b>KILOGRAM TOTALS 47-12/31/49</b>						<b>1,008.9</b>					<b>463,680.7</b>			
<b>MTU TOTALS 47-12/31/49</b>						<b>1.0089</b>					<b>463.6807</b>			

(ALL RECEIPTS ARE OUT OF SCOPE)						St. Louis Area Office New York Ops					Carbide & Carbon Chem Co. ORO Y-12 CYT			
Time Frame	Date		REC RIS	Box #	Doc #	Kg DU	Kg NU	Gm EU	Kg All U	CY	Kg DU	Kg NU	Gm EU	Kg All U
	From	To												
1947	31-Dec-47	BEG. INV.	HGE	38213	HW-15-701									
1947	31-Dec-47	31-Dec-48	HGE	38213	HW-15-701				<b>88,180.1</b>	47			0	0
1948	31-Dec-48	31-Dec-49	HGE	38213	FTS-668		4,288	0	<b>4,288</b>	48	187		0	<b>187</b>
<b>KILOGRAM TOTALS 47-12/31/49</b>						<b>92,468.1</b>					<b>187</b>			
<b>MTU TOTALS 47-12/31/49</b>						<b>92.4681</b>					<b>0.187</b>			

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**Table 3.2.1 (Cont.) Out-of-Scope Hanford Receipts (as reference)**  
**December 1947 thru December 1949 Hanford (GE Company) Uranium Receipts**

<b>(ALL RECEIPTS ARE OUT OF SCOPE)</b>						<b>Oak Ridge Natl Lab ORO ORL</b>				<b>Clinton Laboratory</b>				
<b>Time Frame</b>	<b>Date</b>		<b>REC RIS</b>	<b>Box #</b>	<b>Doc #</b>	<b>Kg DU</b>	<b>Kg NU</b>	<b>Gm EU</b>	<b>Kg All U</b>	<b>CY</b>	<b>Kg DU</b>	<b>Kg NU</b>	<b>Gm EU</b>	<b>Kg All U</b>
	<b>From</b>	<b>To</b>												
1947	31-Dec-47	BEG. INV.	HGE	38213	HW-15-701									
1947	31-Dec-47	31-Dec-48	HGE	38213	HW-15-701			2,635.5	2.64	47		372	16.5	<b>372.02</b>
1948	31-Dec-48	31-Dec-49	HGE	38213	FTS-668	14	60		74	48				<b>0</b>
<b>KILOGRAM TOTALS 47-12/31/49</b>						<b>76.64</b>				<b>372.02</b>				
<b>MTU TOTALS 47-12/31/49</b>						<b>0.0766</b>				<b>0.372</b>				

<b>(ALL RECEIPTS ARE OUT OF SCOPE)</b>						<b>GE Research Laboratory</b>					<b>Joslyn Manufacturing &amp; Supply Co.</b>			
<b>Time Frame</b>	<b>Date</b>		<b>REC RIS</b>	<b>Box #</b>	<b>Doc #</b>	<b>Kg DU</b>	<b>Kg NU</b>	<b>Gm EU</b>	<b>Kg All U</b>	<b>CY</b>	<b>Kg DU</b>	<b>Kg NU</b>	<b>Gm EU</b>	<b>Kg All U</b>
	<b>From</b>	<b>To</b>												
1947	31-Dec-47	BEG. INV.	HGE	38213	HW-15-701									
1947	31-Dec-47	31-Dec-48	HGE	38213	HW-15-701	24.4	1,464.8	0	1,489.2	47		560,900.9	0	<b>560,900.9</b>
1948	31-Dec-48	31-Dec-49	HGE	38213	FTS-668				0	48				<b>0</b>
<b>KILOGRAM TOTALS 47-12/31/49</b>						<b>1,489.2</b>					<b>560,900.9</b>			
<b>MTU TOTALS 47-12/31/49</b>						<b>1.489</b>					<b>560.9009</b>			

**Appendix B**  
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**Table 3.2.1 (Cont.) Out-of-Scope Hanford Receipts (as reference)**  
**December 1947 thru December 1949 Hanford (GE Company) Uranium Receipts**

<b>(ALL RECEIPTS ARE OUT OF SCOPE)</b>						<b>New Brunswick Lab</b>				<b>Sante Fe Ops/Los Alamos</b>			
<b>Time Frame</b>	<b>Date</b>		<b>REC RIS</b>	<b>Box #</b>	<b>Doc #</b>	<b>Kg DU</b>	<b>Kg NU</b>	<b>Gm EU</b>	<b>Kg All U</b>	<b>Kg DU</b>	<b>Kg NU</b>	<b>Gm EU</b>	<b>Kg All U</b>
	<b>From</b>	<b>To</b>											
1947	31-Dec-47	BEG. INV.	HGE	38213	HW-15-701								
1947	31-Dec-47	31-Dec-48	HGE	38213	HW-15-701				0		50	1.3	50
1948	31-Dec-48	31-Dec-49	HGE	38213	FTS-668				0				0
<b>KILOGRAM TOTALS 47-12/31/49</b>									0				50
<b>MTU TOTALS 47-12/31/49</b>									0				0.05

<b>(ALL RECEIPTS ARE OUT OF SCOPE)</b>						<b>Hanford Operations-Crane Company</b>				<b>Schenectady Oper. Office</b>				<b>TOTALS ALL SITES</b> ↓
<b>Time Frame</b>	<b>Date</b>		<b>REC RIS</b>	<b>Box #</b>	<b>Doc #</b>	<b>Kg DU</b>	<b>Kg NU</b>	<b>Gm EU</b>	<b>Kg All U</b>	<b>Kg DU</b>	<b>Kg NU</b>	<b>Gm EU</b>	<b>Kg All U</b>	
	<b>From</b>	<b>To</b>												
1947	31-Dec-47	BEG. INV.	HGE	38213	HW-15-701									
1947	31-Dec-47	31-Dec-48	HGE	38213	HW-15-701				0				0	
1948	31-Dec-48	31-Dec-49	HGE	38213	FTS-668		253		253				0	
<b>KILOGRAM TOTALS 47-12/31/49</b>									253				0	<b>3,402,338.1*</b>
<b>MTU TOTALS 47-12/31/49</b>									0.253				0	<b>3,402.34</b>

\* All receipts (Does not include beginning inventory)

**Appendix B**  
**Section 3 – Supplemental Information**

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**Table 3.2.2 1950 - FY 65 HANFORD (GE Company) URANIUM RECEIPTS FROM OFFSITE**

						MINOR TIER 1 SITE				MINOR TIER 1 SITE					
						Mallinckrodt Chem Works (MCW)				Simonds Saw & Steel Co.					
						NY Ops then ORO Ops				NY Ops					
						Becomes Weldon Springs FY 55									
FY	Date		REC RIS	Box #	Doc #	Kg DU	Kg NU	Gm EU	Kg U subtotal	FY	Kg DU	Kg NU	Gm EU	Kg U subtotal	FY
	From	To													
1950	31-Dec-49	31-Dec-50	HGE	38213	FTS-670	2	10,183	0	10,185	1950	147	743,916	0	744,063	1950
1951	31-Dec-50	30-Jun-51	HGE	38213	FTS-845		7,719	0	7,719	1951		359,069	0	359,069	1951
1952	01-Jul-51	30-Jun-52	HGE	38213	FTS 953		8,513	0	8,513.	1952		1,608,773	0	1,608,773	1952
1953	01-Jul-52	30-Jun-53	HGE	38213	FTS 1085		5,043	0	5,043	1953		941,041	0	941,041	1953
1954	01-Jul-53	30-Jun-54	HGE	38213	FTS 1311		8,788	0	8,788	1954			0	0	1954
1955	01-Jul-54	30-Jun-55	HGE	38213	FTS 1481		3,200	0	3,200	1955	371		0	371	1955
1956	01-Jul-55	30-Jun-56	HGE	38213	FTS 1644		2,921	0	2,921	1956		1913	0	1,913	1956
1957	01-Jul-56	30-Jun-57	HGE	38213	FTS 1980		2,220	0	2,220	1957			0	0	1957
1958	01-Jul-57	30-Jun-58	HGE	38213	FTS CLVI 463		3,615	0	3,615	1958			0	0	1958
1959	01-Jul-58	30-Jun-59	HGE	38213	HAN 72720		2,508	0	2,508	1959			0	0	1959
1960	01-Jul-59	30-Jun-60	HGE	38213	HAN 75996		594,947	0	594,947	1960			0	0	1960
1961	01-Jul-60	30-Jun-61	HGE	38213	HAN 79125		678,474	0	678,474	1961			0	0	1961
1962	01-Jul-61	30-Jun-62	HGE	38213	HAN 82406		866,733	0	866,733	1962			0	0	1962
1963	01-Jul-62	30-Jun-63	HGE	38213	HAN 85615		1,985	0	1,985	1963			0	0	1963
1964	01-Jul-63	30-Jun-64	HGE	38213	HAN 88957		44,880	314,351	45,194.35	1964			0	0	1964
1965	01-Jul-64	30-Jun-65	HZA	38213	HAN 92119			0	0	1965			0	0	1965
<b>FY 53 thru 65 In-Scope subtotals</b>						0	2,215,314	314,351	2,215,628.35		371	942,954	0	943,325	
<b>FY 1950 - FY 65 Total Kgs</b>									2,242,045.35					3,655,230	
<b>FY 1950 - FY 65 Total MTUs</b>									2,242.0454					3,655.23	

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### Section 3 – Supplemental Information

**Table 3.2.2 (Cont.) 1950 - FY 65 HANFORD (GE Company) URANIUM RECEIPTS FROM OFFSITE**

						MINOR TIER 1 SITE					MINOR TIER 1 SITE				
						New Brunswick Lab					New York Ops Office				
						ORO Ops					National Lead Company				
						Aeroprojects Inc., Nuclear Metals Inc									
FY	Date		REC RIS	Box #	Doc #	Kg DU	Kg NU	Gm EU	Kg U Subtotal	FY	Kg DU	Kg NU	Gm EU	Kg U Subtotal	FY
	From	To													
1950	31-Dec-49	31-Dec-50	HGE	38213	FTS-670			0	0	1950		130	0	130	1950
1951	31-Dec-50	30-Jun-51	HGE	38213	FTS-845		34	0	34	1951		4303	0	4,303	1951
1952	01-Jul-51	30-Jun-52	HGE	38213	FTS 953		311	0	311	1952		34,622	0	34,622	1952
1953	01-Jul-52	30-Jun-53	HGE	38213	FTS 1085			0	0	1953		1,371,495	0	1,371,495	1953
1954	01-Jul-53	30-Jun-54	HGE	38213	FTS 1311		1	0	1	1954			0	0	1954
1955	01-Jul-54	30-Jun-55	HGE	38213	FTS 1481			0	0	1955		2	21	2.02	1955
1956	01-Jul-55	30-Jun-56	HGE	38213	FTS 1644		1	0	1	1956			0	0	1956
1957	01-Jul-56	30-Jun-57	HGE	38213	FTS 1980	2	7	0	9	1957		9	0	9	1957
1958	01-Jul-57	30-Jun-58	HGE	38213	FTS CLVI 463	2	12	0	14	1958		1,158	116,949	1,274.95	1958
1959	01-Jul-58	30-Jun-59	HGE	38213	HAN 72720	3	16	0	19	1959	4,600	2,699	324,820	7,623.82	1959
1960	01-Jul-59	30-Jun-60	HGE	38213	HAN 75996	1	10	0	11	1960		3,816	1,119,891	4,935.89	1960
1961	01-Jul-60	30-Jun-61	HGE	38213	HAN 79125		4	0	4	1961		375	9,755	384.76	1961
1962	01-Jul-61	30-Jun-62	HGE	38213	HAN 82406		7	0	7	1962		2	80,930	82.93	1962
1963	01-Jul-62	30-Jun-63	HGE	38213	HAN 85615		5	0	5	1963		20	0	20	1963
1964	01-Jul-63	30-Jun-64	HGE	38213	HAN 88957		4	0	4	1964			76,843	76.84	1964
1965	01-Jul-64	30-Jun-65	HZA	38213	HAN 92119		4	0	4	1965			4,454	4.45	1965
<b>FY 53 thru 65 In-Scope subtotals</b>						8	71	0	79		4,600	1,379,576	1,733,663	1,385,909.66	
<b>FY 1950 - FY 65 Total Kgs</b>						<b>424</b>				<b>1,424,964.66</b>					
<b>FY 1950 - FY 65 Total MTUs</b>						<b>0.424</b>				<b>1,424.9647</b>					

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**Table 3.2.2 (Cont.) 1950 - FY 65 HANFORD (GE Company) URANIUM RECEIPTS FROM OFFSITE**

						MINOR TIER 1 SITE					MINOR TIER 1 SITE				
						St Louis Area Office					Chicago Operations Office				
						NY Ops					Argonne (ANL), Battelle Columbus(BMI), Westinghouse				
						FY	Date		REC RIS	Box #	Doc #	Kg DU	Kg NU	Gm EU	Kg U Subtotal
	From	To													
1950	31-Dec-49	31-Dec-50	HGE	38213	FTS-670			0	0	1950		589	0	589	1950
1951	31-Dec-50	30-Jun-51	HGE	38213	FTS-845		22	0	22	1951		384	4967	388.97	1951
1952	01-Jul-51	30-Jun-52	HGE	38213	FTS 953		105	0	105	1952		28	88.4	28.09	1952
1953	01-Jul-52	30-Jun-53	HGE	38213	FTS 1085			0	0	1953		1,571	0	1,571	1953
1954	01-Jul-53	30-Jun-54	HGE	38213	FTS 1311			0	0	1954		813	2	813	1954
1955	01-Jul-54	30-Jun-55	HGE	38213	FTS 1481			0	0	1955		702	1,007	703.01	1955
1956	01-Jul-55	30-Jun-56	HGE	38213	FTS 1644			0	0	1956	21	1,188	1	1,209	1956
1957	01-Jul-56	30-Jun-57	HGE	38213	FTS 1980			0	0	1957	14	12	5,122	31.12	1957
1958	01-Jul-57	30-Jun-58	HGE	38213	FTS CLVI 463			0	0	1958		1,362	111,067	1,473.07	1958
1959	01-Jul-58	30-Jun-59	HGE	38213	HAN 72720			0	0	1959	6	2,629	0	2,635	1959
1960	01-Jul-59	30-Jun-60	HGE	38213	HAN 75996			0	0	1960			617	0.62	1960
1961	01-Jul-60	30-Jun-61	HGE	38213	HAN 79125			0	0	1961	11	59	53,926	123.93	1961
1962	01-Jul-61	30-Jun-62	HGE	38213	HAN 82406			0	0	1962	14	126	58,847	198.85	1962
1963	01-Jul-62	30-Jun-63	HGE	38213	HAN 85615			0	0	1963		426	160,449	586.45	1963
1964	01-Jul-63	30-Jun-64	HGE	38213	HAN 88957			0	0	1964	5	27	36,689	68.69	1964
1965	01-Jul-64	30-Jun-65	HZA	38213	HAN 92119			0	0	1965	346	1	288,894	635.89	1965
<b>FY 53 thru 65 In-Scope subtotals</b>						0	0	0	0		417	8,916	716,621	10,049.62	
<b>FY 1950 - FY 65 Total Kgs</b>									<b>127</b>					<b>11,055.68</b>	
<b>FY 1950 - FY 65 Total MTUs</b>									<b>0.127</b>					<b>11.0557</b>	



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**Table 3.2.2 (Cont.) 1950 - FY 65 HANFORD (GE Company) URANIUM RECEIPTS FROM OFFSITE**

						MINOR TIER 1 SITE					MAJOR TIER 1 SITE				
						Miscellaneous Site 2					National Lead of Ohio-Fernald				
											Oak Ridge				
											NLO				
FY	Date		REC	Box #	Doc #	Kg DU	Kg NU	Gm EU	Kg U Subtotal	FY	Kg DU	Kg NU	Gm EU	Kg U Subtotal	FY
	From	To	RIS												
1950	31-Dec-49	31-Dec-50	HGE	38213	FTS-670			0	0	1950			0	0	1950
1951	31-Dec-50	30-Jun-51	HGE	38213	FTS-845		53	315	53.32	1951			0	0	1951
1952	01-Jul-51	30-Jun-52	HGE	38213	FTS 953		4	0.4	4	1952			0	0	1952
1953	01-Jul-52	30-Jun-53	HGE	38213	FTS 1085		25	0	25	1953			843,042	843.04	1953
1954	01-Jul-53	30-Jun-54	HGE	38213	FTS 1311	1,555	192	88	1,747.09	1954	106	2,735,042	0	2,735,148	1954
1955	01-Jul-54	30-Jun-55	HGE	38213	FTS 1481		76	1,452	77.45	1955	28	4,550,394	0	4,550,422	1955
1956	01-Jul-55	30-Jun-56	HGE	38213	FTS 1644		2	11,985	13.99	1956	55,626	4,563,828	12,294,710	4,631,748.71	1956
1957	01-Jul-56	30-Jun-57	HGE	38213	FTS 1980			1,099	1.1	1957	46,536	5,784,628	62,281,450	5,893,445.45	1957
1958	01-Jul-57	30-Jun-58	HGE	38213	FTS CLVI 463			0	0	1958	9,926	6,841,004	404,954,783	7,255,884.78	1958
1959	01-Jul-58	30-Jun-59	HGE	38213	HAN 72720			0	0	1959	425	4,699,102	614,862,564	5,314,389.56	1959
1960	01-Jul-59	30-Jun-60	HGE	38213	HAN 75996			0	0	1960		6,352,449	794,184,381	7,146,633.38	1960
1961	01-Jul-60	30-Jun-61	HGE	38213	HAN 79125			922	0.92	1961	1,308	5,305,564	1,308,362,230	6,615,234.23	1961
1962	01-Jul-61	30-Jun-62	HGE	38213	HAN 82406	2		45	2.05	1962	430	4,955,626	1,405,647,755	6,361,703.76	1962
1963	01-Jul-62	30-Jun-63	HGE	38213	HAN 85615			0	0	1963		5,743,441	1,760,583,993	7,504,024.99	1963
1964	01-Jul-63	30-Jun-64	HGE	38213	HAN 88957			101,412	101.41	1964	29,359	4,775,201	1,923,153,350	6,727,713.35	1964
1965	01-Jul-64	30-Jun-65	HZA	38213	HAN 92119			0	0	1965		5,580,480	2,522,987,510	8,103,467.51	1965
<b>FY 53 thru 65 In-Scope subtotals</b>						1,557	295	117,003	1,969		143,744	61,886,759	10,810,155,768	72,840,658.77	
<b>FY 1950 - FY 65 Total Kgs</b>									<b>2,026.32</b>	<b>72,840,658.77</b>					
<b>FY 1950 - FY 65 Total MTUs</b>									<b>2.0263</b>	<b>72,840.6588</b>					

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**Table 3.2.2 (Cont.) 1950 - FY 65 HANFORD (GE Company) URANIUM RECEIPTS FROM OFFSITE**

						MINOR TIER 1 SITE					MINOR TIER 1 SITE				
						Tonawanda Sub-Office					Sylvania Elec. Products				
						New York Ops					New York Ops				
						TOA									
FY	Date		REC RIS	Box #	Doc #	Kg DU	Kg NU	Gm EU	Kg U Subtotal	FY	Kg DU	Kg NU	Gm EU	Kg U Subtotal	FY
	From	To													
1950	31-Dec-49	31-Dec-50	HGE	38213	FTS-670		1,864	0	<b>1,864</b>	1950			0	<b>0</b>	1950
1951	31-Dec-50	30-Jun-51	HGE	38213	FTS-845		280,230	0	<b>280,230</b>	1951			0	<b>0</b>	1951
1952	01-Jul-51	30-Jun-52	HGE	38213	FTS 953		347,122	0	<b>347,122</b>	1952		198	0	<b>198</b>	1952
1953	01-Jul-52	30-Jun-53	HGE	38213	FTS 1085		25,221	0	<b>25,221</b>	1953		1,233	0	<b>1,233</b>	1953
1954	01-Jul-53	30-Jun-54	HGE	38213	FTS 1311			0	<b>0</b>	1954		7,450	0	<b>7,450</b>	1954
1955	01-Jul-54	30-Jun-55	HGE	38213	FTS 1481			0	<b>0</b>	1955		79	0	<b>79</b>	1955
1956	01-Jul-55	30-Jun-56	HGE	38213	FTS 1644			0	<b>0</b>	1956			0	<b>0</b>	1956
1957	01-Jul-56	30-Jun-57	HGE	38213	FTS 1980			0	<b>0</b>	1957			0	<b>0</b>	1957
1958	01-Jul-57	30-Jun-58	HGE	38213	FTS CLVI 463			0	<b>0</b>	1958			0	<b>0</b>	1958
1959	01-Jul-58	30-Jun-59	HGE	38213	HAN 72720			0	<b>0</b>	1959			0	<b>0</b>	1959
1960	01-Jul-59	30-Jun-60	HGE	38213	HAN 75996			0	<b>0</b>	1960			0	<b>0</b>	1960
1961	01-Jul-60	30-Jun-61	HGE	38213	HAN 79125			0	<b>0</b>	1961			0	<b>0</b>	1961
1962	01-Jul-61	30-Jun-62	HGE	38213	HAN 82406			0	<b>0</b>	1962			0	<b>0</b>	1962
1963	01-Jul-62	30-Jun-63	HGE	38213	HAN 85615			0	<b>0</b>	1963			0	<b>0</b>	1963
1964	01-Jul-63	30-Jun-64	HGE	38213	HAN 88957			0	<b>0</b>	1964			0	<b>0</b>	1964
1965	01-Jul-64	30-Jun-65	HZA	38213	HAN 92119			0	<b>0</b>	1965			0	<b>0</b>	1965
<b>FY 53 thru 65 In-Scope subtotals</b>						0	25,221	0	<b>25,221</b>		0	8,762	0	<b>8,762</b>	
<b>FY 1950 - FY 65 Total Kgs</b>									<b>654,437</b>						
<b>FY 1950 - FY 65 Total MTUs</b>									<b>654.437</b>						

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**Table 3.2.2 (Cont.) 1950 - FY 65 HANFORD (GE Company) URANIUM RECEIPTS FROM OFFSITE**

						MAJOR TIER 1 SITE					MAJOR TIER 1 SITE				
						Carbide & Carbon Chem Co.					Union Carbide of Kentucky-Paducah				
						ORO Y-12 & K-25					Oak Ridge Office				
						CYT & CCC					CKY				
FY	Date		REC RIS	Box #	Doc #	Kg DU	Kg NU	Gm EU	Kg U Subtotal	FY	Kg DU	Kg NU	Gm EU	Kg U subtotal	FY
	From	To													
1950	31-Dec-49	31-Dec-50	HGE	38213	FTS-670		2	390,416	<b>392.42</b>	1950			0	<b>0</b>	1950
1951	31-Dec-50	30-Jun-51	HGE	38213	FTS-845			0	<b>0</b>	1951			0	<b>0</b>	1951
1952	01-Jul-51	30-Jun-52	HGE	38213	FTS 953	20	2	11,137.5	<b>33.14</b>	1952			0	<b>0</b>	1952
1953	01-Jul-52	30-Jun-53	HGE	38213	FTS 1085	8	12	594,486	<b>614.49</b>	1953			0	<b>0</b>	1953
1954	01-Jul-53	30-Jun-54	HGE	38213	FTS 1311	1	12	2,076,512	<b>2,089.51</b>	1954			0	<b>0</b>	1954
1955	01-Jul-54	30-Jun-55	HGE	38213	FTS 1481	4	25	361,682	<b>390.68</b>	1955			0	<b>0</b>	1955
1956	01-Jul-55	30-Jun-56	HGE	38213	FTS 1644	28		322	<b>28.32</b>	1956		2	0	<b>2</b>	1956
1957	01-Jul-56	30-Jun-57	HGE	38213	FTS 1980			0	<b>0</b>	1957	2,249		683,211	<b>2,932.21</b>	1957
1958	01-Jul-57	30-Jun-58	HGE	38213	FTS CLVI 463	37		1	<b>37</b>	1958	2,182	49	0	<b>2,231</b>	1958
1959	01-Jul-58	30-Jun-59	HGE	38213	HAN 72720	52	2	57,647	<b>111.65</b>	1959	2,940		967,462	<b>3,907.46</b>	1959
1960	01-Jul-59	30-Jun-60	HGE	38213	HAN 75996	6		440,958	<b>446.96</b>	1960	1,880		80,453	<b>1,960.45</b>	1960
1961	01-Jul-60	30-Jun-61	HGE	38213	HAN 79125		19	434,908	<b>453.91</b>	1961	2,864		50	<b>2,864.05</b>	1961
1962	01-Jul-61	30-Jun-62	HGE	38213	HAN 82406		19	45,158	<b>64.16</b>	1962	3,434		642,143	<b>4,076.14</b>	1962
1963	01-Jul-62	30-Jun-63	HGE	38213	HAN 85615	80		0	<b>80</b>	1963	4,133		676	<b>4,133.68</b>	1963
1964	01-Jul-63	30-Jun-64	HGE	38213	HAN 88957			0	<b>0</b>	1964	2,358		0	<b>2,358</b>	1964
1965	01-Jul-64	30-Jun-65	HZA	38213	HAN 92119	8		0	<b>8</b>	1965			0	<b>0</b>	1965
<i>FY 53 thru 65 In-Scope subtotals</i>						224	89	4,011,674	<b>4,324.67</b>		22,040	51	2,373,995	<b>24,465</b>	
<b>FY 1950 - FY 65 Total Kgs</b>									<b>4,750.23</b>						<b>24,465</b>
<b>FY 1950 - FY 65 Total MTUs</b>									<b>4.7502</b>						<b>24.465</b>

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**Table 3.2.2 (Cont.) 1950 - FY 65 HANFORD (GE Company) URANIUM RECEIPTS FROM OFFSITE**

						MINOR TIER 1 SITE					MINOR TIER 1 SITE				
						Oak Ridge Natl Lab					Hanford Operations				
						Oak Ridge Office					Bureau of Mines				
						ORL									
FY	Date		REC RIS	Box #	Doc #	Kg DU	Kg NU	Gm EU	Kg U Subtotal	FY	Kg DU	Kg NU	Gm EU	Kg U Subtotal	FY
	From	To													
1950	31-Dec-49	31-Dec-50	HGE	38213	FTS-670		1	979	1.98	1950			0	0	1950
1951	31-Dec-50	30-Jun-51	HGE	38213	FTS-845			0	0	1951			0	0	1951
1952	01-Jul-51	30-Jun-52	HGE	38213	FTS 953		21	0	21	1952		13	0	13	1952
1953	01-Jul-52	30-Jun-53	HGE	38213	FTS 1085	3	48	0	51	1953		6	0	6	1953
1954	01-Jul-53	30-Jun-54	HGE	38213	FTS 1311			0	0	1954			0	0	1954
1955	01-Jul-54	30-Jun-55	HGE	38213	FTS 1481			6,770	6.77	1955			0	0	1955
1956	01-Jul-55	30-Jun-56	HGE	38213	FTS 1644			0	0	1956			0	0	1956
1957	01-Jul-56	30-Jun-57	HGE	38213	FTS 1980			0	0	1957		871	0	871	1957
1958	01-Jul-57	30-Jun-58	HGE	38213	FTS CLVI 463			0	0	1958			0	0	1958
1959	01-Jul-58	30-Jun-59	HGE	38213	HAN 72720			399	0.4	1959		797	0	797	1959
1960	01-Jul-59	30-Jun-60	HGE	38213	HAN 75996			0	0	1960		6,194	0	6,194	1960
1961	01-Jul-60	30-Jun-61	HGE	38213	HAN 79125			117,004	117	1961		22,129	0	22,129	1961
1962	01-Jul-61	30-Jun-62	HGE	38213	HAN 82406			27	0.03	1962		3,013	0	3,013	1962
1963	01-Jul-62	30-Jun-63	HGE	38213	HAN 85615			0	0	1963			0	0	1963
1964	01-Jul-63	30-Jun-64	HGE	38213	HAN 88957			0	0	1964			0	0	1964
1965	01-Jul-64	30-Jun-65	HZA	38213	HAN 92119			5	0.01	1965			0	0	1965
<b>FY 53 thru 65 In-Scope subtotals</b>						<b>3</b>	<b>48</b>	<b>124,205</b>	<b>175.21</b>		<b>0</b>	<b>33,010</b>	<b>0</b>	<b>33,010</b>	
<b>FY 1950 - FY 65 Total Kgs</b>									<b>198.18</b>		<b>33,023</b>				
<b>FY 1950 - FY 65 Total MTUs</b>									<b>0.1982</b>		<b>33.023</b>				

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**Table 3.2.2 (Cont.) 1950 - FY 65 HANFORD (GE Company) URANIUM RECEIPTS FROM OFFSITE**

						MINOR TIER 1 SITE					MINOR TIER 1 SITE				
						San Francisco Operations					Bridgeport Brass Co.				
											NY Ops then under ORO				
FY	Date		REC RIS	Box #	Doc #	Kg DU	Kg NU	Gm EU	Kg U Subtotal	FY	Kg DU	Kg NU	Gm EU	Kg U Subtotal	FY
	From	To													
1950	31-Dec-49	31-Dec-50	HGE	38213	FTS-670			0	0	1950			0	0	1950
1951	31-Dec-50	30-Jun-51	HGE	38213	FTS-845			0	0	1951			0	0	1951
1952	01-Jul-51	30-Jun-52	HGE	38213	FTS 953			0	0	1952			0	0	1952
1953	01-Jul-52	30-Jun-53	HGE	38213	FTS 1085		849	0	849	1953		464	0	464	1953
1954	01-Jul-53	30-Jun-54	HGE	38213	FTS 1311		1	0	1	1954		772	0	772	1954
1955	01-Jul-54	30-Jun-55	HGE	38213	FTS 1481			0	0	1955		8,197	0	8,197	1955
1956	01-Jul-55	30-Jun-56	HGE	38213	FTS 1644		43	0	43	1956		4	0	4	1956
1957	01-Jul-56	30-Jun-57	HGE	38213	FTS 1980	2	9	329	11.33	1957		358	0	358	1957
1958	01-Jul-57	30-Jun-58	HGE	38213	FTS CLVI 463			0	1	1958		828	0	828	1958
1959	01-Jul-58	30-Jun-59	HGE	38213	HAN 72720	2	227	267,067	496.07	1959		4,313	0	4,313	1959
1960	01-Jul-59	30-Jun-60	HGE	38213	HAN 75996	342	2,001	17,178	2,360.18	1960		6,935	0	6,935	1960
1961	01-Jul-60	30-Jun-61	HGE	38213	HAN 79125	383	5,794	270,067	6,447.07	1961		2,605	0	2,605	1961
1962	01-Jul-61	30-Jun-62	HGE	38213	HAN 82406			10,546	10.55	1962			0	0	1962
1963	01-Jul-62	30-Jun-63	HGE	38213	HAN 85615		13	1,866	14.87	1963			0	0	1963
1964	01-Jul-63	30-Jun-64	HGE	38213	HAN 88957			108	0.11	1964			0	0	1964
1965	01-Jul-64	30-Jun-65	HZA	38213	HAN 92119	26		53,392	79.39	1965			0	0	1965
<i>FY 53 thru 65 In-Scope subtotals</i>						756	8,937	620,553	10,313.55		0	24,476	0	24,476	
<b>FY 1950 - FY 65 Total Kgs</b>									<b>10,313.55</b>		<b>24,476</b>				
<b>FY 1950 - FY 65 Total MTUs</b>									<b>10.3136</b>		<b>24.476</b>				

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**Table 3.2.2 (Cont.) 1950 - FY 65 HANFORD (GE Company) URANIUM RECEIPTS FROM OFFSITE**

						MINOR TIER 1 SITE					MINOR TIER 1 SITE				
						Savannah River					Sante Fe/Albuquerque Ops				
						DuPont, Sylvania Elec, Sylvania Corning Nuc									
						SRS									
FY	Date		REC RIS	Box #	Doc #	Kg DU	Kg NU	Gm EU	Kg U Subtotal	FY	Kg DU	Kg NU	Gm EU	Kg U Subtotal	FY
	From	To													
1950	31-Dec-49	31-Dec-50	HGE	38213	FTS-670			0	0	1950			0	0	1950
1951	31-Dec-50	30-Jun-51	HGE	38213	FTS-845			0	0	1951			0	0	1951
1952	01-Jul-51	30-Jun-52	HGE	38213	FTS 953			0	0	1952			0	0	1952
1953	01-Jul-52	30-Jun-53	HGE	38213	FTS 1085			0	0	1953			0	0	1953
1954	01-Jul-53	30-Jun-54	HGE	38213	FTS 1311		3	0	3	1954			0	0	1954
1955	01-Jul-54	30-Jun-55	HGE	38213	FTS 1481		3,440	0	3,440	1955			0	0	1955
1956	01-Jul-55	30-Jun-56	HGE	38213	FTS 1644		624	206	624.21	1956			7	0.01	1956
1957	01-Jul-56	30-Jun-57	HGE	38213	FTS 1980		638	0	638	1957			4	0	1957
1958	01-Jul-57	30-Jun-58	HGE	38213	FTS CLVI 463		6,649	0	6,649	1958	65		0	65	1958
1959	01-Jul-58	30-Jun-59	HGE	38213	HAN 72720		318	0	318	1959	16		0	16	1959
1960	01-Jul-59	30-Jun-60	HGE	38213	HAN 75996		36	0	36	1960			0	0	1960
1961	01-Jul-60	30-Jun-61	HGE	38213	HAN 79125		143	0	143	1961			0	0	1961
1962	01-Jul-61	30-Jun-62	HGE	38213	HAN 82406	13	3,164.	0	3,177	1962			0	0	1962
1963	01-Jul-62	30-Jun-63	HGE	38213	HAN 85615		9	2,125,491	2,134.49	1963			0	0	1963
1964	01-Jul-63	30-Jun-64	HGE	38213	HAN 88957			0	0	1964			711	0.71	1964
1965	01-Jul-64	30-Jun-65	HZA	38213	HAN 92119			0	0	1965			83	0.08	1965
<b>FY 53 thru 65 In-Scope subtotals</b>						13	15,024	2,125,697	17,162.7		81	0	805	81.81	
<b>FY 1950 - FY 65 Total Kgs</b>									<b>17,162.7</b>	<b>81.81</b>					
<b>FY 1950 - FY 65 Total MTUs</b>									<b>17.1627</b>	<b>0.0818</b>					

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**Table 3.2.2 (Cont.) 1950 - FY 65 HANFORD (GE Company) URANIUM RECEIPTS FROM OFFSITE**

						MINOR TIER 1 SITE					MINOR TIER 1 SITE				
						Evergreen Ops					AEC Procurement From Licensees				
						EVG									
FY	Date		REC	Box #	Doc #	Kg DU	Kg NU	Gm EU	Kg U Subtotal	FY	Kg DU	Kg NU	Gm EU	Kg U Subtotal	FY
	From	To	RIS												
1950	31-Dec-49	31-Dec-50	HGE	38213	FTS-670			0	0	1950			0	0	1950
1951	31-Dec-50	30-Jun-51	HGE	38213	FTS-845			0	0	1951			0	0	1951
1952	01-Jul-51	30-Jun-52	HGE	38213	FTS 953			0	0	1952			0	0	1952
1953	01-Jul-52	30-Jun-53	HGE	38213	FTS 1085	1		0	1	1953			0	0	1953
1954	01-Jul-53	30-Jun-54	HGE	38213	FTS 1311			0	0	1954			0	0	1954
1955	01-Jul-54	30-Jun-55	HGE	38213	FTS 1481			0	0	1955			0	0	1955
1956	01-Jul-55	30-Jun-56	HGE	38213	FTS 1644			0	0	1956			0	0	1956
1957	01-Jul-56	30-Jun-57	HGE	38213	FTS 1980	803		0	803	1957			0	0	1957
1958	01-Jul-57	30-Jun-58	HGE	38213	FTS CLVI 463			0	20,625	1958			49,804	49.8	1958
1959	01-Jul-58	30-Jun-59	HGE	38213	HAN 72720	6,457		0	6,457	1959		80	0	80	1959
1960	01-Jul-59	30-Jun-60	HGE	38213	HAN 75996			0	0	1960		447	0	447	1960
1961	01-Jul-60	30-Jun-61	HGE	38213	HAN 79125			0	0	1961	80	43	0	123	1961
1962	01-Jul-61	30-Jun-62	HGE	38213	HAN 82406			0	0	1962		95	0	95	1962
1963	01-Jul-62	30-Jun-63	HGE	38213	HAN 85615			0	0	1963	2	45	0	47	1963
1964	01-Jul-63	30-Jun-64	HGE	38213	HAN 88957			0	0	1964	279	12	0	291	1964
1965	01-Jul-64	30-Jun-65	HZA	38213	HAN 92119			0	0	1965	72		0	72	1965
<b>FY 53 thru 65 In-Scope subtotals</b>						27,886	0	0	27,886		433	722	49,804	1,204.8	
<b>FY 1950 - FY 65 Total Kgs</b>									<b>27,886</b>				<b>1,204.8</b>		
<b>FY 1950 - FY 65 Total MTUs</b>									<b>27.886</b>				<b>1.2048</b>		

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**Table 3.2.2 (Cont.) 1950 - FY 65 HANFORD (GE Company) URANIUM RECEIPTS FROM OFFSITE**

						MINOR TIER 1 SITE					MINOR TIER 1 SITE				
						Miscellaneous Site 1					Materials Leasing Office				
											Oak Ridge Headquarters				
FY	Date		REC RIS	Box #	Doc #	Kg DU	Kg NU	Gm EU	Kg U Subtotal	FY	Kg DU	Kg NU	Gm EU	Kg U Subtotal	FY
	From	To													
1950	31-Dec-49	31-Dec-50	HGE	38213	FTS-670			0	0	1950			0	0	1950
1951	31-Dec-50	30-Jun-51	HGE	38213	FTS-845			0	0	1951			0	0	1951
1952	01-Jul-51	30-Jun-52	HGE	38213	FTS 953			0	0	1952			0	0	1952
1953	01-Jul-52	30-Jun-53	HGE	38213	FTS 1085			0	0	1953			0	0	1953
1954	01-Jul-53	30-Jun-54	HGE	38213	FTS 1311			0	0	1954			0	0	1954
1955	01-Jul-54	30-Jun-55	HGE	38213	FTS 1481			0	0	1955			0	0	1955
1956	01-Jul-55	30-Jun-56	HGE	38213	FTS 1644			0	0	1956			0	0	1956
1957	01-Jul-56	30-Jun-57	HGE	38213	FTS 1980			0	0	1957			0	0	1957
1958	01-Jul-57	30-Jun-58	HGE	38213	FTS CLVI 463			0	0	1958			0	0	1958
1959	01-Jul-58	30-Jun-59	HGE	38213	HAN 72720			4,139	4.14	1959			0	0	1959
1960	01-Jul-59	30-Jun-60	HGE	38213	HAN 75996	3	7	2,863	12.86	1960			0	0	1960
1961	01-Jul-60	30-Jun-61	HGE	38213	HAN 79125		4,910	53	4,910.05	1961			0	0	1961
1962	01-Jul-61	30-Jun-62	HGE	38213	HAN 82406		12,595	0	12,595	1962			0	0	1962
1963	01-Jul-62	30-Jun-63	HGE	38213	HAN 85615		4,423	0	4,423	1963			2205	2.21	1963
1964	01-Jul-63	30-Jun-64	HGE	38213	HAN 88957			0	0	1964	65		7	65.01	1964
1965	01-Jul-64	30-Jun-65	HZA	38213	HAN 92119	3,327	226	0	3,553	1965			0	0	1965
<i>FY 53 thru 65 In-Scope subtotals</i>						3,330	22,161	7,055	25,498.06		65	0	2,212	67.21	
									<i>FY 1950 - FY 65 Total Kgs</i>	<b>25,498.06</b>					<b>67.21</b>
									<i>FY 1950 - FY 65 Total MTUs</i>	<b>25.4981</b>					<b>0.0672</b>



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**Table 3.2.2 (Cont.) 1950 - FY 65 HANFORD (GE Company) URANIUM RECEIPTS FROM OFFSITE**

						MINOR TIER 1 SITE					MINOR TIER 1 SITE				
						United Nuclear Corp Chem Oak Ridge					Kerr-McGee Oil Industrial Oak Ridge				
FY	Date		REC RIS	Box #	Doc #	Kg DU	Kg NU	Gm EU	Kg U Subtotal	FY	Kg DU	Kg NU	Gm EU	Kg U Subtotal	FY
	From	To													
1950	31-Dec-49	31-Dec-50	HGE	38213	FTS-670			0	0	1950			0	0	1950
1951	31-Dec-50	30-Jun-51	HGE	38213	FTS-845			0	0	1951			0	0	1951
1952	01-Jul-51	30-Jun-52	HGE	38213	FTS 953			0	0	1952			0	0	1952
1953	01-Jul-52	30-Jun-53	HGE	38213	FTS 1085			0	0	1953			0	0	1953
1954	01-Jul-53	30-Jun-54	HGE	38213	FTS 1311			0	0	1954			0	0	1954
1955	01-Jul-54	30-Jun-55	HGE	38213	FTS 1481			0	0	1955			0	0	1955
1956	01-Jul-55	30-Jun-56	HGE	38213	FTS 1644			0	0	1956			0	0	1956
1957	01-Jul-56	30-Jun-57	HGE	38213	FTS 1980			0	0	1957			0	0	1957
1958	01-Jul-57	30-Jun-58	HGE	38213	FTS CLVI 463			0	0	1958			0	0	1958
1959	01-Jul-58	30-Jun-59	HGE	38213	HAN 72720			0	0	1959			0	0	1959
1960	01-Jul-59	30-Jun-60	HGE	38213	HAN 75996			0	0	1960			0	0	1960
1961	01-Jul-60	30-Jun-61	HGE	38213	HAN 79125			0	0	1961			0	0	1961
1962	01-Jul-61	30-Jun-62	HGE	38213	HAN 82406			0	0	1962			0	0	1962
1963	01-Jul-62	30-Jun-63	HGE	38213	HAN 85615			0	0	1963			0	0	1963
1964	01-Jul-63	30-Jun-64	HGE	38213	HAN 88957		523	0	523	1964	2,246		0	2,246	1964
1965	01-Jul-64	30-Jun-65	HZA	38213	HAN 92119			0	0	1965			0	0	1965
<b>FY 53 thru 65 In-Scope subtotals</b>						0	523	0	523		2,246	0	0	2,246	
<b>FY 1950 - FY 65 Total Kgs</b>									<b>523</b>						<b>2,246</b>
<b>FY 1950 - FY 65 Total MTUs</b>									<b>0.523</b>						<b>2.246</b>

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**Table 3.2.2 (Cont.) 1950 - FY 65 HANFORD (GE Company) URANIUM RECEIPTS FROM OFFSITE**

						MINOR TIER 1 SITE					MINOR TIER 1 SITE							
						Goodyear Atomic Corp					Harshaw Chemical Company					Mass. Institute of Technology NY Ops		
						Oak Ridge												
FY	Date		REC	Box #	Doc #	Kg DU	Kg NU	Gm EU	Kg U Subtotal	FY	Kg DU	Kg NU	Gm EU	Kg U Subtotal	FY	Kg NU		
1950	31-Dec-49	31-Dec-50	HGE	38213	FTS-670			0	0	1950			0	0	1950			
1951	31-Dec-50	30-Jun-51	HGE	38213	FTS-845			0	0	1951			0	0	1951			
1952	01-Jul-51	30-Jun-52	HGE	38213	FTS 953			0	0	1952			0	0	1952		OUT-OF SCOPE	
1953	01-Jul-52	30-Jun-53	HGE	38213	FTS 1085			0	0	1953	9	10	0	19	1953	623	IN-SCOPE	
1954	01-Jul-53	30-Jun-54	HGE	38213	FTS 1311			0	0	1954			0	0	1954			
1955	01-Jul-54	30-Jun-55	HGE	38213	FTS 1481			0	0	1955			0	0	1955			
1956	01-Jul-55	30-Jun-56	HGE	38213	FTS 1644			0	0	1956			0	0	1956			
1957	01-Jul-56	30-Jun-57	HGE	38213	FTS 1980			0	0	1957			0	0	1957			
1958	01-Jul-57	30-Jun-58	HGE	38213	FTS CLVI 463			0	0	1958			0	0	1958			
1959	01-Jul-58	30-Jun-59	HGE	38213	HAN 72720			0	0	1959			0	0	1959			
1960	01-Jul-59	30-Jun-60	HGE	38213	HAN 75996			0	0	1960			0	0	1960			
1961	01-Jul-60	30-Jun-61	HGE	38213	HAN 79125			0	0	1961			0	0	1961			
1962	01-Jul-61	30-Jun-62	HGE	38213	HAN 82406			0	0	1962			0	0	1962			
1963	01-Jul-62	30-Jun-63	HGE	38213	HAN 85615			0	0	1963			0	0	1963			
1964	01-Jul-63	30-Jun-64	HGE	38213	HAN 88957			1,429	1.43	1964			0	0	1964			
1965	01-Jul-64	30-Jun-65	HZA	38213	HAN 92119			0	0	1965			0	0	1965			
<b><i>FY 53 thru 65 In-Scope subtotals</i></b>						0	0	1,429	1.43		9	10	0	19		623	77,603,679.8	ALL IN-SCOPE KG U FY 1953 thru FY 1965
<b>FY 1950 - FY 65 Total Kgs</b>									1.43					19		623	81,013,219	KG U ALL OUT-OF- SCOPE & IN- SCOPE FY 1950-FY 1965
<b>FY 1950 - FY 65 Total MTUs</b>									0.0014					0.019		0.623	81,013.2	MTU ALL OUT-OF- SCOPE & IN- SCOPE FY 1950-FY 1965

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**Table 3.2.3 Hanford FY1966-70 Uranium Receipts**

							MINOR TIER 1 SITE					MINOR TIER 1 SITE				
							Mallinckrodt Chem Works MCW, Weldon Springs (FWA)					New Brunswick Lab				
							ORO Ops					FBE				
FY	Date		REC RIS	Receipts Into Hanford Contractor	Box #	Doc #	Kg DU	Kg NU	Gm EU	Kg Total	FY	Kg DU	Kg NU	Gm EU	Kg Total	FY
	From	To														
1966	1-Jul-65	30-Jun-66	HZA	General Electric	38213	HAN 95170				0	1966		1		1	1966
1966	1-Jul-65	30-Jun-66	HWA	Isochem Inc.	38213	HAN 95136			58346	58.3	1966				0	1966
<b>Hanford Chem Processing Contractor subtotal</b>							<b>0</b>	<b>0</b>	<b>58,346</b>	<b>58.3</b>	<b>1966</b>	<b>0</b>	<b>1</b>	<b>0</b>	<b>1</b>	<b>1966</b>
1966	1-Jul-65	30-Jun-66	HXA	Douglas United Nuc	38214	HAN 95171				0	1966		2		2	1966
<b>Hanford FY Aggregate subtotal</b>							<b>0</b>	<b>0</b>	<b>58,346</b>	<b>58.3</b>	<b>1966</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>3</b>	<b>1966</b>
1967	1-Jul-66	31-Dec-66	HZA	General Electric	39213	HAN 96413				0	1967				0	1967
1967	1-Jan-67	30-Jun-67	HZA	General Electric	39213	HAN 98198										
1967	1-Jul-66	31-Dec-67	HWA	Isochem Inc.	38213	HAN 96400			45,697	45.7						
1967	1-Jan-67	30-Jun-67	HWA	Isochem Inc.	38213	HAN 98196				0	1967				0	1967
<b>Hanford Chem Processing Contractor subtotal</b>							<b>0</b>	<b>0</b>	<b>45,697</b>	<b>46</b>	<b>1967</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>1967</b>
1967	1-Jul-66	31-Dec-66	HWA	Douglas United Nuc	38214	DUN-1916				0				0		
1967	1-Jan-67	30-Jun-67	HXA	Douglas United Nuc	38214	HAN 98194				0	1967				0	1967
<b>Hanford FY Aggregate subtotal</b>							<b>0</b>	<b>0</b>	<b>45,697</b>	<b>45.7</b>	<b>1967</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>1967</b>
1968	1-Jul-67	31-Dec-67	HVA	Atlantic Richfield Han	46425	HAN 99439				0	1968				0	1968
1968	1-Jan-68	30-Jun-68	HVA	Atlantic Richfield Han	46425	ARH 699				0	1968				0	1968
<b>Hanford Chem Processing Contractor subtotal</b>							<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>1968</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>1968</b>
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	1968				0	1968
<b>Hanford FY Aggregate subtotal</b>							<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>1968</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>1968</b>
1969	1-Jul-68	31-Dec-68	HVA	Atlantic Richfield Han	46425	ARH 1036				0	1969				0	1969
1969	1-Jan-69	30-Jun-69	HVA	Atlantic Richfield Han	46425	ARH 1099-6				0	1969				0	1969
<b>Hanford Chem Processing Contractor subtotal</b>							<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>1969</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>1969</b>
1969	1-Jul-68	31-Dec-68	HXA	Douglas United Nuc	38214	DUN 5250				0				0		
1969	1-Jan-69	30-Jun-69	HXA	Douglas United Nuc	38214	DUN 5942				0	1969				0	1969
<b>Hanford FY Aggregate subtotal</b>							<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>1969</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>1969</b>
1970	1-Jul-69	31-Dec-69	HVA	Atlantic Richfield Han	46425	ARH 1099-12				0	1970				0	1970
1970	1-Jan-70	30-Jun-70	HVA	Atlantic Richfield Han	46425	ARH 1540-6				0	1970				0	1970
<b>Hanford Chem Processing Contractor subtotal</b>																
1970	1-Jul-69	31-Dec-69	HXA	Douglas United Nuc	38214	DUN 6557				0				0		
1970	1-Jan-70	30-Jun-70	HXA	Douglas United Nuc	38214	DUN 7049				0	1970				0	1970
<b>Hanford FY Aggregate subtotal</b>							<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>1970</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>1970</b>
<b>FY 66 thru 70 kilogram subtotals</b>							<b>0</b>	<b>0</b>	<b>104 043</b>	<b>104</b>	<b>66-70</b>	<b>0</b>	<b>3</b>	<b>0</b>	<b>3</b>	<b>66-70</b>

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**Table 3.2.3 Hanford FY1966-70 Uranium Receipts (Cont.)**

							<b>MINOR TIER 1 SITE</b>					<b>MAJOR TIER 1 SITE</b>					
							New York Ops Office					National Lead of Ohio-Fernald					
							Nuclear Materials/Equipment					NLO,FVA,FVB,FVC					
							NY Ops (MBN(MAN)(MCY))					Oak Ridge Ops					
FY	Date		REC RIS	Receipts Into Hanford Contractor	Box#	Doc#	Kg DU	Kg NU	Gm EU	Kg Total	FY	Kg DU	Kg NU	Gm EU	Kg Total	FY	
	From	To															
1966	1-Jul-65	30-Jun-66	HZA	General Electric	38213	HAN 95170			23,928	23.9	1966			1,126,519	1,202,216,343	2,328,735.3	1966
1966	1-Jul-65	30-Jun-66	HWA	Isochem Inc.	38213	HAN 95136				0	1966			335,077	335.1	1966	
<b>Hanford Chem Processing Contractor subtotal</b>							<b>0</b>	<b>0</b>	<b>23,928</b>	<b>23.9</b>	<b>1966</b>	<b>0</b>	<b>1,126,519</b>	<b>1,202,551,420</b>	<b>2,329,070.4</b>	<b>1966</b>	
1966	1-Jul-65	30-Jun-66	HXA	Douglas United Nuc	38214	HAN 95171				0	1966			1,992,772	1,282,816,022	3,275,588	1966
<b>Hanford FY Aggregate subtotal</b>							<b>0</b>	<b>0</b>	<b>23,928</b>	<b>23.9</b>	<b>1966</b>	<b>0</b>	<b>3,119,291</b>	<b>2,485,367,442</b>	<b>5,604,658.4</b>	<b>1966</b>	
1967	1-Jul-66	31-Dec-66	HZA	General Electric	39213	HAN 96413				0	1967			2,051	303,875,880	305,926.9	1967
1967	1-Jan-67	30-Jun-67	HZA	General Electric	39213	HAN 98198								458	186,082,081	186,540.1	1967
1967	1-Jul-66	31-Dec-67	HWA	Isochem Inc.	38213	HAN 96400								184,655	184.7	1967	
1967	1-Jan-67	30-Jun-67	HWA	Isochem Inc.	38213	HAN 98196				0	1967			345,212	345.2	1967	
<b>Hanford Chem Processing Contractor subtotal</b>							<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>1967</b>	<b>0</b>	<b>2,509</b>	<b>490,487,828</b>	<b>492,997</b>	<b>1967</b>	
1967	1-Jul-66	31-Dec-66	HWA	Douglas United Nuc	38214	DUN-1916				0		89,551	1,502,677	321,747,262	1,913,975.3		
1967	1-Jan-67	30-Jun-67	HXA	Douglas United Nuc	38214	HAN 98194				0	1967	4,711.9	1,694,884	950,686,084	2,650,282	1967	
<b>Hanford FY Aggregate subtotal</b>							<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>1967</b>	<b>94,262.9</b>	<b>3,200,070</b>	<b>1,762,921,174</b>	<b>5,057,254.1</b>	<b>1967</b>	
1968	01-Jul-67	31-Dec-67	HVA	Atlantic Richfield Han	46425	HAN 99439		15	1,536	16.5	1968			229	200,804	429.8	1968
1968	1-Jan-68	30-Jun-68	HVA	Atlantic Richfield Han	46425	ARH 699		2	5,846	7.8	1968				368,997	369	1968
<b>Hanford Chem Processing Contractor subtotal</b>							<b>0</b>	<b>17</b>	<b>7,382</b>	<b>24.4</b>	<b>1968</b>	<b>0</b>	<b>229</b>	<b>569,801</b>	<b>798.8</b>	<b>1968</b>	
1968	01-Jul-67	31-Dec-67	HXA	Douglas United Nuc	38214	DUN-3624				0				956,737	934,698,368	1,891,435.4	
1968	1-Jan-68	30-Jun-68	HXA	Douglas United Nuc	38214	DUN 4436				0	1968			296,046	1,233,538,005	1,529,584	1968
<b>Hanford FY Aggregate subtotal</b>							<b>0</b>	<b>17</b>	<b>7,382</b>	<b>24.4</b>	<b>1968</b>	<b>0.0</b>	<b>1,253,012</b>	<b>2,168,806,174</b>	<b>3,421,818.2</b>	<b>1968</b>	
1969	1-Jul-68	31-Dec-68	HVA	Atlantic Richfield Han	46425	ARH 1036				0	1969			124,189	124.2	1969	
1969	1-Jan-69	30-Jun-69	HVA	Atlantic Richfield Han	46425	ARH 1099-6				0	1969			244,596	244.6	1969	
<b>Hanford Chem Processing Contractor subtotal</b>							<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>1969</b>	<b>0</b>	<b>0</b>	<b>368,785</b>	<b>368.8</b>	<b>1969</b>	
1969	1-Jul-68	31-Dec-68	HXA	Douglas United Nuc	38214	DUN 5250				0				75,334	1,320,440,206	1,395,774.2	
1969	1-Jan-69	30-Jun-69	HXA	Douglas United Nuc	38214	DUN 5942				0	1969			63,273	1,122,521,853	1,185,794.9	1969
<b>Hanford FY Aggregate subtotal</b>							<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>1969</b>	<b>0</b>	<b>138,600</b>	<b>2,443,330,844</b>	<b>2,581,937.8</b>	<b>1969</b>	
1970	1-Jul-69	31-Dec-69	HVA	Atlantic Richfield Han	46425	ARH 1099-				0	1970	63	152	318,662	533.7	1970	
1970	1-Jan-70	30-Jun-70	HVA	Atlantic Richfield Han	46425	ARH 1540-6			3,178	3.2	1970			98,665	98.7	1970	
<b>Hanford Chem Processing Contractor subtotal</b>																	
1970	1-Jul-69	31-Dec-69	HXA	Douglas United Nuc	38214	DUN 6557				0				1,074,322	345,447,652	1,419,769.7	
1970	1-Jan-70	30-Jun-70	HXA	Douglas United Nuc	38214	DUN 7049				0	1970			707,771	316,319,868	1,024,090.9	1970
<b>Hanford FY Aggregate subtotal</b>							<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>1970</b>	<b>0</b>	<b>1,782,093</b>	<b>661,767,520</b>	<b>2,443,860.5</b>	<b>1970</b>	
<b>FY 66 thru 70 kilogram subtotals</b>							<b>0</b>	<b>17</b>	<b>31,310</b>	<b>48.3</b>	<b>66-70</b>	<b>94,262.9</b>	<b>9,493,073</b>	<b>9,522,193,154</b>	<b>19,109,529.1</b>	<b>66-70</b>	

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**Table 3.2.3 Hanford FY1966-70 Uranium Receipts (Cont.)**

							MAJOR TIER 1 SITE					MINOR TIER 1 SITE				
							Carbide & Carbon Chem					Oak Ridge Natl Lab				
							ORO Y-12					FZC				
							CYT, FZB					ORL				
FY	Date		REC RIS	Receipts Into Hanford Contractor	Box#	Doc#	Kg DU	Kg NU	Gm EU	Kg Total	FY	Kg DU	Kg NU	Gm EU	Kg Total	FY
	From	To														
1966	1-Jul-65	30-Jun-66	HZA	General Electric	38213	HAN 95170				0	1966				0	1966
1966	1-Jul-65	30-Jun-66	HWA	Isochem Inc.	38213	HAN 95136				0	1966				0	1966
<b>Hanford Chem Processing Contractor subtotal</b>							<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>1966</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>1966</b>
1966	1-Jul-65	30-Jun-66	HXA	Douglas United Nuc	38214	HAN 95171				0	1966				0	1966
<b>Hanford FY Aggregate subtotal</b>							<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>1966</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>1966</b>
1967	1-Jul-66	31-Dec-66	HZA	General Electric	39213	HAN 96413				0	1967				0	1967
1967	1-Jan-67	30-Jun-67	HZA	General Electric	39213	HAN 98198										
1967	1-Jul-66	31-Dec-67	HWA	Isochem Inc.	38213	HAN 96400									0	1967
1967	1-Jan-67	30-Jun-67	HWA	Isochem Inc.	38213	HAN 98196				0	1967				0	1967
<b>Hanford Chem Processing Contractor subtotal</b>							<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>1967</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>1967</b>
1967	1-Jul-66	31-Dec-66	HWA	Douglas United Nuc	38214	DUN-1916				0					0	
1967	1-Jan-67	30-Jun-67	HXA	Douglas United Nuc	38214	HAN 98194		34		34	1967				0	1967
<b>Hanford FY Aggregate subtotal</b>							<b>0</b>	<b>34</b>	<b>0</b>	<b>34</b>	<b>1967</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>1967</b>
1968	1-Jul-67	31-Dec-67	HVA	Atlantic Richfield Han	46425	HAN 99439				0	1968				0	1968
1968	1-Jan-68	30-Jun-68	HVA	Atlantic Richfield Han	46425	ARH 699				0	1968			13,874	13.9	1968
<b>Hanford Chem Processing Contractor subtotal</b>							<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>1968</b>	<b>0</b>	<b>0</b>	<b>13,874</b>	<b>13.9</b>	<b>1968</b>
1968	1-Jul-67	31-Dec-67	HXA	Douglas United Nuc	38214	DUN-3624			4	0					0	
1968	1-Jan-68	30-Jun-68	HXA	Douglas United Nuc	38214	DUN 4436				0	1968				0	1968
<b>Hanford FY Aggregate subtotal</b>							<b>0</b>	<b>0</b>	<b>4</b>	<b>0</b>	<b>1968</b>	<b>0</b>	<b>0</b>	<b>13,874</b>	<b>13.9</b>	<b>1968</b>
1969	1-Jul-68	31-Dec-68	HVA	Atlantic Richfield Han	46425	ARH 1036				0	1969				0	1969
1969	1-Jan-69	30-Jun-69	HVA	Atlantic Richfield Han	46425	ARH 1099-6				0	1969				0	1969
<b>Hanford Chem Processing Contractor subtotal</b>							<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>1969</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>1969</b>
1969	1-Jul-68	31-Dec-68	HXA	Douglas United Nuc	38214	DUN 5250		50		50					0	
1969	1-Jan-69	30-Jun-69	HXA	Douglas United Nuc	38214	DUN 5942				0	1969				0	1969
<b>Hanford FY Aggregate subtotal</b>							<b>0</b>	<b>50</b>	<b>0</b>	<b>50</b>	<b>1969</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>1969</b>
1970	1-Jul-69	31-Dec-69	HVA	Atlantic Richfield Han	46425	ARH 1099-12				0	1970				0	1970
1970	1-Jan-70	30-Jun-70	HVA	Atlantic Richfield Han	46425	ARH 1540-6				0	1970				0	1970
<b>Hanford Chem Processing Contractor subtotal</b>																
1970	1-Jul-69	31-Dec-69	HXA	Douglas United Nuc	38214	DUN 6557				0					0	
1970	1-Jan-70	30-Jun-70	HXA	Douglas United Nuc	38214	DUN 7049				0	1970				0	1970
<b>Hanford FY Aggregate subtotal</b>							<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>1970</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>1970</b>
<b>FY 66 thru 70 kilogram subtotals</b>							<b>0</b>	<b>84</b>	<b>4</b>	<b>84</b>	<b>66-70</b>	<b>0</b>	<b>0</b>	<b>13,874</b>	<b>13.9</b>	<b>66-70</b>

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**Table 3.2.3 Hanford FY1966-70 Uranium Receipts (Cont.)**

							MINOR TIER 1 SITE					MINOR TIER 1 SITE					
							San Francisco Operations					Savannah River DuPont					
							LAZ					SRS					
FY	Date		REC RIS	Receipts Into Hanford Contractor	Box #	Doc#	Kg DU	Kg NU	Gm EU	Kg Total	FY	Kg DU	Kg NU	Gm EU	Kg Total	FY	
	From	To															
1966	01-Jul-65	30-Jun-66	HZA	General Electric	38213	HAN 95170			249	0.2	1966				0	1966	
1966	01-Jul-65	30-Jun-66	HWA	Isochem Inc.	38213	HAN 95136				0	1966				0	1966	
<b>Hanford Chem Processing Contractor subtotal</b>							<i>0</i>	<i>0</i>	<i>249</i>	<i>0.2</i>	<i>1966</i>	<i>0</i>	<i>0</i>	<i>0</i>	<i>0</i>	<i>1966</i>	
1966	1-Jul-65	30-Jun-66	HXA	Douglas United Nuc	38214	HAN 95171				0	1966		32	29610	61.6	1966	
<b>Hanford FY Aggregate subtotal</b>							<i>0</i>	<i>0</i>	<i>249</i>	<i>0.2</i>	<i>1966</i>	<i>0</i>	<i>32</i>	<i>29,610</i>	<i>61.6</i>	<i>1966</i>	
1967	1-Jul-66	31-Dec-66	HZA	General Electric	39213	HAN 96413				0	1967				0	1967	
1967	1-Jan-67	30-Jun-67	HZA	General Electric	39213	HAN 98198											
1967	1-Jul-66	31-Dec-67	HWA	Isochem Inc.	38213	HAN 96400											
1967	1-Jan-67	30-Jun-67	HWA	Isochem Inc.	38213	HAN 98196		1.5	1151	2.7	1967				0	1967	
<b>Hanford Chem Processing Contractor subtotal</b>							<i>0</i>	<i>2</i>	<i>1,151</i>	<i>3</i>	<i>1967</i>	<i>0</i>	<i>0</i>	<i>0</i>	<i>0</i>	<i>1967</i>	
1967	1-Jul-66	31-Dec-66	HWA	Douglas United Nuc	38214	DUN-1916				0					0		
1967	1-Jan-67	30-Jun-67	HXA	Douglas United Nuc	38214	HAN 98194			58	0.1	1967				0	1967	
<b>Hanford FY Aggregate subtotal</b>							<i>0</i>	<i>1.5</i>	<i>1,209</i>	<i>2.7</i>	<i>1967</i>	<i>0</i>	<i>0</i>	<i>0</i>	<i>0</i>	<i>1967</i>	
1968	1-Jul-67	31-Dec-67	HVA	Atlantic Richfield Han	46425	HAN 99439				0	1968				0	1968	
1968	1-Jan-68	30-Jun-68	HVA	Atlantic Richfield Han	46425	ARH 699				0	1968				0	1968	
<b>Hanford Chem Processing Contractor subtotal</b>							<i>0</i>	<i>0</i>	<i>0</i>	<i>0</i>	<i>1968</i>	<i>0</i>	<i>0</i>	<i>0</i>	<i>0</i>	<i>1968</i>	
1968	1-Jul-67	31-Dec-67	HXA	Douglas United Nuc	38214	DUN-3624			152	0.2					0		
1968	1-Jan-68	30-Jun-68	HXA	Douglas United Nuc	38214	DUN 4436				0	1968				0	1968	
<b>Hanford FY Aggregate subtotal</b>							<i>0</i>	<i>0</i>	<i>152</i>	<i>0.2</i>	<i>1968</i>	<i>0</i>	<i>0</i>	<i>0</i>	<i>0</i>	<i>1968</i>	
1969	01-Jul-68	31-Dec-68	HVA	Atlantic Richfield Han	46425	ARH 1036		362	794	362.8	1969				0	1969	
1969	01-Jan-69	30-Jun-69	HVA	Atlantic Richfield Han	46425	ARH 1099-6				0	1969				0	1969	
<b>Hanford Chem Processing Contractor subtotal</b>							<i>0</i>	<i>362</i>	<i>794</i>	<i>362.8</i>	<i>1969</i>	<i>0</i>	<i>0</i>	<i>0</i>	<i>0</i>	<i>1969</i>	
1969	01-Jul-68	31-Dec-68	HXA	Douglas United Nuc	38214	DUN 5250				0					0		
1969	01-Jan-69	30-Jun-69	HXA	Douglas United Nuc	38214	DUN 5942				0	1969				0	1969	
<b>Hanford FY Aggregate subtotal</b>							<i>0</i>	<i>362</i>	<i>794</i>	<i>362.8</i>	<i>1969</i>	<i>0</i>	<i>0</i>	<i>0</i>	<i>0</i>	<i>1969</i>	
1970	01-Jul-69	31-Dec-69	HVA	Atlantic Richfield Han	46425	ARH 1099-12				0	1970		93		93	1970	
1970	01-Jan-70	30-Jun-70	HVA	Atlantic Richfield Han	46425	ARH 1540-6				0	1970				0	1970	
<b>Hanford Chem Processing Contractor subtotal</b>																	
1970	01-Jul-69	31-Dec-69	HXA	Douglas United Nuc	38214	DUN 6557		17		17					0		
1970	01-Jan-70	30-Jun-70	HXA	Douglas United Nuc	38214	DUN 7049				0	1970				0	1970	
<b>Hanford FY Aggregate subtotal</b>							<i>0</i>	<i>17</i>	<i>0</i>	<i>17</i>	<i>1970</i>	<i>0</i>	<i>0</i>	<i>0</i>	<i>0</i>	<i>1970</i>	
<b>FY 66 thru 70 kilogram subtotals</b>							<b>0</b>	<b>380.5</b>	<b>2,404</b>	<b>382.9</b>	<b>66-70</b>	<b>0</b>	<b>32</b>	<b>29,610</b>	<b>61.6</b>	<b>66-70</b>	

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**Table 3.2.3 Hanford FY1966-70 Uranium Receipts (Cont.)**

							MINOR TIER 1 SITE				MINOR TIER 1 SITE					
							Sante Fe/Albuquerque Ops				ORO Nuclear Fuels Services					
											FAX					
FY	Date		REC RIS	Receipts Into Hanford Contractor	Box #	Doc #	Kg DU	Kg NU	Gm EU	Kg Total	FY	Kg DU	Kg NU	Gm EU	Kg Total	FY
	From	To														
1966	1-Jul-65	30-Jun-66	HZA	Hanford	38213	HAN 95170				0	1966				0	1966
1966	1-Jul-65	30-Jun-66	HWA	Isochem Inc.	38213	HAN 95136				0	1966				0	1966
<b>Hanford Chem Processing Contractor subtotal</b>							<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>1966</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>1966</b>
1966	1-Jul-65	30-Jun-66	HXA	Douglas United Nuc	38214	HAN 95171				0	1966				0	1966
<b>Hanford FY Aggregate subtotal</b>							<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>1966</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>1966</b>
1967	1-Jul-66	31-Dec-66	HZA	General Electric	39213	HAN 96413				0	1967				0	1967
1967	1-Jan-67	30-Jun-67	HZA	General Electric	39213	HAN 98198										
1967	1-Jul-66	31-Dec-67	HWA	Isochem Inc.	38213	HAN 96400										
1967	1-Jan-67	30-Jun-67	HWA	Isochem Inc.	38213	HAN 98196				0	1967				0	1967
<b>Hanford Chem Processing Contractor subtotal</b>							<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>1967</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>1967</b>
1967	1-Jul-66	31-Dec-66	HWA	Douglas United Nuc	38214	DUN-1916				0	1967				0	1967
1967	1-Jan-67	30-Jun-67	HXA	Douglas United Nuc	38214	HAN 98194				0	1967				0	1967
<b>Hanford FY Aggregate subtotal</b>							<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>1967</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>1967</b>
1968	1-Jul-67	31-Dec-67	HVA	Atlantic Richfield Han	46425	HAN 99439				0	1968				0	1968
1968	1-Jan-68	30-Jun-68	HVA	Atlantic Richfield Han	46425	ARH 699				0	1968	84	126	224	210.2	1968
<b>Hanford Chem Processing Contractor subtotal</b>							<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>1968</b>	<b>84</b>	<b>126</b>	<b>224</b>	<b>210.2</b>	<b>1968</b>
1968	1-Jul-67	31-Dec-67	HXA	Douglas United Nuc	38214	DUN-3624				0	1968				0	1968
1968	1-Jan-68	30-Jun-68	HXA	Douglas United Nuc	38214	DUN 4436				0	1968				0	1968
<b>Hanford FY Aggregate subtotal</b>							<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>1968</b>	<b>84</b>	<b>126</b>	<b>224</b>	<b>210.2</b>	<b>1968</b>
1969	1-Jul-68	31-Dec-68	HVA	Atlantic Richfield Han	46425	ARH 1036				0	1969				0	1969
1969	1-Jan-69	30-Jun-69	HVA	Atlantic Richfield Han	46425	ARH 1099-6				0	1969				0	1969
<b>Hanford Chem Processing Contractor subtotal</b>							<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>1969</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>1969</b>
1969	1-Jul-68	31-Dec-68	HXA	Douglas United Nuc	38214	DUN 5250				0	1969				0	1969
1969	1-Jan-69	30-Jun-69	HXA	Douglas United Nuc	38214	DUN 5942				0	1969				0	1969
<b>Hanford FY Aggregate subtotal</b>							<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>1969</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>1969</b>
1970	1-Jul-69	31-Dec-69	HVA	Atlantic Richfield Han	46425	ARH 1099-12	2			2	1970				0	1970
1970	1-Jan-70	30-Jun-70	HVA	Atlantic Richfield Han	46425	ARH 1540-6				0	1970				0	1970
<b>Hanford Chem Processing Contractor subtotal</b>																
1970	1-Jul-69	31-Dec-69	HXA	Douglas United Nuc	38214	DUN 6557				0	1970				0	1970
1970	1-Jan-70	30-Jun-70	HXA	Douglas United Nuc	38214	DUN 7049				0	1970				0	1970
<b>Hanford FY Aggregate subtotal</b>							<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>1970</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>1970</b>
<b>FY 66 thru 70 kilogram subtotals</b>							<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>66-70</b>	<b>84</b>	<b>126</b>	<b>224</b>	<b>210.2</b>	<b>66-70</b>

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**Table 3.2.3 Hanford FY1966-70 Uranium Receipts (Cont.)**

							MINOR TIER 1 SITE					MINOR TIER 1 SITE				
							AEC Procurement From Licensees					Miscellaneous Site 1				
							SMB									
FY	Date		REC RIS	Receipts into Hanford Contractor	Box #	Doc #	Kg DU	Kg NU	Gm EU	Kg Total	FY	Kg DU	Kg NU	Gm EU	Kg Total	FY
	From	To														
1966	1-Jul-65	30-Jun-66	HZA	General Electric	38213	HAN 95170				0	1966	5,101	226		5,327	1966
1966	1-Jul-65	30-Jun-66	HWA	Isochem Inc.	38213	HAN 95136				0	1966	1,620			1,620	1966
<b>Hanford Chem Processing Contractor subtotal</b>							<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>1966</b>	<b>6,721</b>	<b>226</b>	<b>0</b>	<b>6,947</b>	<b>1966</b>
1966	1-Jul-65	30-Jun-66	HXA	Douglas United Nuc	38214	HAN 95171				0	1966				0	1966
<b>Hanford FY Aggregate subtotal</b>							<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>1966</b>	<b>6,721</b>	<b>226</b>	<b>0</b>	<b>6,947</b>	<b>1966</b>
1967	1-Jul-66	31-Dec-66	HZA	General Electric	39213	HAN 96413				0	1967				0	1967
1967	1-Jan-67	30-Jun-67	HZA	General Electric	39213	HAN 98198									0	1967
1967	1-Jul-66	31-Dec-67	HWA	Isochem Inc.	38213	HAN 96400					1967	2,139	16		2,155	1967
1967	1-Jan-67	30-Jun-67	HWA	Isochem Inc.	38213	HAN 98196				0	1967				0	1967
<b>Hanford Chem Processing Contractor subtotal</b>							<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>1967</b>	<b>2,139</b>	<b>16</b>	<b>0</b>	<b>2,155</b>	<b>1967</b>
1967	1-Jul-66	31-Dec-66	HWA	Douglas United Nuc	38214	DUN-1916				0	1967				0	1967
1967	1-Jan-67	30-Jun-67	HXA	Douglas United Nuc	38214	HAN 98194				0	1967				0	1967
<b>Hanford FY Aggregate subtotal</b>							<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>1967</b>	<b>2,139</b>	<b>16</b>	<b>0</b>	<b>2,155</b>	<b>1967</b>
1968	1-Jul-67	31-Dec-67	HVA	Atlantic Richfield Han	46425	HAN 99439		9		9	1968				0	1968
1968	1-Jan-68	30-Jun-68	HVA	Atlantic Richfield Han	46425	ARH 699				0	1968				0	1968
<b>Hanford Chem Processing Contractor subtotal</b>							<b>0</b>	<b>9</b>	<b>0</b>	<b>9</b>	<b>1968</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>1968</b>
1968	1-Jul-67	31-Dec-67	HXA	Douglas United Nuc	38214	DUN-3624				0	1968				0	1968
1968	1-Jan-68	30-Jun-68	HXA	Douglas United Nuc	38214	DUN 4436				0	1968				0	1968
<b>Hanford FY Aggregate subtotal</b>							<b>0</b>	<b>9</b>	<b>0</b>	<b>9</b>	<b>1968</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>1968</b>
1969	1-Jul-68	31-Dec-68	HVA	Atlantic Richfield Han	46425	ARH 1036				0	1969				0	1969
1969	1-Jan-69	30-Jun-69	HVA	Atlantic Richfield Han	46425	ARH 1099-6				0	1969				0	1969
<b>Hanford Chem Processing Contractor subtotal</b>							<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>1969</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>1969</b>
1969	1-Jul-68	31-Dec-68	HXA	Douglas United Nuc	38214	DUN 5250				0	1969				0	1969
1969	1-Jan-69	30-Jun-69	HXA	Douglas United Nuc	38214	DUN 5942				0	1969				0	1969
<b>Hanford FY Aggregate subtotal</b>							<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>1969</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>1969</b>
1970	1-Jul-69	31-Dec-69	HVA	Atlantic Richfield Han	46425	ARH 1099-12				0	1970				0	1970
1970	1-Jan-70	30-Jun-70	HVA	Atlantic Richfield Han	46425	ARH 1540-6				0	1970				0	1970
<b>Hanford Chem Processing Contractor subtotal</b>																
1970	1-Jul-69	31-Dec-69	HXA	Douglas United Nuc	38214	DUN 6557				0	1970				0	1970
1970	1-Jan-70	30-Jun-70	HXA	Douglas United Nuc	38214	DUN 7049				0	1970				0	1970
<b>Hanford FY Aggregate subtotal</b>							<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>1970</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>1970</b>
<b>FY 66 thru 70 kiloaram subtotals</b>							<b>0</b>	<b>9</b>	<b>0</b>	<b>9</b>	<b>66-70</b>	<b>8,860</b>	<b>242</b>	<b>0</b>	<b>9,102</b>	<b>66-70</b>



APPENDIX B

DOE/RL-2000-43

Section 3 Supplemental Information

Table 3.2.3 Hanford FY1966-70 Uranium Receipts (Cont.)

FY	Date		REC RIS	Receipts Into Hanford Contractor	Box #	Doc #	MINOR TIER 1 SITE Materials Leasing Office (ORO) Oak Ridge Headquarters					MINOR TIER 1 SITE Gulf United Nuc Fuels (MBU,CCT)					Receipt FY TOTALS KG U ALL TYPES			
	From	To					Kg DU	Kg NU	Gm EU	Kg Total	FY	Kg DU	Kg NU	Gm EU	Kg Total	FY				
1966	1-Jul-65	30-Jun-66	HZA	General Electric	38213	HAN 95170			4	0		1966				0				
1966	1-Jul-65	30-Jun-66	HWA	Isochem Inc.	38213	HAN 95136				0		1966				0				
<b>Hanford Chem Processing Contractor subtotal</b>							0	0	4	0		1966	0	0	0	0			1966	
1966	1-Jul-65	30-Jun-66	HXA	Douglas United Nuc	38214	HAN 95171				0		1966				0				
<b>Hanford FY Aggregate subtotal</b>							0	0	4	0		1966	0	0	0	0			1966	5,611,752.6
1967	1-Jul-66	31-Dec-66	HZA	General Electric	39213	HAN 96413				0		1967				0.0				
1967	1-Jan-67	30-Jun-67	HZA	General Electric	39213	HAN 98198						1967								
1967	1-Jul-66	31-Dec-67	HWA	Isochem Inc.	38213	HAN 96400						1967								
1967	1-Jan-67	30-Jun-67	HWA	Isochem Inc.	38213	HAN 98196				0.0		1967				0.0				
<b>Hanford Chem Processing Contractor subtotal</b>							0	0	0	0		1967	0	0	0	0			1967	
1967	1-Jul-66	31-Dec-66	HWA	Douglas United Nuc	38214	DUN-1916				0		1967				0				
1967	1-Jan-67	30-Jun-67	HXA	Douglas United Nuc	38214	HAN 98194				0		1967				0				
<b>Hanford FY Aggregate subtotal</b>							0	0	0	0		1967	0	0	0	0			1967	5,059,491.5
1968	1-Jul-67	31-Dec-67	HVA	Atlantic Richfield Han	46425	HAN 99439				0		1968				0				
1968	1-Jan-68	30-Jun-68	HVA	Atlantic Richfield Han	46425	ARH 699				0		1968				0				
<b>Hanford Chem Processing Contractor subtotal</b>							0	0	0	0		1968	0	0	0	0			1968	
1968	1-Jul-67	31-Dec-67	HXA	Douglas United Nuc	38214	DUN-3624			30	0		1968				0				
1968	1-Jan-68	30-Jun-68	HXA	Douglas United Nuc	38214	DUN 4436			136	0.1		1968				0				
<b>Hanford FY Aggregate subtotal</b>							0	0	166	0.2		1968	0	0	0	0			1968	3,422,076.0
1969	1-Jul-68	31-Dec-68	HVA	Atlantic Richfield Han	46425	ARH 1036				0		1969				0				
1969	1-Jan-69	30-Jun-69	HVA	Atlantic Richfield Han	46425	ARH 1099-6				0		1969				0				
<b>Hanford Chem Processing Contractor subtotal</b>							0	0	0	0		1969	0	0	0	0			1969	
1969	1-Jul-68	31-Dec-68	HXA	Douglas United Nuc	38214	DUN 5250				0		1969			60	0.1				
1969	1-Jan-69	30-Jun-69	HXA	Douglas United Nuc	38214	DUN 5942			98	0.1		1969				0				
<b>Hanford FY Aggregate subtotal</b>							0	0	98	0.1		1969	0	0	60	0.1			1969	2,582,350.8
1970	1-Jul-69	31-Dec-69	HVA	Atlantic Richfield Han	46425	ARH 1099-12				0		1970				0				
1970	1-Jan-70	30-Jun-70	HVA	Atlantic Richfield Han	46425	ARH 1540-6				0		1970				0				
<b>Hanford Chem Processing Contractor subtotal</b>																				
1970	1-Jul-69	31-Dec-69	HXA	Douglas United Nuc	38214	DUN 6557				0		1970				0				
1970	1-Jan-70	30-Jun-70	HXA	Douglas United Nuc	38214	DUN 7049				0		1970				0				
<b>Hanford FY Aggregate subtotal</b>							0	0	0	0		1970	0	0	0	0			1970	2,443,877.5
<b>FY 66 thru 70 kilogram subtotals</b>							0	0	268	0.3		66-70	0	0	60	0.1		66-70	19,119,548.4	

## Appendix B:

## Table 3.2.4

## Hanford Chemical Processing Contractor (HVA) Uranium Receipts FY 1971-March 31, 1999

Based on NMMSS Document SROO-00009 RECEIPTS (classified)

ATLANTIC RICHFIELD CONTRACTOR (HVA)

KG DU					GM EU	
FY	MAJOR TIER 1: FROM PADUCAH Kg DU CKY, FYA	MAJOR TIER 1: FROM FERNALD Kg DU FVA, FVB,FVC	MAJOR TIER 1: FROM OAK RIDGE Kg DU FZA,FZE,FZB,FZF	Total Kg DU External to Hanford	MAJOR TIER 1: FROM PADUCAH Gm EU CKY, FYA	MAJOR TIER 1: FROM FERNALD Gm EU FVA, FVB,FVC
	71	0	0	0	171	0
72	0	0	0	5,863	0	0
73	0	0	0	43	0	0
74	0	0	0	106	0	0
75	0	1,165	0	1,165	0	0
76	0	1,162	0	1,162	0	0
76T	0	0	0	0	0	0
77	0	0	0	0	0	0
78						
AFTER FY 1977 - HVA CONTRACTOR TURNOVER TO ROCKWELL HANFORD (HRA)						
79						
80						
81						
82						
83						
84						
85						
86						
87						
88						
89						
90						
91						
92						
93						
94						
95						
96						
97						
98						
99						
KG TOTAL	0	2,327	0	8,510	0	42
MTU TOTAL	0.00	2.33	0.00	8.51	0.00	0.04

HVA

**KG NU**

MAJOR TIER 1: FROM OAK RIDGE Gm EU FZA,FZE,FZB,FZF		MAJOR TIER 1: FROM PADUCAH Kg NU CKY, FYA		MAJOR TIER 1: FROM FERNALD Kg NU FVA, FVB,FVC		MAJOR TIER 1: FROM OAK RIDGE Kg NU FZA,FZE,FZB,FZF		Total Kg NU External to Hanford
0	65,167	0	0	0	0	0	17	
0	355,739	0	0	0	11	69		
0	2,599,481	0	0	0	0	39		
0	1,307	0	0	0	0	771		
0	-1,099	0	0	0	0	-1		
0	2,265	0	0	0	0	444		
0	0	0	0	0	0	4		
0	1,121	0	0	0	0	347		
0	3,024	0	0	0	11	1,690	13,223.98	
0.00	3.02	0.00	0.00	0.00	0.01	1.69	13.22	

# Appendix B:

# Table 3.2.5

DOE/RL-2000-43

## Hanford Chemical Processing Contractor (HRA) Uranium Receipts FY 1971-March 31, 1999

Based on NMMSS Document SROO-00009 RECEIPTS (classified)

ROCKWELL HANFORD OPERATIONS (RHO)

FY	KG DU				GM EU	
	MAJOR TIER 1: FROM PADUCAH Kg DU CKY, FYA	MAJOR TIER 1: FROM FERNALD Kg DU FVA, FVB,FVC	MAJOR TIER 1: FROM OAK RIDGE Kg DU FZA,FZE,FZB,FZF	Total Kg DU External to Hanford	MAJOR TIER 1: FROM PADUCAH Gm EU CKY, FYA	MAJOR TIER 1: FROM FERNALD Gm EU FVA, FVB,FVC
	71	PRIOR TO FY 1977 - HVA CONTRACTOR				
72						
73						
74						
75						
76	0	0	0	0	0	0
77	0	0	0	0	0	0
78	0	0	0	10,574	0	0
79	0	0	0	15,371	0	0
80	0	0	0	14	0	0
81	0	0	0	0	0	0
82	0	0	0	0	0	0
83	0	0	0	0	0	0
84	0	0	0	32	0	1,848,790
85	0	0	0	0	0	2,245,129
86	0	0	0	0	0	1,769,986
87	0	0	0	0	0	789,794
88	AFTER FY 1988 - HRA CONTRACTOR TURNOVER TO WESTINGHOUSE HANFORD (HUD)					
89						
90						
91						
92						
KG TOTAL	0	0	0	25,991	0	6,654
MTU TOTAL	0.00	0.00	0.00	25.99	0.00	6.65

HRA

KG NU							
MAJOR TIER 1: FROM OAK RIDGE Gm EU FZA,FZE,FZB,FZF		Total Gm EU External to Hanford	MAJOR TIER 1: FROM PADUCAH Kg NU CKY, FYA	MAJOR TIER 1: FROM FERNALD Kg NU FVA, FVB,FVC	MAJOR TIER 1: FROM OAK RIDGE Kg NU FZA,FZE,FZB,FZF	Total Kg NU External to Hanford	
0		5	0	0	0	2	
0		72,350	0	0	0	0	
0		72,331	0	0	0	2	
0		63,046	0	0	0	39	
0		260	0	0	0	66	
0		212	0	0	0	0	
0		212	0	5	0	5	
0		1,849,108	0	13	0	13	
0		2,245,157	0	5	0	5	
0		1,770,466	0	5	0	5	
0		789,794	0	5	0	5	
0		6,863	0	33	0	142	32,996
0.00		6.86	0.00	0.03	0.00	0.14	33.00

# Appendix B:

# Table 3.2.6

DOE/RL-2000-43

## Hanford Chemical Processing Contractors (HUD & HTA) Uranium Receipts FY 1971-March 31, 1999

Based on NMMSS Document SROO-00009 RECEIPTS (classified)

WESTINGHOUSE HANFORD (HUD) & FLUOR (HTA)

FY	DU				EU	
	MAJOR TIER 1: FROM PADUCAH	MAJOR TIER 1: FROM FERNALD	MAJOR TIER 1: FROM OAK RIDGE	Total Kg DU External to Hanford	MAJOR TIER 1: FROM PADUCAH	MAJOR TIER 1: FROM FERNALD
	Kg DU CKY, FYA	Kg DU FVA, FVB,FVC	Kg DU FZA,FZE,FZB,FZF		Gm EU CKY, FYA	Gm EU FVA, FVB,FVC
71						
72						
73						
74						
75						
76						
77						
78						
79						
80						
81						
82						
83						
84						
85						
86						
87	0	0	0	0	0	0
88	0	0	0	0	0	183,387
89	0	0	0	0	0	112,537
90	0	0	0	0	0	313,608
91	0	0	0	0	0	0
92	0	0	0	0	0	0
93	0	0	0	0	0	0
94	0	0	0	0	0	0
95	0	0	0	2	0	0
HUD UNTIL 96	0	0	0	0	0	0
HTA IN 97	0	0	0	7,812	0	0
98	0	0	0	62	0	0
99	0	0	0	0	0	0
<b>KG TOTAL</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>7,876</b>	<b>0</b>	<b>610</b>
<b>MTU TOTAL</b>	<b>0.00</b>	<b>0.00</b>	<b>0.00</b>	<b>7.88</b>	<b>0.00</b>	<b>0.61</b>

Appendix B:

**Table 3.2.6  
HUD & HTA**

NU						
MAJOR TIER 1:		MAJOR TIER 1:	MAJOR TIER 1:	MAJOR TIER 1:		
FROM OAK RIDGE	Total Gm EU	FROM PADUCAH	FROM FERNALD	FROM OAK RIDGE	Total Kg NU	
Gm EU	External to	Kg NU	Kg NU	Kg NU	External to	
FZA,FZE,FZB,FZF	Hanford	CKY, FYA	FVA, FVB,FVC	FZA,FZE,FZB,FZF	Hanford	
0	0	0	0	0	0	0
0	183,437	0	444	0	444	
0	112,685	0	0	0	0	
0	313,608	0	0	0	0	
0	0	0	0	0	0	
0	0	0	0	0	0	
0	0	0	0	0	0	
0	0	0	0	0	0	
0	0	0	0	0	0	
0	26,152	0	0	0	0	
0	0	0	0	0	0	
0	0	0	0	0	0	
0	0	0	0	0	0	
0	12,424	0	0	0	0	2
0	404	0	0	0	0	0
0	649	0	444	0	446	<b>8,971</b>
<b>0.00</b>	<b>0.65</b>	<b>0.00</b>	<b>0.44</b>	<b>0.00</b>	<b>0.45</b>	<b>8.97071</b>

# Appendix B:

# Table 3.2.7

DOE/RL-2000-43

## Hanford Reactor/Fuel Fab Contractor (HXA) Uranium Receipts FY 1971-March 31, 1999

Based on NMSS Document SROO-00009 RECEIPTS (classified)

UNITED NUCLEAR INC. (UNI)

FY	DU				EU	
	MAJOR TIER 1: FROM PADUCAH	MAJOR TIER 1: FROM FERNALD	MAJOR TIER 1: FROM OAK RIDGE	Total Kg DU External to Hanford	MAJOR TIER 1: FROM PADUCAH	MAJOR TIER 1: FROM FERNALD
	Kg DU CKY, FYA	Kg DU FVA, FVB,FVC	Kg DU FZA,FZE,FZB,FZF		Gm EU CKY, FYA	Gm EU FVA, FVB,FVC
71	0	51	0	51	0	332,107,792
72	0	0	0	0	0	28,210,576
73	0	0	0	0	0	0
74	0	0	0	0	0	0
75	0	0	0	167	0	0
76	0	0	0	0	0	0
76T	0	0	0	0	0	0
77	0	0	0	0	0	0
78	0	0	0	0	0	0
79	0	0	0	0	0	0
80	0	0	0	0	0	0
81	0	0	0	0	0	0
82	0	0	0	0	0	0
83	0	0	0	0	0	0
84	0	0	0	0	0	0
85	0	0	915	11,085	0	0
86	0	0	0	0	0	0
87	0	0	0	0	0	0
AFTER FY 1987 - HXA CONTRACTOR TURNOVER TO WESTINGHOUSE (HUE)						
<b>KG TOTAL</b>	<b>0</b>	<b>51</b>	<b>915</b>	<b>11,303</b>	<b>0</b>	<b>360,318</b>
<b>MTU TOTAL</b>	<b>0.00</b>	<b>0.05</b>	<b>0.92</b>	<b>11.30</b>	<b>0.00</b>	<b>360.32</b>



Appendix B:

Table 3.2.7

HXA

NU									
MAJOR TIER 1: FROM OAK RIDGE Gm EU FZA,FZE,FZB,FZF		Total Gm EU External to Hanford	MAJOR TIER 1: FROM PADUCAH Kg NU CKY, FYA		MAJOR TIER 1: FROM FERNALD Kg NU FVA, FVB,FVC		MAJOR TIER 1: FROM OAK RIDGE Kg NU FZA,FZE,FZB,FZF		Total Kg NU External to Hanford
0	0	334,302,487	0	0	398,385	0	0	398,385	
0	0	453,227,027	0	0	0	0	0	3	
0	0	345,411,280	0	0	0	0	0	2,492	
0	0	674,296,917	0	0	0	0	0	0	
0	0	419,265,481	0	0	0	0	0	24,188	
0	0	384,253,777	0	0	225	0	0	225	
0	0	83,715,478	0	0	0	0	0	0	
0	0	307,214,693	0	0	0	0	0	0	
0	0	466,551,792	0	0	0	0	0	2,312	
0	0	438,616,539	0	0	0	0	0	2,496	
0	0	317,662,232	0	0	0	0	0	0	
0	0	499,444,774	0	0	0	0	0	0	
0	0	778,031,283	0	0	0	0	0	0	
0	0	1,293,900,476	0	0	0	0	0	0	
0	0	1,335,235,605	0	0	0	0	0	0	
0	0	1,375,495,776	0	0	0	0	0	56,174	
0	0	1,457,751,669	0	0	0	0	0	104,318	
0	0	510,029,719	0	0	0	0	0	10,645	
0	0	11,474,407	0	0	398,610	0	0	601,238	
0.00	0.00	11,474.41	0.00	0.00	398.61	0.00	0.00	601.24	
								12,086.95	

# Appendix B:

## Table 3.2.8

DOE/RL-2000-43

### Pacific Northwest National Laboratory (PNNL) Uranium Receipts FY 1965-March 31, 1999


Based on NMMSS Document SROO-00009 RECEIPTS (classified)

FY	MAJOR TIER 1 FROM PADUCAH	MAJOR TIER 1 FROM FERNALD	MAJOR TIER 1 FROM OAK RIDGE	DU	MAJOR TIER 1 FROM PADUCAH	MAJOR TIER 1 FROM FERNALD	MAJOR TIER 1 FROM OAK RIDGE
	Kg DU CKY, FYA	Kg DU FVA	Kg DU FZA,FZE,FZB,FZF	Total Kg DU Offsite Total (Excludes Hanford)	Gm EU CKY, FYA	Gm EU FVA	Gm EU FZA,FZE,FZB,FZF
FY 65-FY 70	0	143	152	1,183	0	371,489	49,291
71	0	0	5	83	0	0	622,819
72	0	0	31	165	0	0	0
73	0	0	0	641	0	0	12
74	0	0	669	2,317	0	0	0
75	0	0	18	3,950	0	0	13,068
76	0	0	0	3,810	0	0	3,843
76T	0	209	0	1,742	0	0	0
77	0	797	87	19,431	0	0	52,779
78	0	548	84	6,205	0	0	0
79	0	265	13	16,684	0	0	10
80	0	1,256	0	5,936	0	0	17,451
81	0	957	13	13,750	0	0	2,060
82	0	0	0	35,912	0	0	0
83	0	35	0	8,063	0	0	0
84	0	0	8	13,355	0	0	0
85	0	0	29	12,909	0	0	0
86	0	0	0	18,492	0	0	0
87	0	0	0	11,764	0	0	0
88	0	0	0	8,223	0	0	0
89	0	0	42	20,043	0	0	0
90	0	0	1,033	20,574	0	0	0
91	0	0	8,956	12,354	0	0	0
92	0	0	1,316	7,627	0	0	0
93	0	0	182	182	0	0	0
94	0	0	0	218	0	0	0
95	0	0	0	924	0	0	0
96	0	0	0	0	0	0	0
97	0	0	0	1,618	0	0	0
98	0	0	0	0	0	0	0
99	0	0	0	0	0	0	0
<b>KG TOTAL</b>	<b>0</b>	<b>4,210</b>	<b>12,638</b>	<b>248,155</b>	<b>0</b>	<b>371</b>	<b>761</b>
<b>MTU TOTAL</b>	<b>0.00</b>	<b>4.21</b>	<b>12.64</b>	<b>248.16</b>	<b>0.00</b>	<b>0.37</b>	<b>0.76</b>

Appendix B:

Table 3.2.8

DOE/RL-2000-43

EU Total Gm EU PNNL External (Excludes Hanford)	MAJOR TIER 1 FROM PADUCAH	MAJOR TIER 1 FROM FERNALD	MAJOR TIER 1 FROM OAK RIDGE	NU Kg NU PNNL External (Excludes Hanford)	ALL U Total Kg U External Receipts
	Kg NU CKY, FYA	Kg NU FVA	Kg NU FZA,FZE,FZB,FZF		
8,367,607	0	36	0	4060	
658,595	0	0	0	9	
725,784	0	0	0	107	
-11,993	0	0	0	0	
90,360	0	0	0	0	
392,115	0	0	0	17	
961,971	0	0	0	777	
3,942,113	0	0	0	10	
4,030,959	0	0	0	0	
3,597,476	0	0	0	0	
48,615	0	0	0	1	
534,954	0	0	0	0	
-10,549	0	0	0	0	
364	0	0	0	0	
4,016	0	0	0	0	
38,118	0	0	0	0	
11,369	0	0	0	0	
1,151,358	0	0	0	0	
75	0	0	0	0	
1,698	0	0	0	0	
56,819	0	0	0	0	
34,320	0	0	0	0	
0	0	0	0	0	
188	0	0	0	6	
560	0	0	0	0	
0	0	0	0	0	
2,280	0	0	0	0	
491,522	0	0	0	0	
6	0	0	0	0	
0	0	0	0	0	
27	0	0	0	0	
25,121	0	36	0	4,987	278,263
25.12	0.00	0.04	0.00	4.99	278.26

# Appendix B:

# Table 3.3.1

DOE/RL-2000-43

## DECEMBER 1947 THROUGH JUNE 51 HANFORD (GE Company) URANIUM SHIPMENTS OFFSITE

All Shipments are Out-of-Scope (for reference use)

Time Frame	Date From	Date To	RIS From	Box #	Doc #	GE- Hanford Works Beginning Inventory			Mallinckrodt Cher New York Operat
						BEG. INV. Kg NU	IN PROCESS Kg NU	IN WASTE TANKS Kg DU	Kg DU
1947	31-Dec-47	BEG. INV.	HGE	38213	HW-15-701	SEE RECEIPTS	SEE RECEIPTS	SEE RECEIPTS	
1947	31-Dec-47	31-Dec-48	HGE	38213	HW-15-701				
1948	31-Dec-48	31-Dec-49	HGE	38213	FTS-668				
1949 FY 50	31-Dec-49	31-Dec-50	HGE	38213	FTS-670				
FY 1951	01-Jan-51	30-Jun-51	HGE	38213	FTS 845				
OUT OF SCOPE						<b>Total Kg Shipped</b>			
OUT OF SCOPE						<b>Total MTU Shipped</b>			

# Appendix B:

# Table 3.3.1

DOE/RL-2000-43

m Works tions (later under ORO Ops)			Simonds Saw & Steel Co. NY Ops			Electro Metallurgical Chem Wks NY Ops			Metal Hydri NY Ops		
Kg NU	Gm EU	Total Kg	Kg DU	Kg NU	Gm EU	Total Kg	Kg DU	Kg NU	Gm EU	Total Kg	Kg DU
		0.0		35,633.3		35,633.3				0.0	
77,868.0		77,868.0		170,963.0		170,963.0				0.0	
61668		61,668.0		212369		212,369.0				0.0	
		0.0				0.0				0.0	
12606		12,606.0		93045		93,045.0				0.0	
		0.0				0.0				0.0	
		0.0				0.0				0.0	
		152,142.0				512,010.3				0.0	
		<b>152.142</b>				<b>512.01</b>				<b>0.00</b>	

# Appendix B:

# Table 3.3.1

DOE/RL-2000-43

ides Inc.			Vulcan Crucible Steel NY Ops				Chicago Operations Office Argonne National Lab				Chicago Operations Of Battelle Memorial Institut		
Kg NU	Gm EU	Total Kg	Kg DU	Kg NU	Gm EU	Total Kg	Kg DU	Kg NU	Gm EU	Total Kg	Kg DU	Kg NU	
		0.0		332,037.9		332,037.9	0.7	1,840.3		1,841.0		1,101.4	
		0.0		75,037.0		75,037.0		458.0	9.6	458.0		515.0	
		0.0				0.0		14101		14,101.0		239	
		0.0				0.0				0.0			
		0.0				0.0		5006		5,006.0		11	
		0.0				0.0				0.0			
		0.0				0.0				0.0			
		0.0				0.0				0.0			
		0.0					407,074.9				21,406.0		
		0.00					407.07				21.41		

# Appendix B:

# Table 3.3.1

DOE/RL-2000-43

Office Location	New York Ops Office NY Ops			Towanda Sub-Office TOA			St. Louis Area Office New York Ops				
	Gm EU	Total Kg	Kg DU	Kg NU	Gm EU	Total Kg	Kg DU	Kg NU	Gm EU		
		1,101.4				0.0		40,808.8		40,808.8	
		515.0				0.0				22,048.0	
		239.0				0.0					
		0.0				0.0					
		11.0				0.0					
		0.0				0.0					
		0.0				0.0					
		0.0				0.0					
		1,866.4				0.0				40,808.8	
		1.87				0.00				40.81	

# Appendix B:

# Table 3.3.1

DOE/RL-2000-43

Total Kg	Carbide & Carbon Chem Co. ORO Y-12 & K-25			Total Kg	Oak Ridge Natl Lab ORO			Total Kg	Clinton Laboratory			Total Kg
	CYT Kg DU	Kg NU	Gm EU		ORL Kg DU	Kg NU	Gm EU		Kg DU	Kg NU	Gm EU	
0.0		273.8		273.8		478.4	165.0	478.6				0.0
22,048.0				0.0		191.0	9,505.0	200.5				0.0
0.0		5447	32,224	5,479.2		1499	803	1,499.8				0.0
0.0				0.0				0.0				0.0
0.0		447	64,008	511.0				0.0				0.0
0.0				0.0				0.0				0.0
0.0				0.0				0.0				0.0
22,048.0				6,264.0				2,178.9				0.0
22.05				6.26				2.18				0.00



# Appendix B:

# Table 3.3.1

DOE/RL-2000-43

GE Research Laboratory  
Schenectady Ops

Joslyn Manufacturing & Supply Co.

New Brunswick Lab

Sante Fe O

SGE												
Kg DU	Kg NU	Gm EU	Total Kg	Kg DU	Kg NU	Gm EU	Total Kg	Kg DU	Kg NU	Gm EU	Total Kg	Kg DU
	1,102.2	0.4	1,102.2		201,914.0		201,914.0					0.0
	77.0		77.0				0.0					0.0
	1062		1,062.0				0.0					0.0
			0.0				0.0					0.0
	142		142.0				0.0					0.0
			0.0				0.0					0.0
			0.0				0.0					0.0
			2,383.2				201,914.0					0.0
			2.38				201.91					0.00

# Appendix B:

# Table 3.3.1

DOE/RL-2000-43

Dps/Los Alamos

Hanford Operations-Crane Company

Schenectady Operations Office

Savannah River  
El DuPont

Kg NU	Gm EU	Total Kg	Kg DU	Kg NU	Gm EU	Total Kg	Kg DU	Kg NU	Gm EU	Total Kg	Kg DU	Kg NU
30,681.8		30,681.8				0.0				0.0		
6,804.0		6,804.0				0.0				0.0		
24941		24,941.0				0.0				0.0		
		0.0				0.0				0.0		
27280		27,280.0				0.0				0.0		315
		0.0				0.0				0.0		
		0.0				0.0				0.0		
		89,706.8				0.0				0.0		
		89.71				0.00				0.00		

# Appendix B:

## Table 3.3.1

DOE/RL-2000-43

Berkley NDL  
Chicago Ops

Vitro Manufacturing Co  
NY Ops

USAEC X-10  
Operations Office

Gm EU	Total Kg	Kg DU	Kg NU	Gm EU	Total Kg	Kg DU	Kg NU	Gm EU	Total Kg	Kg DU	Kg NU	Gm EU
	0.0				0.0		99,365.2		99,365.2		428.5	
	0.0		4.0		4.0		17,516.0		17,516.0			
	0.0				0.0				0.0			
	0.0				0.0				0.0			
	315.0				0.0				0.0			
	0.0				0.0				0.0			
	0.0				0.0				0.0			
	0.0				0.0				0.0			
	315.0				4.0				116,881.2			
	0.32				0.00				116.88			

# Appendix B:

# Table 3.3.1

DOE/RL-2000-43

Chapman Valve Manuf. Co.

Total Kg	Kg DU	Kg NU	Gm EU	Total Kg	Total
428.5		24,129.7		24,129.7	
0.0				0.0	
0.0				0.0	
0.0				0.0	
0.0				0.0	
0.0				0.0	
0.0				0.0	
0.0				0.0	
428.5				24,129.7	
<b>0.43</b>				<b>24.13</b>	<b>1,601.56</b>

# Appendix B:

# Table 3.3.2

DOE/RL-2000-43

## FY 1952-65 HANFORD (GE Company) URANIUM SHIPMENTS TO OFFSITE LOCATIONS

						MINOR TIER 1 SITE				MINOR TIER 1 SITE			
						Mallinckrodt Chem Works (MCW) NY Ops - ORO Ops (IN FY55 Weldon Spring)				Simonds Saw & Steel Co. New York Ops			
FY	Date From	Date To	From RIS	Box #	Doc #	Kg DU	Kg NU	Gm EU	Kg U subtotal	FY	Kg DU	Kg NU	
1950	31-Dec-49	31-Dec-50	HGE	38213	FTS-670	OUT-OF-SCOPE, SEE APPENDIX B, TABLE 3.3.1							
1951	31-Dec-50	30-Jun-51	HGE	38213	FTS-845	OUT-OF-SCOPE, SEE APPENDIX B, TABLE 3.3.1							
1952	01-Jul-51	31-Dec-51	HGE	38213	FTS-864			0.00	0.00	1952		130,377.00	
1952	01-Jan-52	30-Jun-52	HGE	38213	FTS 953		4,719.00	0.00	4,719.00	1952		326,377.00	
1953	01-Jul-52	30-Jun-53	HGE	38213	FTS 1085		60,627.00	0.00	60,627.00	1953		438,066.00	
1954	01-Jul-53	30-Jun-54	HGE	38213	FTS 1311		86,317.00	0.00	86,317.00	1954			
1955	01-Jul-54	30-Jun-55	HGE	38213	FTS 1481	3.00	33,536.00	0.00	33,539.00	1955			
1956	01-Jul-55	30-Jun-56	HGE	38213	FTS 1644		318.00	0.00	318.00	1956			
1957	01-Jul-56	30-Jun-57	HGE	38213	FTS 1980		154.00	0.00	154.00	1957			
1958	01-Jul-57	30-Jun-58	HGE	38213	FTS CLVI 463			0.00	0.00	1958			
1959	01-Jul-58	30-Jun-59	HGE	38213	HAN 72720	4.00	1,554.00	0.00	1,558.00	1959			
1960	01-Jul-59	30-Jun-60	HGE	38213	HAN 75996		138.00	0.00	138.00	1960			
1961	01-Jul-60	30-Jun-61	HGE	38213	HAN 79125		118.00	0.00	118.00	1961			
1962	01-Jul-61	30-Jun-62	HGE	38213	HAN 82406	5.00	611.00	0.00	616.00	1962			
1963	01-Jul-62	30-Jun-63	HGE	38213	HAN 85615			0.00	0.00	1963			
1964	01-Jul-63	30-Jun-64	HGE	38213	HAN 88957			0.00	0.00	1964			
1965	01-Jul-64	30-Jun-65	HZA	38213	HAN 92119				0.00	1965			
<b>FY 52 thru FY 65 Kilogram totals</b>						12.00	188,092.00	0.00	188,104.00		0.00	894,820.00	
<b>FY 52 thru FY 65 MTU totals</b>									188.104				
<b>IN-SCOPE KG TOTALS</b>						12.0	183,373.0	0.0	183,385.0		0.0	438,066.0	

# Appendix B:

## Table 3.3.2

DOE/RL-2000-43

MINOR TIER 1 SITE							MINOR TIER 1 SITE				
New York Operations Harshaw Chemical Co., Cleveland							New York Operations Massachusetts Institute of Technology				
Gm EU	KgU subtotal	FY	MHR		Gm EU	subtotal	FY	Kg DU	Kg NU	Gm EU	subtotal
			Kg DU	Kg NU							
0.00	130,377.00	1952			0.00	0.00	1952			0.00	0.00
0.00	326,377.00	1952		11.00	0.00	11.00	1952			0.00	0.00
0.00	438,066.00	1953	1,674,970.00	0.00	0.00	1,674,970.00	1953	3,920.00		0.00	3,920.00
0.00	0.00	1954	238,736.00		0.00	238,736.00	1954	267.00		0.00	267.00
0.00	0.00	1955			0.00	0.00	1955			0.00	0.00
0.00	0.00	1956			0.00	0.00	1956			0.00	0.00
0.00	0.00	1957			0.00	0.00	1957			0.00	0.00
0.00	0.00	1958			0.00	0.00	1958			0.00	0.00
0.00	0.00	1959			0.00	0.00	1959			0.00	0.00
0.00	0.00	1960			0.00	0.00	1960			0.00	0.00
0.00	0.00	1961			0.00	0.00	1961			0.00	0.00
0.00	0.00	1962			0.00	0.00	1962			0.00	0.00
0.00	0.00	1963			0.00	0.00	1963			0.00	0.00
0.00	0.00	1964			0.00	0.00	1964			0.00	0.00
0.00	0.00	1965			0.00	0.00	1965			0.00	0.00
0.00	894,820.00		1,913,706.00	11.00	0.00	1,913,717.00		0.00	4,187.00	0.00	4,187.00
	894.820					1,913.717					4.187
0.0	438,066.0		1,913,706.0	0.0	0.0	1,913,706.0		0.0	4,187.0	0.0	4,187.0

# Appendix B:

# Table 3.3.2

DOE/RL-2000-43

MINOR TIER 1 SITE					MINOR TIER 1 SITE					MINOR TIER 1 SIT		
New York Ops Office National Lead Company (MNL) Aeroprojects, Nuclear Metals Inc.(MIO)					St Louis Area Office SubOffice to New York Ops					Chicago Operations Of GE, Battelle Columbus		
FY	Kg DU	Kg NU	Gm EU	subtotal	FY	Kg DU	Kg NU	Gm EU	Kg U subtotal	FY	Kg DU	Kg NU
1952			0.00	0.00	1952		14,355.00	0.00	14,355.00	1952		28.00
1952		90.00	0.00	90.00	1952		35,617.00	0.00	35,617.00	1952		119.00
1953		111,637.00	0.00	111,637.00	1953			0.00	0.00	1953		267.00
1954		372,669.00	0.00	372,669.00	1954			0.00	0.00	1954		
1955			0.00	0.00	1955			0.00	0.00	1955		236.00
1956			0.00	0.00	1956			0.00	0.00	1956		3.00
1957			0.00	0.00	1957			0.00	0.00	1957		84.00
1958			0.00	0.00	1958			0.00	0.00	1958		302.00
1959	4,614.00	1,515.00	1,012,413.00	7,141.41	1959			0.00	0.00	1959	3.00	65.00
1960		1,172.00	0.00	1,172.00	1960			0.00	0.00	1960	31.00	2.00
1961		2,558.00	85,672.00	2,643.67	1961			0.00	0.00	1961	9.00	67.00
1962		2,161.00	87,116.00	2,248.12	1962			0.00	0.00	1962		136.00
1963			0.00	0.00	1963			0.00	0.00	1963		510.00
1964			0.00	0.00	1964			0.00	0.00	1964		20.00
1965		24.00	45,454.00	69.45	1965			0.00	0.00	1965		
4,614.00 491,826.00 1,230,655.00 497,670.66					0.00 49,972.00 0.00 49,972.00					43.00 1,839.00		
<b>497.671</b>					<b>49.972</b>							
	4,614.0	491,736.0	1,230,655.0	497,580.7		0.0	0.0	0.0	0.0		43.0	1,692.0

# Appendix B:

## Table 3.3.2

DOE/RL-2000-43

OFFICE			MINOR TIER 1 SITE					MINOR TIER 1 SITE				
Office (BMI), Westinghouse			Chicago Operations Office Argonne Nat Lab ANL					Chicago Operations Office Iowa State College (sent uranium slugs)				
Gm EU	Kg U subtotal	FY	Kg DU	Kg NU	Gm EU	Kg U subtotal	FY	Kg DU	Kg NU	Gm EU	Kg U subtotal	FY
2.00	28.00	1952		15.00	5,166.00	20.17	1952			0.00	0.00	1952
0.00	119.00	1952		864.00	1,675.00	865.68	1952			0.00	0.00	1952
0.00	267.00	1953		242.00	0.00	242.00	1953		196.00	0.00	196.00	1953
2.00	0.00	1954	65.00	50.00	192,000.00	307.00	1954		95.00	0.00	95.00	1954
1,007.00	237.01	1955	2.00		1,729.00	3.73	1955		155.00	0.00	155.00	1955
287.00	3.29	1956	14.00	1,173.00	11.00	1,187.01	1956		170.00	0.00	170.00	1956
1,187.00	85.19	1957	14.00		13.00	14.01	1957			0.00	0.00	1957
1,222.00	303.22	1958			0.00	0.00	1958			0.00	0.00	1958
47,096.00	115.10	1959			0.00	0.00	1959			0.00	0.00	1959
0.00	33.00	1960			0.00	0.00	1960			0.00	0.00	1960
2,894.00	78.89	1961		1.00	0.00	1.00	1961			0.00	0.00	1961
60,160.00	196.16	1962			0.00	0.00	1962			0.00	0.00	1962
179,309.00	689.31	1963			0.00	0.00	1963			0.00	0.00	1963
18.00	20.02	1964	19.00	8.00	0.00	27.00	1964			0.00	0.00	1964
677.00	0.68	1965	970.00		0.00	970.00	1965			0.00	0.00	1965
293,861.00	2,175.86		1,084.00	2,353.00	200,594.00	3,637.59		0.00	616.00	0.00	616.00	
	2.176					3.638					0.616	
293,859.0	2,028.9		1,084.0	1,474.0	193,753.0	2,751.8		0.0	616.0	0.0	616.0	



# Appendix B:

## Table 3.3.2

DOE/RL-2000-43

MINOR TIER 1 SITE					MINOR TIER 1 SITE					MAJOR TIER 1 SITE			
Miscellaneous Site 2					New Brunswick Lab Oak Ridge Operations					National Lead of Ohio/Fernald Oak Ridge Operations			
Kg DU	Kg NU	Gm EU	Kg U subtotal	FY	NBL Kg DU	Kg NU	Gm EU	Kg U subtotal	FY	NLO Kg DU	Kg NU	Gm EU	
	121.00	377.00	121.38	1952		1.00	0.00	1.00	1952			0.00	
	623.00	0.00	623.00	1952		312.00	0.00	312.00	1952			0.00	
	697.00	0.00	697.00	1953			0.00	0.00	1953	124.00		0.00	
392.00	1,037.00	1,433.00	1,430.43	1954			0.00	0.00	1954			0.00	
	179.00	29.00	179.03	1955			0.00	0.00	1955		266,206.00	0.00	
21.00	260.00	89.00	281.09	1956			0.00	0.00	1956		411,533.00	0.00	
		67.00	0.07	1957	22.00		0.00	22.00	1957		348,388.00	462,208.00	
		7.00	0.01	1958	28.00	1.00	0.00	29.00	1958		359,711.00	5,497,057.00	
		0.00	0.00	1959	27.00		0.00	27.00	1959	1,363.00	489,893.00	17,736,122.00	
		0.00	0.00	1960	18.00	1.00	0.00	19.00	1960	18.00	362,114.00	20,546,711.00	
2.00		0.00	2.00	1961			0.00	0.00	1961		283,949.00	49,937,914.00	
		0.00	0.00	1962			0.00	0.00	1962		144,415.00	284,990,701.00	
		0.00	0.00	1963			136.00	0.14	1963		227,797.00	1,215,954,820.00	
		0.00	0.00	1964	1.00		109.00	1.11	1964		241,931.00	1,269,135,177.00	
		0.00	0.00	1965	1.00		979.00	1.98	1965		89,293.00	1,946,833,080.00	
415.00	2,917.00	2,002.00	3,334.00		97.00	315.00	1,224.00	413.22		1,505.00	3,225,230.00	4,811,093,790.00	
<b>3.334</b>					<b>0.413</b>								
415.0	2,173.0	1,625.0	2,589.6		97.0	2.0	1,224.0	100.2		1,505.0	3,225,230.0	4,811,093,790.0	

# Appendix B:

# Table 3.3.2

DOE/RL-2000-43

## MAJOR TIER 1 SITE

## MAJOR TIER 1 SITE

Carbide & Carbon Chem Co. Oak Ridge Y-12 & K-25 GDP CYT & CCC					Union Carbide of Kentucky-Paducah Oak Ridge Operations CKY				
Kg U subtotal	FY	Kg DU	Kg NU	Gm EU	Kg U subtotal	FY	Kg DU	Kg NU	Gm EU
0.00	1952	70	0	0	70.0	1952			0.00
0.00	1952	154,394	16,238	0	170,632.0	1952			0.00
124.00	1953	557,145	46,405	21,356	603,571.4	1953			0.00
0.00	1954	1,147,291	28,508	289,605	1,176,088.6	1954	2,233,024.00		0.00
266,206.00	1955	498,888		519,689	499,407.7	1955	2,586,213.00		496,031.00
411,533.00	1956	289,124		69,259	289,193.3	1956	4,105,038.00		0.00
348,850.21	1957	98,083		680,000	98,763.0	1957	5,385,900.00		11,564.00
365,208.06	1958	8,598	14	489,870	9,101.9	1958	6,056,423.00		0.00
508,992.12	1959	82		288,203,113	288,285.1	1959	5,202,424.00		0.00
382,678.71	1960	15		610,585,416	610,600.4	1960	5,148,061.00		0.00
333,886.91	1961			614,923,511	614,923.5	1961	6,093,776.00		0.00
429,405.70	1962			46,799,845	46,799.8	1962	4,576,354.00		915,461,646.00
1,443,751.82	1963			1,571,464	1,571.5	1963	5,771,936.00		0.00
1,511,066.18	1964			5,230	5.2	1964	4,087,367.00		0.00
2,036,126.08	1965			3,283	3.3	1965			0.00
<b>8,037,828.79</b>		<b>2,753,690</b>	<b>91,165</b>	<b>1,564,161,641</b>	<b>4,409,016.6</b>		<b>51,246,516.00</b>	<b>0.00</b>	<b>915,969,241.00</b>
<b>8,037.829</b>					<b>4,409.017</b>				
<b>8,037,828.8</b>		<b>2,753,620.0</b>	<b>74,927.0</b>	<b>1,564,161,641.0</b>	<b>4,392,708.6</b>		<b>51,246,516.0</b>	<b>0.0</b>	<b>915,969,241.0</b>

# Appendix B:

# Table 3.3.2

DOE/RL-2000-43

MINOR TIER 1 SITE						MINOR TIER 1 SITE						MINOR T
Oak Ridge National Lab Oak Ridge Operations						Tonawanda Sub-Office New York Ops						Sylvania El New York C
Kg U subtotal	FY	ORNL			Kg U subtotal	FY	TOA			Kg U subtotal	FY	Kg DU
		Kg DU	Kg NU	Gm EU			Kg DU	Kg NU	Gm EU			
0.00	1952		1,693.00	0.00	1,693.00	1952		295	0.00	295.00	1952	
0.00	1952			0.00	0.00	1952		670	0.00	670.00	1952	
0.00	1953	3,989.00		0.00	3,989.00	1953			0.00	0.00	1953	
2,233,024.00	1954	1,953.00	21.00	0.00	1,974.00	1954			0.00	0.00	1954	
2,586,709.03	1955	1,206.00		0.00	1,206.00	1955			0.00	0.00	1955	
4,105,038.00	1956	1,520.00	57.00	0.00	1,577.00	1956			0.00	0.00	1956	
5,385,911.56	1957	742.00	90.00	439.00	832.44	1957			0.00	0.00	1957	
6,056,423.00	1958	68.00		180,134.00	248.13	1958			0.00	0.00	1958	
5,202,424.00	1959	24.00	182.00	921,808.00	1,127.81	1959			0.00	0.00	1959	
5,148,061.00	1960	6,103.00	14.00	1.00	6,117.00	1960			0.00	0.00	1960	
6,093,776.00	1961			385,642.00	385.64	1961			0.00	0.00	1961	
5,491,815.65	1962			115,534.00	115.53	1962			0.00	0.00	1962	
5,771,936.00	1963			0.00	0.00	1963			0.00	0.00	1963	
4,087,367.00	1964			170,921.00	170.92	1964			0.00	0.00	1964	
0.00	1965			0.00	0.00	1965			0.00	0.00	1965	
<b>52,162,485.24</b>		<b>15,605.00</b>	<b>2,057.00</b>	<b>1,774,479.00</b>	<b>19,436.48</b>		<b>0.00</b>	<b>965.00</b>	<b>0.00</b>	<b>965.00</b>		<b>0.00</b>
<b>52,162.485</b>					<b>19.436</b>					<b>0.965</b>		
<b>52,162,485.2</b>		<b>15,605.0</b>	<b>364.0</b>	<b>1,774,479.0</b>	<b>17,743.5</b>		<b>0.0</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>		<b>0.0</b>

# Appendix B:

# Table 3.3.2

DOE/RL-2000-43

## TIER 1 SITE

## MINOR TIER 1 SITE

## MINOR TIER 1 SITE

lec. Products  
Ops

San Francisco Operations  
North Amer Aviation (DNA),  
Oregon Metallurgical

Bridgeport Brass Co.  
NY Ops then under ORO

Kg NU	Gm EU	Kg U subtotal	FY	Kg DU	Kg NU	Gm EU	Kg U subtotal	FY	Kg DU	Kg NU	Gm EU	Kg U subtotal	FY
16.00	0.00	16.00	1952			0.00	0.00	1952			0.00	0.00	1952
234.00	0.00	234.00	1952			0.00	0.00	1952			0.00	0.00	1952
774.00	0.00	774.00	1953	14.00	37.00	0.00	51.00	1953			0.00	0.00	1953
196.00	0.00	196.00	1954			3.00	0.00	1954			0.00	0.00	1954
	0.00	0.00	1955		54.00	0.00	54.00	1955			0.00	0.00	1955
	0.00	0.00	1956	22.00	35.00	0.00	57.00	1956		87.00	0.00	87.00	1956
	0.00	0.00	1957		54.00	0.00	54.00	1957			0.00	0.00	1957
	0.00	0.00	1958	21.00	228.00	0.00	249.00	1958			0.00	0.00	1958
	0.00	0.00	1959	1.00	1,183.00	11,362.00	1,195.36	1959		2,096.00	0.00	2,096.00	1959
	0.00	0.00	1960	2.00	5,025.00	290,491.00	5,317.49	1960		1,542.00	0.00	1,542.00	1960
	0.00	0.00	1961		806.00	10,864.00	816.86	1961			0.00	0.00	1961
	0.00	0.00	1962		4.00	1,173.00	5.17	1962			0.00	0.00	1962
	0.00	0.00	1963		13.00	3,983.00	16.98	1963			0.00	0.00	1963
	0.00	0.00	1964			0.00	0.00	1964			0.00	0.00	1964
	0.00	0.00	1965			1.00	0.00	1965			0.00	0.00	1965
1,220.00	0.00	1,220.00		60.00	7,439.00	317,877.00	7,816.88		0.00	3,725.00	0.00	3,725.00	
<b>1.220</b>				<b>7.817</b>					<b>3.725</b>				
970.0	0.0	970.0		60.0	7,439.0	317,877.0	7,816.9		0.0	3,725.0	0.0	3,725.0	

# Appendix B:

# Table 3.3.2

DOE/RL-2000-43

MINOR TIER 1 SITE					MINOR TIER 1 SITE					MINOR TIER 1 SITE					
Savannah River (SR) DuPont Sylvania Elec, Sylvania Corning Nuc Co.					Idaho Operations Phillips Petroleum Co. (MTI), AEC Health Physics Div					Idaho Operations American Cyanamid Co.					
Kg DU	Kg NU	Gm EU	Kg U subtotal	FY	Kg DU	Kg NU	Gm EU	Kg U subtotal	FY	Kg DU	Kg NU	Gm EU	Kg U subtotal		
					OUT-OF SCOPE					OUT-OF SCOPE					
					IRRADIATED FUEL					IRRADIATED FUEL					
	185.00	0.00	185.00	1952											
	11.00	0.00	11.00	1952											
	21.00	0.00	21.00	1953											
		0.00	0.00	1954											
	1,207.00	0.00	1,207.00	1955											
	104.00	0.00	104.00	1956											
	297.00	0.00	297.00	1957											
	943.00	0.00	943.00	1958											
	318.00	0.00	318.00	1959											
	59.00	0.00	59.00	1960											
	4,248.00	0.00	4,248.00	1961											
	46.00	0.00	46.00	1962											
	34.00	20,226.00	54.23	1963											
		0.00	0.00	1964											
		0.00	0.00	1965											
0.00	7,473.00	20,226.00	7,493.23												
				7.493											
0.0	7,277.0	20,226.0	7,297.2												

# Appendix B:

# Table 3.3.2

DOE/RL-2000-43

MINOR TIER 1 SITE					MINOR TIER 1 SITE					MINOR TIER 1 SITE			
Sante Fe/Albuquerque Ops					Division of International Affairs					Miscellaneous Site 1			
FY	Kg DU	Kg NU	Gm EU	Kg U subtotal	FY	Kg DU	Kg NU	Gm EU	Kg U subtotal	FY	Kg DU	Kg NU	Gm EU
			0.00	0.00	1952			0.00	0.00	1952			0.00
			0.00	0.00	1952			0.00	0.00	1952			0.00
		11,420.00	0.00	11,420.00	1953			0.00	0.00	1953			0.00
		4,611.00	0.00	4,611.00	1954			0.00	0.00	1954			0.00
			0.00	0.00	1955			0.00	0.00	1955			0.00
			0.00	0.00	1956			0.00	0.00	1956			0.00
			0.00	0.00	1957			0.00	0.00	1957			0.00
			0.00	0.00	1958			0.00	0.00	1958			0.00
	2.00		0.00	2.00	1959			0.00	0.00	1959		6.00	4,137.00
			0.00	0.00	1960			0.00	0.00	1960		5.00	1,462.00
			0.00	0.00	1961			0.00	0.00	1961	1.00	1.00	1,402.00
			0.00	0.00	1962			0.00	0.00	1962			16.00
			0.00	0.00	1963			0.00	0.00	1963			0.00
			0.00	0.00	1964		27.00	59.00	27.06	1964			0.00
	4.00		0.00	4.00	1965			0.00	0.00	1965			0.00
	6.00	16,031.00	0.00	16,037.00		0.00	27.00	59.00	27.06		1.00	12.00	7,017.00
				16.037					0.027				
	6.0	16,031.0	0.0	16,037.0		0.0	27.0	59.0	27.1		1.0	12.0	7,017.0

# Appendix B:

# Table 3.3.2

DOE/RL-2000-43

MINOR TIER 1 SITE						MINOR TIER 1 SITE						MINOR TIER 1 SITE	
Materials Leasing Office Leases to Licensees Division of Licensing & Regulations						United Nuclear Corp Chem Division Oak Ridge						Kerr-McGee Oil Indust Oak Ridge	
Kg U subtotal	FY	Kg DU	Kg NU	Gm EU	Kg U subtotal	FY	Kg DU	Kg NU	Kg EU	Kg U subtotal	FY	Kg DU	Kg NU
0.00	1952			0.00	0.00	1952			0.00	0.00	1952		
0.00	1952			0.00	0.00	1952			0.00	0.00	1952		
0.00	1953			0.00	0.00	1953			0.00	0.00	1953		
0.00	1954			0.00	0.00	1954			0.00	0.00	1954		
0.00	1955			0.00	0.00	1955			0.00	0.00	1955		
0.00	1956			0.00	0.00	1956			0.00	0.00	1956		
0.00	1957			0.00	0.00	1957			0.00	0.00	1957		
0.00	1958		7,369.00	4,586.00	7,373.59	1958			0.00	0.00	1958		
10.14	1959		2,519.00	-4,586.00	2,514.41	1959			0.00	0.00	1959		
6.46	1960			0.00	0.00	1960			0.00	0.00	1960		
3.40	1961			0.00	0.00	1961			0.00	0.00	1961		
0.02	1962			0.00	0.00	1962			0.00	0.00	1962		
0.00	1963			2,194,696.00	2,194.70	1963			0.00	0.00	1963		
0.00	1964	6.00		0.00	6.00	1964		564.00	0.00	564.00	1964	2,273.00	
0.00	1965			0.00	0.00	1965			0.00	0.00	1965		
<b>20.02</b>		6.00	9,888.00	2,194,696.00	<b>12,088.70</b>		0.00	564.00	0.00	<b>564.00</b>		2,273.00	0.00
<b>0.020</b>					<b>12.089</b>					<b>0.564</b>			
<b>20.0</b>		6.0	9,888.0	2,194,696.0	<b>12,088.7</b>		0.0	564.0	0.0	<b>564.0</b>		2,273.0	0.0

# Appendix B:

## Table 3.3.2

DOE/RL-2000-43

TE			MINOR TIER 1 SITE					MINOR TIER 1 SITE					MINOR TIER 1 SIT	
trial			Brookhaven Nat Lab New York Operations					Vitro Manufacturing Co. New York Operations					Hanford Operations US Bureau of Mines Oregon Metallurgical	
Gm EU	Kg U subtotal	FY	Kg DU	Kg NU	Gm EU	Kg U subtotal	FY	Kg DU	Kg NU	Gm EU	Kg U subtotal	FY	Kg DU	Kg NU
0.00	0.00	1952		22.00	0.00	22.00	1952		284.00	0.00	284.00	1952		830.00
0.00	0.00	1952			313.00	0.31	1952		3,328.00	0.00	3,328.00	1952		1,637.00
0.00	0.00	1953		76.00	0.00	76.00	1953		1,629.00	0.00	1,629.00	1953		484.00
0.00	0.00	1954			0.00	0.00	1954		2.00	0.00	2.00	1954		
0.00	0.00	1955			0.00	0.00	1955			0.00	0.00	1955		
0.00	0.00	1956			0.00	0.00	1956			0.00	0.00	1956		
0.00	0.00	1957		229.00	0.00	229.00	1957			0.00	0.00	1957		
0.00	0.00	1958			0.00	0.00	1958			0.00	0.00	1958		
0.00	0.00	1959			0.00	0.00	1959			0.00	0.00	1959		
0.00	0.00	1960			0.00	0.00	1960			0.00	0.00	1960		8,326.00
0.00	0.00	1961			0.00	0.00	1961			0.00	0.00	1961		23,015.00
0.00	0.00	1962			0.00	0.00	1962			0.00	0.00	1962		
0.00	0.00	1963	4.00		0.00	4.00	1963			0.00	0.00	1963		
0.00	2,273.00	1964			0.00	0.00	1964			0.00	0.00	1964		
0.00	0.00	1965			0.00	0.00	1965			0.00	0.00	1965		
0.00	2,273.00		4.00	327.00	313.00	331.31		0.00	5,243.00	0.00	5,243.00		0.00	34,292.00
<b>2.273</b>					<b>0.331</b>					<b>5.243</b>				
0.0	2,273.0		4.0	305.0	0.0	309.0		0.0	1,631.0	0.0	1,631.0		0.0	31,825.0



# Appendix B:

## Table 3.3.2

TE								MINOR TIER 1 SITE	
Division of Raw Materials								National Bureau of Standards	
Gm EU	Kg U subtotal	FY	Kg DU	Kg NU	Gm EU	Kg U subtotal	FY		
0.00	830.00	1952			0.00	0.00	1952	OUT OF SCOPE	
0.00	1,637.00	1952			0.00	0.00	1952	IN-SCOPE DU	OUT OF SCOPE NU & EU
0.00	484.00	1953			0.00	0.00	1953		IN-SCOPE NU & EU
0.00	0.00	1954			0.00	0.00	1954		
0.00	0.00	1955		5	0.00	5.00	1955		
0.00	0.00	1956			0.00	0.00	1956		
0.00	0.00	1957			0.00	0.00	1957		
0.00	0.00	1958			0.00	0.00	1958		
0.00	0.00	1959			0.00	0.00	1959		
0.00	8,326.00	1960			0.00	0.00	1960		
0.00	23,015.00	1961			0.00	0.00	1961		
0.00	0.00	1962			0.00	0.00	1962		
18.00	0.02	1963			0.00	0.00	1963		
0.00	0.00	1964			0.00	0.00	1964		
0.00	0.00	1965			0.00	0.00	1965		
18.00	34,292.02		0.00	5.00	0.00	5.00		68,282,597.44	
	34.292					0.005		68,282.597	
18.0	31,825.0		0.0	5.0	0.0	5.0		67,740,366.2	

**Appendix B:**  
**FY 1966-70 Hanford Uranium Offsite Shipments**

**Table 3.3.3**

**DOE/RL-2000-43**

BASED ON HANFORD MBR REPORTS

FY	Date From	Date To	RIS From	Shipped From Hanford Contractor	Box #	Doc #	MINOR TIER 1 SITE				MINOR TIER 1 SITE				MAJOR TIE		
							New Brunswick Lab Oak Ridge Ops FBE				New York Ops Office Babcox & Wilcox				National Lead of FVA, FVB, FVC Oak Ridge Ops		
							Kg DU	Kg NU	Gm EU	Kg U subtotal	FY	Kg DU	Kg NU	Gm EU	Kg U subtotal	FY	Kg DU
1966	01-Jul-65	30-Jun-66	HZA	General Electric	38213	HAN 95170	1		776	1.78	1966				0.00	1966	
1966	01-Jul-65	30-Jun-66	HWA	Isochem Inc.	38213	HAN 95136			1372	1.37	1966				0.00	1966	
<i>Hanford Chem Processing Contractor subtotals</i>							1.00	0.00	2,148.00	3.15		0.00	0.00	0.00	0.00		0.00
1966	01-Jul-65	30-Jun-66	HXA	Douglas United Nuc	38214	HAN 95171				0.00	1966				0.00	1966	
<i>Hanford FY Aggregate subtotal</i>							1.00	0.00	2,148.00	3.15		0.00	0.00	0.00	0.00		0.00
1967	01-Jul-66	31-Dec-66	HZA	General Electric	39213	HAN 96413				0.00	1967				0.00	1967	
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			422	0.42							
1967	01-Jan-67	30-Jun-67	HWA	Isochem Inc.	38213	HAN 98196	0.5		645	1.15	1967				0.00	1967	
<i>Hanford Chem Processing Contractor subtotals</i>							0.50	0.00	1,067.00	1.57		0.00	0.00	0.00	0.00		0.00
1967	01-Jul-66	31-Dec-66	HXA	Douglas United Nuc	38214	DUN 1916				0.00					0.00		
1967	01-Jan-67	30-Jun-67	HXA	Douglas United Nuc	38214	HAN 98194				0.00	1967				0.00	1967	
<i>Hanford FY Aggregate subtotal</i>							0.50	0.00	1,067.00	1.57		0.00	0.00	0.00	0.00		0.00
1968	01-Jul-67	31-Dec-67	HVA	Atlantic Richfield Han	46425	HAN 99439			495	0.50	1968				0.00	1968	
1968	01-Jan-68	30-Jun-68	HVA	Atlantic Richfield Han	46425	ARH 699			472	0.47	1968				0.00	1968	
<i>Hanford Chem Processing Contractor subtotals</i>							0.00	0.00	967.00	0.97		0.00	0.00	0.00	0.00		0.00
1968	01-Jul-67	31-Dec-67	HXA	Douglas United Nuc	38214	DUN 3624				0.00					0.00		
1968	01-Jan-68	30-Jun-68	HXA	Douglas United Nuc	38214	DUN 4436				0.00	1968				0.00	1968	
<i>Hanford FY Aggregate subtotal</i>							0.00	0.00	967.00	0.97		0.00	0.00	0.00	0.00		0.00
1969	01-Jul-68	31-Dec-68	HVA	Atlantic Richfield Han	46425	ARH 1036			38	0.04	1969				0.00	1969	
1969	01-Jan-69	30-Jun-69	HVA	Atlantic Richfield Han	46425	ARH 1099-6			104	0.10	1969		361		361.00	1969	
<i>Hanford Chem Processing Contractor subtotals</i>							0.00	0.00	142.00	0.14		0.00	361.00	0.00	361.00		0.00
1969	01-Jul-68	31-Dec-68	HXA	Douglas United Nuc	38214	DUN 5250				0.00					0.00		
1969	01-Jan-69	30-Jun-69	HXA	Douglas United Nuc	38214	DUN 5942				0.00	1969				0.00	1969	
<i>Hanford FY Aggregate subtotal</i>							0.00	0.00	142.00	0.14		0.00	361.00	0.00	361.00		0.00
1970	01-Jul-69	31-Dec-69	HVA	Atlantic Richfield Han	46425	ARH 1099-12			125	0.13	1970				0.00	1970	
1970	01-Jan-70	30-Jun-70	HVA	Atlantic Richfield Han	46425	ARH 1540-6			220	0.22	1970				0.00	1970	467857
<i>Hanford Chem Processing Contractor subtotals</i>							0.00	0.00	345.00	0.35		0.00	0.00	0.00	0.00		467,857.00
1970	01-Jul-69	31-Dec-69	HXA	Douglas United Nuc	38214	DUN 6557				0.00					0.00		8698
1970	01-Jan-70	30-Jun-70	HXA	Douglas United Nuc	38214	DUN 7049				0.00	1970				0.00	1970	
<i>Hanford FY Aggregate subtotal</i>							0.00	0.00	345.00	0.35		0.00	0.00	0.00	0.00		476,555.00
<b>KG TOTAL: ALL U TYPES</b>											<b>6.17</b>					<b>361.00</b>	
<b>MTU TOTAL: ALL U TYPES:</b>											<b>0.01</b>					<b>0.36</b>	
<b>IN-SCOPE RECYCLE TOTAL: ALL U TYPES MTU</b>											<b>0.01</b>					<b>0.36</b>	

Appendix B:

Table 3.3.3

DOE/RL-2000-43

ER 1 SITE				MAJOR TIER 1 SITE				MINOR TIER 1 SITE				MAJOR TIER 1 SITE				
Ohio (NLO), Fernald, FEMP				Carbide & Carbon Chem Co. ORO Y-12 & K-25 GDP (CYT, FZB), (FZA, FZE, FZF)				Oak Ridge Natl Lab Oak Ridge Operations FZC				Union Carbide Co.-Paducah Paducah: Oak Ridge Operations FYA				
Kg NU	Gm EU	Kg U subtotal	FY	Kg DU	Kg NU	Gm EU	Kg U subtotal	FY	Kg DU	Kg NU	Gm EU	Kg U subtotal	FY	Kg DU	Kg NU	Gm EU
122166	895631472	1,017,797.47	1966				0.00	1966				0.00	1966			
	1128064845	1,128,064.85	1966				0.00	1966				0.00	1966			
122,166.00	2,023,696,317.00	2,145,862.32		0.00	0.00	0.00	0.00		0.00	0.00	0.00	0.00		0.00	0.00	0.00
82,398.00	14,038,206.00	96,436.21	1966		84		84.00	1966				0.00	1966			
<b>204,564.00</b>	<b>2,037,734,523.00</b>	<b>2,242,298.52</b>		<b>0.00</b>	<b>84.00</b>	<b>0.00</b>	<b>84.00</b>		<b>0.00</b>	<b>0.00</b>	<b>0.00</b>	<b>0.00</b>		<b>0.00</b>	<b>0.00</b>	<b>0.00</b>
2,454	56,738,050	59,192.05	1967				0.00	1967				0.00	1967			
1,413	117,584,456	118,997.46														
	550,001,735	550,001.74														
	735,171,140	735,171.14	1967				0.00	1967				0.00	1967	14,432,875.00		
3,867.00	1,459,495,381	1,463,362.38		0.00	0.00	0.00	0.00		0.00	0.00	0.00	0.00		14,432,875.00	0.00	0.00
32174	10,790,511	42,964.51					0.00					0.00				
40443	14,413,920	54,856.92	1967				0.00	1967				0.00	1967			
<b>76,484.00</b>	<b>1,484,699,812.00</b>	<b>1,561,183.81</b>		<b>0.00</b>	<b>0.00</b>	<b>0.00</b>	<b>0.00</b>		<b>0.00</b>	<b>0.00</b>	<b>0.00</b>	<b>0.00</b>		<b>14,432,875.00</b>	<b>0.00</b>	<b>0.00</b>
	552206881	552,206.88	1968				0.00	1968				0.00	1968			
	1001717324	1,001,717.32	1968				0.00	1968				0.00	1968			
0.00	1,553,924,205.00	1,553,924.21		0.00	0.00	0.00	0.00		0.00	0.00	0.00	0.00		0.00	0.00	0.00
58158	88359837	146,517.84					0.00					0.00				
26421	173,619,791	200,040.79	1968				0.00	1968				0.00	1968			
<b>84,579.00</b>	<b>1,815,903,833.00</b>	<b>1,900,482.83</b>		<b>0.00</b>	<b>0.00</b>	<b>0.00</b>	<b>0.00</b>		<b>0.00</b>	<b>0.00</b>	<b>0.00</b>	<b>0.00</b>		<b>0.00</b>	<b>0.00</b>	<b>0.00</b>
	835039056	835,039.06	1969				0.00	1969				0.00	1969			
	1034973841	1,034,973.84	1969				0.00	1969				0.00	1969	3,537,144.00		
0.00	1,870,012,897.00	1,870,012.90		0.00	0.00	0.00	0.00		0.00	0.00	0.00	0.00		3,537,144.00	0.00	0.00
46447	112,223,945	158,670.95					0.00					0.00				
27208	83,035,338	110,243.34	1969				0.00	1969				0.00	1969			
<b>73,655.00</b>	<b>2,065,272,180.00</b>	<b>2,138,927.18</b>		<b>0.00</b>	<b>0.00</b>	<b>0.00</b>	<b>0.00</b>		<b>0.00</b>	<b>0.00</b>	<b>0.00</b>	<b>0.00</b>		<b>3,537,144.00</b>	<b>0.00</b>	<b>0.00</b>
	1149060201	1,149,060.20	1970				0.00	1970				0.00	1970			
13	619946796	1,087,816.80	1970				0.00	1970				0.00	1970			
13.00	1,769,006,997.00	2,236,877.00		0.00	0.00	0.00	0.00		0.00	0.00	0.00	0.00		0.00	0.00	0.00
36661	130,535,155	175,894.16					0.00					0.00				
14541	49,369,234	63,910.23	1970				0.00	1970				0.00	1970			
<b>51,215.00</b>	<b>1,948,911,386.00</b>	<b>2,476,681.39</b>		<b>0.00</b>	<b>0.00</b>	<b>0.00</b>	<b>0.00</b>		<b>0.00</b>	<b>0.00</b>	<b>0.00</b>	<b>0.00</b>		<b>0.00</b>	<b>0.00</b>	<b>0.00</b>
				<b>10,319,573.7</b>				<b>84.00</b>				<b>0.00</b>				
				<b>10,319.57</b>				<b>0.08</b>				<b>0.00</b>				
				<b>10,319.57</b>				<b>0.08</b>				<b>0.00</b>				

Appendix B:

Table 3.3.3

DOE/RL-2000-43

MINOR TIER 1 SITE						MINOR TIER 1 SITE				MINOR TIER 1 SITE					MINOR			
San Francisco Operations GE Nuclear Fuels Div. LAZ, LAE						Savannah River DZA DuPont SRS				Oak Ridge Ops Nuclear Fuel Services FAX					Materials L Oak Ridge			
Kg U subtotal	FY	Kg DU	Kg NU	Gm EU	Kg U subtotal	FY	Kg DU	Kg NU	Gm EU	Kg U subtotal	FY	Kg DU	Kg NU	Gm EU	Kg U subtotal	FY	Kg DU	
0.00	1966				0.00	1966				0.00	1966				0.00	1966		
0.00	1966				0.00	1966				0.00	1966				0.00	1966		
0.00		0.00	0.00	0.00	0.00		0.00	0.00	0.00	0.00		0.00	0.00	0.00	0.00			0.00
0.00	1966				0.00	1966			29,610.00	29.61	1966			9,479.00	9.48	1966		
<b>0.00</b>		<b>0.00</b>	<b>0.00</b>	<b>0.00</b>	<b>0.00</b>		<b>0.00</b>	<b>0.00</b>	<b>29,610.00</b>	<b>29.61</b>		<b>0.00</b>	<b>0.00</b>	<b>9,479.00</b>	<b>9.48</b>			<b>0.00</b>
0.00	1967				0.00	1967				0.00	1967				0.00	1967		
14,432,875.00	1967				0.00	1967				0.00	1967	84.00	126.00	224.00	210.22	1967		
14,432,875.00		0.00	0.00	0.00	0.00		0.00	0.00	0.00	0.00		84.00	126.00	224.00	210.22			0.00
0.00				136	0.14					0.00				-358.00	-0.36			
0.00	1967				0.00	1967				0.00	1967				0.00	1967		
<b>14,432,875.00</b>		<b>0.00</b>	<b>0.00</b>	<b>136.00</b>	<b>0.14</b>		<b>0.00</b>	<b>0.00</b>	<b>0.00</b>	<b>0.00</b>		<b>84.00</b>	<b>126.00</b>	<b>-134.00</b>	<b>209.87</b>			<b>0.00</b>
0.00	1968				0.00	1968				0.00	1968				0.00	1968		
0.00	1968				0.00	1968				0.00	1968				0.00	1968		
0.00		0.00	0.00	0.00	0.00		0.00	0.00	0.00	0.00		0.00	0.00	0.00	0.00			0.00
0.00	1968				0.00	1968				0.00	1968				0.00	1968		
<b>0.00</b>		<b>0.00</b>	<b>0.00</b>	<b>0.00</b>	<b>0.00</b>		<b>0.00</b>	<b>0.00</b>	<b>0.00</b>	<b>0.00</b>		<b>0.00</b>	<b>0.00</b>	<b>0.00</b>	<b>0.00</b>			<b>0.00</b>
0.00	1969				0.00	1969				0.00	1969				0.00	1969		
3,537,144.00	1969				0.00	1969				0.00	1969				0.00	1969		
3,537,144.00		0.00	0.00	0.00	0.00		0.00	0.00	0.00	0.00		0.00	0.00	0.00	0.00			0.00
0.00				58	0.06					0.00					0.00			
0.00	1969				0.00	1969				0.00	1969				0.00	1969		
<b>3,537,144.00</b>		<b>0.00</b>	<b>0.00</b>	<b>58.00</b>	<b>0.06</b>		<b>0.00</b>	<b>0.00</b>	<b>0.00</b>	<b>0.00</b>		<b>0.00</b>	<b>0.00</b>	<b>0.00</b>	<b>0.00</b>			<b>0.00</b>
0.00	1970				0.00	1970				0.00	1970				0.00	1970		
0.00	1970				0.00	1970				0.00	1970				0.00	1970		
0.00		0.00	0.00	0.00	0.00		0.00	0.00	0.00	0.00		0.00	0.00	0.00	0.00			0.00
0.00				9	152					0.00					0.00			
0.00	1970			7	7.00	1970				0.00	1970				0.00	1970		
<b>0.00</b>		<b>0.00</b>	<b>16.00</b>	<b>152.00</b>	<b>16.15</b>		<b>0.00</b>	<b>0.00</b>	<b>0.00</b>	<b>0.00</b>		<b>0.00</b>	<b>0.00</b>	<b>0.00</b>	<b>0.00</b>			<b>0.00</b>
<b>17,970,019.00</b>					<b>16.35</b>					<b>29.61</b>					<b>219.35</b>			
<b>17,970.02</b>					<b>0.02</b>					<b>0.03</b>					<b>0.22</b>			
<b>17,970.02</b>					<b>0.02</b>					<b>0.03</b>					<b>0.22</b>			

TIER 1 SITE				MINOR TIER 1 SITE				MINOR TIER 1 SITE				Annual Totals	
Leasing Office Headquarters				Chicago Operations Office Atomic International (CAE) Argonne Nat. Lab (CZA)				Savannah River Ops Nuclear Fuels Services (DAX, YDE) OUT-OF-SCOPE: IRRADIATED FUEL					
Kg NU	Gm EU	Kg U subtotal	FY	Kg DU	Kg NU	Gm EU	Kg U subtotal	FY	Kg DU	Kg NU	Gm EU	Kg U subtotal	FY
		0.00	1966				0.00	1966					
		0.00	1966				0.00	1966					
0.00	0.00	0.00		0.00	0.00	0.00	0.00						
2,050.00		2,050.00	1966			160	0.16	1966					
2,050.00	0.00	2,050.00		0.00	0.00	160.00	0.16						2,341,826.8
		0.00	1967				0.00	1967					
		0.00	1967				0.00	1967					
0.00	0.00	0.00		0.00	0.00	0.00	0.00						
		0.00	1967				0.00	1967					
0.00	0.00	0.00		0.00	0.00	0.00	0.00						16,053,101.2
		0.00	1968				0.00	1968					
		0.00	1968				0.00	1968					
0.00	0.00	0.00		0.00	0.00	0.00	0.00						
	33.00	0.03	1968				0.00	1968					
0.00	33.00	0.03		0.00	0.00	0.00	0.00						2,040,742.7
		0.00	1969				0.00	1969					
		0.00	1969				0.00	1969					
0.00	0.00	0.00		0.00	0.00	0.00	0.00						
	46.00	0.05					0.00						
	8.00	0.01	1969				0.00	1969					
0.00	54.00	0.05		0.00	0.00	0.00	0.00						5,731,129.1
		0.00	1970				0.00	1970					
		0.00	1970				0.00	1970					
0.00	0.00	0.00		0.00	0.00	0.00	0.00						
	72.00	0.07					0.00						
	16.00	0.02	1970				0.00	1970					
0.00	88.00	0.09		0.00	0.00	0.00	0.00						2,476,698.0
		2,050.18					0.16						28,643,497.8
		2.05					0.00						28,643.50
		2.05					0.00						28,292.36

# Appendix B:

# Table 3.3.4

DOE/RL-2000-43

## Hanford Chemical Processing Contractor (HVA) Uranium Shipments FY 1971-March 31, 1999

Based on NMMSS Document RL2000-I-00002 SHIPMENTS (classified)

ATLANTIC RICHFIELD HANFORD

FY	DU				EU	
	MAJOR TIER 1:	MAJOR TIER 1:	MAJOR TIER 1:	Total Kg DU	MAJOR TIER 1:	MAJOR TIER 1:
	To PADUCAH Kg DU CKY, FYA	To FERNALD Kg DU FVA, FVB,FVC	To OAK RIDGE Kg DU FZA,FZE,FZB,FZF	To External From Hanford	To PADUCAH Gm EU CKY, FYA	To FERNALD Gm EU FVA, FVB,FVC
71	624,855	0	0	1,206,462	96,721,586	130,928
72	1,292,075	0	0	1,292,201	1,786,421,765	0
73	208,144	0	0	208,144	349,974,776	0
74	0	0	0	1,017,222	0	0
75	0	0	0	4	0	0
76	0	0	0	0	0	0
76T	0	0	0	0	0	0
77	0	0	0	0	0	0
<div style="border: 1px solid black; padding: 10px; width: fit-content; margin: 0 auto;">                     AFTER FY 1977 - HVA CONTRACTOR TURNOVER TO                      ROCKWELL HANFORD (HRA)                 </div>						
<b>KG TOTAL</b>	<b>2,125,074</b>	<b>0</b>	<b>0</b>	<b>3,724,033</b>	<b>2,233,118</b>	<b>131</b>
<b>MTU TOTAL</b>	<b>2,125.07</b>	<b>0.00</b>	<b>0.00</b>	<b>3,724.03</b>	<b>2,233.12</b>	<b>0.13</b>

HVA

NU						Total
MAJOR TIER 1:		MAJOR TIER 1:	MAJOR TIER 1:	MAJOR TIER 1:	Total Kg NU To External From Hanford	
To OAK RIDGE Gm EU FZA,FZE,FZB,FZF	Total Gm EU To External From Hanford	To PADUCAH Kg NU CKY, FYA	To FERNALD Kg NU FVA, FVB,FVC	To OAK RIDGE Kg NU FZA,FZE,FZB,FZF		
0	96,927,511	0	0	0	390	
0	1,786,423,319	0	0	0	0	
0	349,975,003	0	0	0	0	
0	0	0	0	0	63	
0	7	0	0	0	0	
0	1,924	0	0	0	0	
0	0	0	0	0	0	
0	1,187	0	222	0	224	
0	2,233,329	0	222	0	677	
0.00	2,233.33	0.00	0.22	0.00	0.68	

# Appendix B:

# Table 3.3.5

DOE/RL-2000-43

## Hanford Chemical Processing Contractor (HRA) Uranium Shipments FY 1971-March 31, 1999

Based on NMMSS Document RL2000-I-00002 SHIPMENTS (classified)

ROCKWELL HANFORD OPERATIONS (RHO)

FY	DU				EU	
	MAJOR TIER 1: To PADUCAH Kg DU	MAJOR TIER 1: To FERNALD Kg DU	MAJOR TIER 1: To OAK RIDGE Kg DU	Total Kg DU To External From Hanford	MAJOR TIER 1: To PADUCAH Gm EU	MAJOR TIER 1: To FERNALD Gm EU
	CKY, FYA	FVA, FVB,FVC	FZA,FZE,FZB,FZF		CKY, FYA	FVA, FVB,FVC
71						
72						
73						
74						
75						
76						
77						
78	0	0	0	29	0	0
79	0	0	0	258	0	0
80	0	0	0	640	0	0
81	0	0	0	40	0	0
82	0	0	0	167	0	0
83	0	0	0	0	0	0
84	0	0	0	0	0	705,955,924
85	0	0	0	0	0	917,915,947
86	0	0	0	0	0	1,150,902,482
87	0	0	0	0	0	313,510,829
88						
89						
90						
91						
92						
93						
94						
95						
96						
97						
98						
99						
<b>KG TOTAL</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>1,134</b>	<b>0</b>	<b>3,088,285</b>
<b>MTU TOTAL</b>	<b>0.00</b>	<b>0.00</b>	<b>0.00</b>	<b>1.13</b>	<b>0.00</b>	<b>3,088.29</b>



# Appendix B:

# Table 3.3.5

DOE/RL-2000-43

## HRA

)

NU						Total
MAJOR TIER 1:		MAJOR TIER 1:	MAJOR TIER 1:	MAJOR TIER 1:		
To OAK RIDGE Gm EU FZA,FZE,FZB,FZF	Total Gm EU To External From Hanford	To PADUCAH Kg NU CKY, FYA	To FERNALD Kg NU FVA, FVB,FVC	To OAK RIDGE Kg NU FZA,FZE,FZB,FZF	Total Kg NU To External From Hanford	
0	242,491	0	0	0	0	
0	87,492	0	0	0	108	
0	63,032	0	0	0	609	
0	40,995	0	0	0	373	
0	162,333	0	0	0	543	
0	1,723,373	0	0	0	0	
0	716,519,454	0	4	0	5	
0	925,684,279	0	0	0	0	
0	1,159,704,192	0	0	0	0	
0	317,852,929	0	0	0	0	
0	3,122,081	0	4	0	1,638	
0.00	3,122.08	0.00	0.00	0.00	1.64	

# Appendix B:

# Table 3.3.6

DOE/RL-2000-43

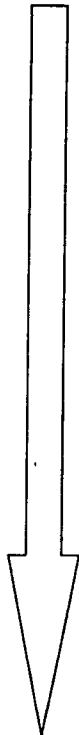
## Hanford Chem. Processing Contrs (HUD & HTA) Uranium Shipments FY 1971-March 31, 1999

Based on NMMSS Document RL2000-I-00002 SHIPMENTS (classified)

WESTINGHOUSE HANFORD (HUD) & FLUOR (HTA)

FY	DU				EU	
	MAJOR TIER 1:	MAJOR TIER 1:	MAJOR TIER 1:	Total Kg DU	MAJOR TIER 1:	MAJOR TIER 1:
	To PADUCAH Kg DU CKY, FYA	To FERNALD Kg DU FVA, FVB,FVC	To OAK RIDGE Kg DU FZA,FZE,FZB,FZF	To External From Hanford	To PADUCAH Gm EU CKY, FYA	To FERNALD Gm EU FVA, FVB,FVC
71						
PRIOR TO FY 1987 - HRA CONTRACTOR						
87	0	0	0	0	0	0
88	0	0	0	4,792	0	123,425,579
89	0	0	0	0	0	212,831
90	0	0	0	0	0	0
91	0	0	0	0	0	0
92	0	0	0	1	0	0
93	0	0	2,937	2,943	0	0
94	0	0	0	138	0	0
95	0	0	0	0	0	0
96	0	0	0	102,463	0	0
HUD UNTIL 97	0	0	0	0	0	0
HTA IN 97	0	0	0	29,855	0	0
98	0	0	0	0	0	0
99	0	0	0	2	0	0
<b>KG TOTAL</b>	<b>0</b>	<b>0</b>	<b>2,937</b>	<b>140,194</b>	<b>0</b>	<b>123,638</b>
<b>MTU TOTAL</b>	<b>0.00</b>	<b>0.00</b>	<b>2.94</b>	<b>140.19</b>	<b>0.00</b>	<b>123.64</b>

HUD & HTA

NU						Total
MAJOR TIER 1:		MAJOR TIER 1:	MAJOR TIER 1:	MAJOR TIER 1:		
To OAK RIDGE Gm EU FZA,FZE,FZB,FZF	Total Gm EU To External From Hanford	To PADUCAH Kg NU CKY, FYA	To FERNALD Kg NU FVA, FVB,FVC	To OAK RIDGE Kg NU FZA,FZE,FZB,FZF	Total Kg NU To External From Hanford	
						
0	2,071,199	0	0	0	0	
0	128,626,188	0	0	0	0	
0	3,081,999	0	0	0	77	
0	2,210,149	0	0	0	0	
3,276	274,769	0	0	0	0	
0	40,103	0	0	0	0	
0	246,036,417	0	0	0	0	
0	4,437,840	0	0	0	47	
0	16,597,765	0	0	0	61	
0	62,758,744	0	0	0	80,999	
0	0	0	0	0	0	
0	49,703	0	0	0	2	
0	3,349	0	0	0	0	
11,528	11,831	0	0	0	0	
<b>15</b>	<b>466,200</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>81,186</b>	
<b>0.01</b>	<b>466.20</b>	<b>0.00</b>	<b>0.00</b>	<b>0.00</b>	<b>81.19</b>	
					<b>687,580</b>	
					<b>687.58</b>	

# Appendix B:

# Table 3.3.7

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## Hanford Reactor Contractor (HXA) Uranium Shipments FY 1971-March 31, 1999

Based on NMMSS Document RL2000-I-00002 Shipments (classified)

UNITED NUCLEAR INC. (UNI)

FY	DU				EU	
	MAJOR TIER 1: To PADUCAH Kg DU	MAJOR TIER 1: To FERNALD Kg DU	MAJOR TIER 1: To OAK RIDGE Kg DU	Total Kg DU To External From Hanford	MAJOR TIER 1: To PADUCAH Gm EU	MAJOR TIER 1: To FERNALD Gm EU
	CKY, FYA	FVA, FVB,FVC	FZA,FZE,FZB,FZF		CKY, FYA	FVA, FVB,FVC
71	0	195	0	2,807	0	268,837,731
72	0	0	0	2	0	80,729,637
73	0	0	0	0	0	366,733,111
74	0	0	0	0	0	122,947,745
75	0	167	0	167	0	55,173,776
76	0	0	0	0	0	16,293,460
76T	0	0	0	0	0	1,531,320
77	0	0	0	0	0	121,614,441
78	0	0	0	0	0	92,030,675
79	0	0	0	0	0	56,744,559
80	0	0	0	17	0	56,647,925
81	0	0	0	0	0	91,358,407
82	0	0	0	0	0	77,508,844
83	0	0	0	17	0	159,046,418
84	0	0	0	45	0	236,609,566
85	0	0	0	36	0	170,342,951
86	0	0	0	1	0	158,122,879
87	0	5,075	0	5,075	0	54,070,469
AFTER FY 1987 - HXA CONTRACTOR TURNOVER TO WESTINGHOUSE						
<b>KG TOTAL</b>	<b>0</b>	<b>5,437</b>	<b>0</b>	<b>8,167</b>	<b>0</b>	<b>2,186,344</b>
<b>MTU TOTAL</b>	<b>0.00</b>	<b>5.44</b>	<b>0.00</b>	<b>8.17</b>	<b>0.00</b>	<b>2,186.34</b>

HXA

NU						Total	
MAJOR TIER 1:		MAJOR TIER 1:	MAJOR TIER 1:	MAJOR TIER 1:	Total Kg NU To External From Hanford		
To OAK RIDGE Gm EU FZA,FZE,FZB,FZF	Total Gm EU To External From Hanford	To PADUCAH Kg NU CKY, FYA	To FERNALD Kg NU FVA, FVB,FVC	To OAK RIDGE Kg NU FZA,FZE,FZB,FZF			
4,473	271,052,547	0	294,782	0	294,787		
0	80,818,881	0	32	0	35		
0	366,733,111	0	2	0	2		
0	124,128,581	0	1,079,051	0	1,079,051		
0	55,294,056	0	273	0	273		
0	16,376,285	0	9,570	0	9,576		
0	1,544,493	0	0	0	0		
0	121,673,126	0	25,132	0	25,132		
0	184,032,236	0	258	0	258		
0	56,801,590	0	4,831	0	4,831		
0	56,683,550	0	16	0	16		
0	106,767,550	0	0	0	0		
0	77,882,087	0	11	0	11		
0	159,578,973	0	0	0	0		
0	237,020,621	0	328	0	328		
0	170,618,638	0	4,760	0	4,774		
0	164,284,960	0	10,574	0	10,717		
0	54,302,961	0	1,716	0	1,716		
4	2,305,594	0	1,431,336	0	1,431,507		3,745,268
0.00	2,305.59	0.00	1,431.34	0.00	1,431.51		3,745.27

## Pacific Northwest National Laboratory (PNNL) Offsite Uranium Shipments

Based on NMMSS Document SROO-00009 SHIPMENTS (classified)

FY	TO PADUCAH	TO FERNALD	TO OAK RIDGE	DU	TO PADUCAH	TO FERNALD	TO OAK RIDGE	EU
	MT 20 Kg DU CKY,FYA	MT 20 Kg DU FVA,FVB,FVC	MT 20 Kg DU FZA,FZE,FZB,FZF	Total Kg DU PNNL External (Excludes Hanford)	MT 20 Gm EU CKY,FYA	MT 20 Gm EU FVA,FVB,FVC	MT 20 Gm EU FZA,FZE,FZB,FZF	Total Gm EU PNNL External (Excludes Hanford)
FY65 - FY 1970	0	2	0	3,029	0	5,350,361	1,108	5,612,875
71	0	7,608	1	7,761	0	3,347,630	515	3,491,460
72	0	4,490	0	5,349	0	5,689,782	172,707	7,089,438
73	0	0	0	477	0	1,700,676	760	1,705,331
74	0	0	66	1,467	0	4,040,965	1,850,671	5,998,886
75	0	0	4	2,290	0	6,852	0	1,127,615
76	0	0	0	2,246	0	1,383,773	0	1,613,160
76T	0	0	0	559	0	0	0	193
77	0	360	357	4,610	0	15,565	0	95,263
78	0	608	207	5,257	0	26,723	242	155,382
79	0	100	274	5,808	0	1,486	18,169	2,329,082
80	0	666	11	8,582	0	1,155,465	0	1,345,290
81	0	0	16	9,814	0	-951	0	103,413
82	0	210	0	16,872	0	7,784	0	115,112
83	0	114	1	4,409	0	973,544	100	1,004,581
84	0	11	4	1,761	0	0	0	57,779
85	0	0	30	1,807	0	0	0	39,407
86	0	0	0	3,389	0	0	45,472	63,501
87	0	0	0	1,535	0	0	0	17,206
88	0	0	16	16,645	0	382,173	0	385,442
89	0	0	26	15,291	0	0	0	29,659
90	0	0	0	10,544	0	0	0	49,472
91	0	0	0	16,422	0	0	0	22,540
92	0	0	0	12,531	0	0	0	5,169
93	0	0	5,570	6,164	0	0	0	6,267
94	0	0	0	12,630	0	0	0	0
95	0	0	0	2,570	0	0	0	145,118
96	0	0	0	0	0	0	0	1,743,425
97	0	0	0	0	0	0	0	95
98	0	0	0	0	0	0	0	0
99	0	0	0	0	0	0	0	6,718
<b>KG TOTAL</b>	<b>0</b>	<b>14,169</b>	<b>6,583</b>	<b>179,819</b>	<b>0</b>	<b>24,082</b>	<b>2,090</b>	<b>34,359</b>
<b>MTU TOTAL</b>	<b>0</b>	<b>14.169</b>	<b>6.583</b>	<b>179.819</b>	<b>0</b>	<b>24.081828</b>	<b>2.089744</b>	<b>34.358879</b>

TO PADUCAH MT 81 Kg NU CKY,FYA	TO FERNALD MT 81 Kg NU FVA,FVB,FVC	TO OAK RIDGE MT 81 Kg NU FZA,FZE,FZB,FZF	NU MT 81 External (Excludes Hanford)	ALL U Total Kg U External Shipments
0	4358	0	10109	18,751
0	1,467	0	1,675	12,927
0	3,918	0	6,518	18,956
0	-40	0	-7	2,175
0	10,288	0	10,296	17,762
0	3	0	20	3,438
0	160	0	936	4,795
0	0	0	10	569
0	0	0	5	4,710
0	0	0	29	5,441
0	0	0	1	8,138
0	0	0	1	9,928
0	0	0	2	9,919
0	0	0	93	17,080
0	0	0	1	5,415
0	0	0	0	1,819
0	0	0	0	1,846
0	0	0	1	3,454
0	0	0	0	1,552
0	0	0	0	17,030
0	0	0	4	15,325
0	0	0	2	10,595
0	0	0	7	16,452
0	0	0	0	12,536
0	0	0	43	6,213
0	0	0	0	12,630
0	0	0	0	2,715
0	0	0	3	1,746
0	0	0	0	0
0	0	0	0	0
0	0	0	0	7
0	20,154	0	29,749	243,927
0	20.154	0	29.749	243.93

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**Section 3 Supplemental Information**

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## **Appendix C**

### **Section 4 - Supplemental Information**

**APPENDIX C**  
**Section 4 Supplemental Information**

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**Table 4-1 Detailed Analyses of 1952 Produced UO<sub>3</sub>**

Month	Lot No.	Pu (ppb)	Beta %ANU	Gamma %ANU
Mar-52	7	<5	<5	<70
Mar-52	8	<5	<5	<100
Mar-52	9	<5	<10	<56
Mar-52	10	<5	<5	83
Mar-52	11	<1	29	105
Mar-52	12	<5	18	82
Mar-52	13	<1	18	77
Jun-52	36	<5	23	261
Jun-52	37	<5	26	262
Jun-52	38	<5	25	245
Jun-52	39	<5	23	259
Jun-52	40	<5	1	191
Jun-52	41	<5	5	203
Jun-52	42	<5	15	200
Jun-52	43	<5	4	196
Jun-52	44	<5	1	137
Jun-52	45	<5	2	150
Nov-52	197-200	3	12	46

# APPENDIX C

## Section 4 Supplemental Information

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**Table 4-2 Detailed Analysis of LEU UO<sub>3</sub>**

Month	Lot No.	Pu <sup>(1)</sup>	<sup>103</sup> Ru	<sup>106</sup> RhRu	<sup>95</sup> ZrNb	<sup>234</sup> Th(Pa)
Dec-64	E-122	1	15.80		0.360	
Jan-65	E-123	1	17.50		0.519	
Jan-65	E-124	<1	17.20		0.410	
Jan-65	E-125	3	14.80		0.300	
Feb-65	E-126	<1	20.20		0.330	
Feb-65	E-127	1	21.90		0.375	
Feb-65	E-128	4	22.80		0.420	
Feb-65	E-129	2	21.80		0.350	
Mar-65	E-130	2	17.80		0.281	
Mar-65	E-131	2	17.60		0.220	
Mar-65	E-132	1	16.10		0.294	
Mar-65	E-133	2	14.10		0.231	
Apr-65	E-134	4	14.70		0.264	
Apr-65	E-135	6	13.80		0.223	
Apr-65	E-136	6	15.80		0.320	
Apr-65	E-137	6	14.20		0.340	
May-65	E-138	8	13.50		0.394	
May-65	E-139	7	11.90		0.490	
May-65	E-140	5	12.30		0.540	
May-65	E-141	7	15.50		0.514	
May-65	E-142	8	14.00		0.446	
Jun-65	E-143	10	(2)		(2)	
Jun-65	E-144	9	12.20		0.846	
Jun-65	E-145	7	14.20		0.843	
Aug-65	E-146	4	15.80		0.540	
Aug-65	E-147	2	16.40		0.600	
Aug-65	E-148	2	16.00		0.630	
Aug-65	E-149	1	18.60		0.650	
Sep-65	E-150	1	16.90		0.590	
Sep-65	E-151	3	16.90		1.000	
Sep-65	E-152	4	13.90		0.650	
Sep-65	E-153	3	12.10		0.512	
Oct-65	E-154	2	12.00		0.421	
Nov-65	E-155	1	12.90	9.670	0.210	
Nov-65	E-156	4	1.39	7.350	0.230	
Dec-65	E-157	1	(2)	(2)	(2)	
Dec-65	E-158	1	1.60	5.590	0.560	
Dec-65	E-159	1	1.41	3.940	0.470	47.8
Dec-65	E-160	2	1.15	2.790	0.360	43.3
Jan-66	E-161	1	1.55	4.170	1.040	55.7
Jan-66	E-162	2	1.98	5.810	0.640	47.0
Jan-66	E-163	2	2.02	6.340	0.355	45.0
Jan-66	E-164	2	1.43	4.790	0.280	38.9
Jan-66	E-165	1	0.91	2.930	0.230	39.0
Feb-66	E-166	2	0.77	2.480	0.260	43.1
Feb-66	E-167	1	0.86	2.690	0.360	41.6
Feb-66	E-168	1	0.90	2.960	0.262	(2)
Feb-66	E-169	1	0.64	2.600	0.740	37.0
Mar-66	E-170	4	0.29	0.670	1.470	331.4
Mar-66	E-171	1	0.40	0.220	1.540	42.0

(1) For Pu units are parts Pu per billion parts uranium.

For all others units are microCuries per pound of uranium.

(2) Data not recorded.

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## Section 4 Supplemental Information

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**Table 4-2 Detailed Analysis of LEU UO<sub>3</sub>(Cont'd)**

Month	Lot No.	Pu <sup>(1)</sup>	<sup>103</sup> Ru	<sup>106</sup> RhRu	<sup>95</sup> ZrNb	<sup>234</sup> Th(Pa)
Mar-66	E-172	5	0.32	0.830	1.650	42.1
Mar-66	E-173	1	0.35	0.842	1.920	45.1
Mar-66	E-174	1	0.35	0.678	2.380	44.4
Mar-66	E-175	1	0.44	0.936	2.770	55.0
Mar-66	E-176	4	0.50	0.893	3.010	63.6
Mar-66	E-177	1	0.56	1.110	2.940	68.4
Apr-66	E-178	1	0.60	1.660	3.070	66.0
Apr-66	E-179	1	0.62	1.380	3.040	79.1
May-66	E-180	1	0.70	1.610	3.010	89.0
May-66	E-181	<1	0.70	1.820	0.397	67.7
May-66	E-182	1	0.92	4.020	0.346	65.7
May-66	E-183	<1	0.99	5.240	0.774	72.4
Jun-66	E-184	1	0.95	5.500	0.596	67.9
Jun-66	E-185	1	1.38	4.560	0.723	59.9
Jun-66	E-186	1	1.29	4.250	0.475	40.9
Jun-66	E-187	1	1.30	4.500	0.510	41.0
Jun-66	E-188	1	0.38	1.250	4.140	(2)
Jul-66	E-189	1	1.54	2.940	0.314	40.1
Sep-66	E-190	1	1.45	4.410	0.355	114.0
Sep-66	E-191	1	1.90	4.200	0.400	112.0
Sep-66	E-192	1	1.60	4.700	0.430	110.0
Sep-66	E-193	1	1.80	4.800	0.460	105.0
Oct-66	E-194	1	2.80	10.500	1.300	99.0
Oct-66	E-195	1	2.90	11.900	0.870	82.9
Oct-66	E-196	1	2.90	10.400	3.600	50.1
Oct-66	E-197	1	3.00	11.800	0.380	59.3
Nov-66	E-198	1	2.50	9.800	0.480	66.4
Nov-66	E-199	1	2.80	11.300	0.530	76.0
Nov-66	E-200	1	2.60	10.000	0.400	72.3
Dec-66	E-201	1	1.70	8.300	0.750	97.5
Dec-66	E-202	2	0.61	2.200	3.900	46.6
Dec-66	E-203	5	0.15	0.900	5.800	39.2
Jan-67	E-204	1	0.36	0.830	3.600	38.1
Jan-67	E-205	3	0.36	0.750	3.400	42.0
Jan-67	E-206	2	0.31	0.640	3.200	41.2
Feb-67	E-207	2	0.34	0.660	2.900	46.2
Feb-67	E-208	2	1.10	1.100	2.800	60.1
Feb-67	E-209	1	0.62	2.700	2.700	68.9
Mar-67	E-210	3	0.59	3.200	2.400	69.0
Mar-67	E-211	1	0.10	2.000	3.400	70.6
Mar-67	E-212	1	0.55	2.200	2.800	72.6
Mar-67	E-213	<1	0.54	1.800	2.900	76.3
Mar-67	E-214	<1	0.19	0.990	3.800	85.6
Mar-67	E-215	2	2.50	0.930	3.200	92.2
Apr-67	E-216	1	0.03	0.320	5.100	62.6
Apr-67	E-217	2	0.19	0.360	6.800	51.2
Apr-67	E-218	2	0.08	0.190	6.800	59.2
Apr-67	E-219	3	0.43	1.000	0.490	62.0
Apr-67	E-220	2	0.43	0.710	4.600	52.0
Aug-67	E-221	2	0.37	0.750	3.700	42.6

(1) For Pu units are parts Pu per billion parts uranium.  
 For all others units are microCuries per pound of uranium.

(2) Data not recorded.

# APPENDIX C

## Section 4 Supplemental Information

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**Table 4-2 Detailed Analysis of LEU UO<sub>3</sub> (Cont'd)**

Month	Lot No.	Pu <sup>(1)</sup>	<sup>103</sup> Ru	<sup>106</sup> RhRu	<sup>95</sup> ZrNb	<sup>234</sup> Th(Pa)
Aug-67	E-223	2		3.600	0.600	61.9
Sep-71	E1-8-1	1	0.12	0.646	0.271	65.6
Sep-71	E1-8-2	2	0.11	0.763	0.233	62.3
Sep-71	E1-8-3	2	0.11	<2.09	0.297	67.6
Sep-71	E1-8-4	2	0.12	<2.08	0.255	64.6
Sep-71	E1-8-5	<1	0.01	1.980	2.410	69.1
Sep-71	E1-8-6	1	1.67	1.190	1.590	56.8
Sep-71	E1-8-7	<1	0.02	0.044	0.214	83.7
Oct-71	E1-8-8	9	0.20	2.410	0.219	78.6
Oct-71	E1-8-9	<1	0.13	0.222	0.285	79.3
Oct-71	E1-8-10	1	0.13	0.063	0.790	71.5
Oct-71	E1-8-11	1	0.14	0.270	1.040	64.0
Oct-71	E1-8-12	<1	0.14	2.330	1.030	73.9
Oct-71	E1-9-1	1	0.17	2.650	1.490	79.3
Oct-71	E1-9-2	<1	0.18	2.710	1.710	72.4
Oct-71	E1-9-3	<1	0.17	.2.35	1.700	76.7
Oct-71	E1-9-4	<1	0.17	2.670	1.670	68.7
Oct-71	E1-9-5	<1	0.05	0.268	1.470	77.3
Nov-71	E1-9-6	<1	0.18	2.430	1.460	68.9
Nov-71	E1-9-7	1	0.18	1.250	1.520	72.4
Nov-71	E1-9-8	<1	0.03	0.657	2.540	63.9
Nov-71	E1-9-9	<1	0.04	0.189	1.590	64.3
Nov-71	E1-9-10	<1	0.00	0.619	2.170	62.8
Nov-71	E1-9-11	<1	0.06	0.262	2.220	67.0
Nov-71	E1-9-12	4	0.20	0.983	2.270	74.0
Nov-71	E1-9-13	4	0.19	0.536	2.350	63.6
Nov-71	E1-9-14	4	0.02	0.743	2.140	73.9
Nov-71	E1-9-15	4	0.19	2.620	2.110	75.7
Nov-71	E1-9-16	5	0.20	0.547	2.170	80.1
Nov-71	E1-10-1	5	0.20	0.994	2.240	70.9
Nov-71	E1-10-2	3	0.21	0.720	2.440	69.2
Nov-71	E1-10-3	3	0.22	0.182	2.820	72.6
Nov-71	E1-10-4	<1	0.22	0.920	3.250	59.0
Nov-71	E1-10-5	3	0.23	0.864	3.270	68.0
Nov-71	E1-10-6	4	0.22	1.110	2.890	67.6
Nov-71	E1-10-7	4	0.21	0.893	2.390	73.4
Nov-71	E1-10-8	4	0.20	0.953	2.220	72.7
Mar-72	E2-2-1	3	<0.179	0.592	0.956	95.2
Feb-72	E2-2-2	2	0.06	0.168	0.854	78.3
Feb-72	E2-2-3	3	0.00	0.266	0.928	76.1
Mar-72	E2-2-4	2	0.16	<2.81	0.757	127.0
Mar-72	E2-2-5	2	0.16	0.268	1.270	63.2
Mar-72	E2-2-6	2	0.17	1.090	1.590	57.8
Mar-72	E2-2-7	3	0.23	1.020	2.590	96.1
Mar-72	E2-2-8	2	0.27	1.100	2.870	105.0
Mar-72	E2-2-9	4	0.12	0.571	2.390	108.0
Mar-72	E2-2-10	4	0.08	0.270	1.380	84.6
Mar-72	E2-2-12	4	<0.182	0.498	1.380	89.2

(1) For Pu units are parts Pu per billion parts uranium.

For all others units are microCuries per pound of uranium.

(2) Data not recorded.



# APPENDIX C

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## Section 4 Supplemental Information

**Table 4-3 Detailed Analysis of Drummed UO<sub>3</sub> Product**

Plutonium Contamination and Beta-Gamma Activity of Recovered Uranium <sup>1</sup> for the Period May 1964 to October 1964																										
May-64				Jun-64				Jul-64				Aug-64				Sep-64				Oct-64						
Lot	Pu	Beta	Gamma	Lot	Pu	Beta	Gamma	Lot	Pu	Beta	Gamma	Lot	Pu	Beta	Gamma	Lot	Pu	Beta	Gamma	Lot	Pu	Beta	Gamma			
45-1	3	5	36	46-1	5	5	40	47-1	4	6	49	48-1	5	6	45	49-1	3	5	45	410-1	3	9	101			
45-2	4	5	26	46-2	4	5	41	47-2	4	6	47	48-2	4	6	47	49-2	3	5	46	410-2	4	9	106			
45-3	4	5	36	46-3	4	5	40	47-3	3	6	48	48-3	3	5	46	49-3	3	5	46	410-3	3	8	98			
45-4	3	5	39	46-4	4	5	43	47-4	3	6	48	48-4	3	5	48	49-4	3	5	52	410-4	4	7	98			
45-5	2	5	38	46-5	3	4	42	47-5	5	6	44	48-5	4	4	47	49-5	4	6	57	410-5	3	7	80			
45-6	2	5	40	46-6	7	6	69					48-6	3	5	50	49-6	4	7	77	410-6	5	8	96			
45-7	2	5	43	46-7	3	6	54					48-7	4	6	54	49-7	4	7	72	410-7	3	8	91			
45-8	3	4	42	46-8	7	4	45					48-8	4	5	52	49-8	3	7	76	410-8	2	7	89			
45-9	2	5	41	46-9	6	5	47					48-9	3	5	47	49-9	2	7	74	410-9	2	7	92			
45-10	1	4	39	46-10	8	5	48					48-10	4	5	44	49-10	3	7	75	410-10	2	6	76			
45-11	2	3	39	46-11	5	4	43					48-11	4	4	43	49-11	2	7	73	410-11	2	6	63			
45-12	2	5	41	46-12	2	5	46					48-12	3	5	48	49-12	4	8	80	410-12	1	6	70			
45-13	1	5	42	46-13	5	5	49					48-13	2	5	44	49-13	3	7	80	410-13	2	5.6	66			
45-14	4	5	42	46-14	5	3	50					48-14	2	4	39	49-14	2	7	83	410-14	3	5	61			
45-15	5	5	41	46-15	4	5.3	48					48-15	3	4	42	49-15	3	8	89	410-15	5	5	58			
				46-16	4	6	49									49-16	2	8	91							
Average	2.7	4.7	39.0		4.8	4.9	50.3			3.8	6.0	47.2			3.4	4.9	46.4			3.0	6.6	69.8		2.9	6.9	83.0

1. Units for Pu are parts Pu per billion parts of U, and for beta and gamma are percent of activity relative to natural uranium

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**Section 4 Supplemental Information**

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**Table 4-3 Detailed Analyses of Drummed UO<sub>3</sub> Product (Cont.)**

Plutonium Contamination and Beta-Gamma Activity of Recovered Uranium <sup>1</sup> for the Period November 1964 to April 1965																							
Nov-64				Dec-64				Jan-65				Feb-65				Mar-65				Apr-65			
Lot	Pu	Beta	Gamma	Lot	Pu	Beta	Gamma	Lot	Pu	Beta	Gamma	Lot	Pu	Beta	Gamma	Lot	Pu	Beta	Gamma	Lot	Pu	Beta	Gamma
411-1	1	5.1	58.13	412-1	2	9.6	116	51-1	2	9.2	99.3	52-1	2	13.2	176.4	53-1	1	11	168	54-1	1	11	152
411-2	3	5.58	64	412-2	2	9.4	117					52-2	2	12	183	53-2	1	10.7	152	54-2	2	10.9	142
411-3	4	6.6	69.9	412-3	2	9.2	115									53-3	1	10.7	148	54-3	2	9.6	131
411-4	3	7.2	73.33	412-4	2	8.7	107									53-4	1	10.8	140	54-4	2	9.4	126
411-5	5	6.4	75.9	412-5	2	9.8	114									53-5	1	10.8	149	54-5	1	9	116
411-6	3	6.7	77.6	412-6	1	10.7	132									53-6	1	10.1	148	54-6	1	10.2	132.1
411-7	3	7.9	82.4	412-7	2	10.1	129									53-7	1	10.1	141	54-7	1	10.4	122
411-8	4	7.6	88.9	412-8	2	11.2	136.15									53-8	1	11.1	153	54-8	1	9.2	117
411-9	6	8.3	97.6	412-9	2	10.9	131									53-9	3	10.5	146	54-9	1	36.5	178
411-10	3	8.7	106	412-10	2	10.8	130									53-10	1	11.3	158	54-10	1	8.7	112
411-11	3	9.2	111.6	412-11	2	10	131									53-11	2	11.3	163	54-11	2	8.9	111
411-12	3	9.9	114.9	412-12	1	11	130									53-12	1	12	143	54-12	1	9.7	116
																53-13	1	4.2	30.2	54-13	2	10.1	119
																				54-14	2	10.2	124
																				54-15	1	9.6	124
																				54-16	3	10	122
																				54-17	2	10.8	127
																				54-18	1	11	133
																				54-19	1	11	163
Average	3.4	7.4	85.0		1.8	10.1	124.0		2.0	9.2	99.3		2.0	12.6	179.7		1.2	10.4	141.5		1.5	11.4	129.8

<sup>1</sup>From Analytical Data Reports

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**Table 4-3 Detailed Analyses of Drummed UO<sub>3</sub> Product (Cont.)**

Plutonium Contamination and Beta-Gamma Activity of Recovered Uranium <sup>1</sup> for the Period May 1965 to October 1965																							
May-65				Jun-65				Jul-65				Aug-65				Sep-65				Oct-65			
Lot	Pu	Beta	Gamma	Lot	Pu	Beta	Gamma	Lot	Pu	Beta	Gamma	Lot	Pu	Beta	Gamma	Lot	Pu	Beta	Gamma	Lot	Pu	Beta	Gamma
55-1	1	10.2	127	56-1	5	10.5	123	57-1	1	8.1	78.8	58-1	1	7.4	70.5	59-1	3	5.77	63.07	510-1	2	6.08	63.1
55-2	1	11	126.1	56-2	1	10.2	122	57-2	2	10.2	90	58-2	1	8.4	73	59-2	4	6.8	79	510-2	3	4.3	42.9
55-3	1	11.8	138.7	56-3	1	10.5	118.9	57-3	2	9.2	87	58-3	2	7	66.9	59-3	3	6.9	82.8	510-3	3	2.82	27.03
55-4	1	11.7	145.5	56-4	1	10.4	118.5	57-4	2	8.1	78	58-4	1	8.3	74	59-4	2	6.34	76.74	510-4	4	2.39	24.9
55-5	1	10.3	115.9	56-5	3	11	116	57-5	2	8.1	78.2	58-5	1	9.8	125	59-5	2	5.47	67.84	510-5	3	4.05	39.39
55-6	1	12.4	155	56-6	***	9.6	103.3	57-6	2	7.4	73.7	58-6	2	12.1	157.6	59-6	2	6.75	72.12	510-6	4	4.1	48
55-7	1	13.4	156	56-7	1	7.9	86.1					58-7	2	10.1	133.94	59-7	1	6.54	79.13	510-7	3	4.93	62.9
55-8	2	13.5	162	56-8	1	8	77.7					58-8	1	8	102.9	59-8	3	6.51	80.07	510-8	3	5.6	70.62
55-9	1	13.2	150.2	56-9	1	6.82	73.8					58-9	2	7.77	96.1	59-9	1	5.46	72.34	510-9	2	6.46	77.27
55-10	1	12.4	148	56-10	1	6.9	71					58-10	2	7.2	92.7	59-10	1	5.88	65.81	510-10	1	7.13	86.41
55-11	1	12.4	145	56-11	1	6.6	69					58-11	2	7.4	9.1	59-11	1	5.71	63.83				
55-12	1	12.1	149	56-12	1	6.5	71.3									59-12	1	5.56	65.3				
55-13	1	12.2	157	56-13	1	6.46	68																
55-14	1	11	148	56-14	1	6.6	64.6																
55-15	1	12.5	166	56-15	1	6.24	63.68																
55-16	1	11.8	147.7	56-16	1	5	66.78																
55-17	1	10.6	133	56-17	1	18.6	212																
55-18	1	10.5	134																				
55-19	1	12.3	143																				
55-20	1	10.6	140																				
Average	1.1	11.8	144.4		1.3	8.7	95.6		1.8	8.5	81.0		1.5	8.5	91.1		2.0	6.1	72.3		2.8	4.8	54.3

<sup>1</sup>From Analytical Data Reports

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## Section 4 Supplemental Information

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**Table 4-3 Detailed Analyses of Drummed UO<sub>3</sub> Product (Cont.)**

Plutonium Contamination and Beta-Gamma Activity of Recovered Uranium <sup>1</sup> for the Period November 1965 to April 1966																							
Nov-65				Dec-65				Jan-66				Feb-66				Mar-66				Apr-66			
Lot	Pu	Beta	Gamma	Lot	Pu	Beta	Gamma	Lot	Pu	Beta	Gamma	Lot	Pu	Beta	Gamma	Lot	Pu	Beta	Gamma	Lot	Pu	Beta	Gamma
511-1	1	8.37	98.45	512-1	1	8.8	124	61-1	1	10.9	120.9	62-1	1	5.99	80.59	63-1	2	4.2	51.8	64-1	1	1.65	23.4
511-2	2	8.5	125	512-2	1	8.6	117	61-2	1	7.11	99.4	62-2	4	5.66	75	63-2	2	4.09	50.72	64-2	1	1.74	25.798
511-3	1	11.5	149.3	512-3	1	8.2	111	61-3	3	6.98	92.25	62-3	3	5.3	69.8	63-3	1	2.1	29.3	64-3	1	2.3	32
511-4	1	9.9	144	512-4	2	7.8	107	61-4	1	6.62	89.1	62-4	4	4.9	62.06	63-4	2	1.63	24.19	64-4	2	2.4	34
				512-5	1	8	111	61-5	3	5.89	78.35	62-5	3	4.6	55.4	63-5	1	1.61	23.86	64-5	1	2.6	39
				512-6	2	7.46	101.3	61-6	2	5.1	69.01	62-6	4	4.3	52.1	63-6	1	1.56	23.4	64-6	1	2.8	44
								61-7	3	5.14	67.36					63-7	1	1.7	24	64-7	1	3	45
								61-8	3	5.06	66.99									64-8	1	2.66	30.57
								61-9	3	5.2	69.9												
								61-10	1	5.01	67.7												
								61-11	2	5.71	76.78												
								61-12	2	5.95	80.6												
Average	1.3	9.6	129.2		1.3	8.1	111.9		2.1	6.2	81.5		3.2	5.1	65.8		1.4	2.4	32.5		1.1	2.4	34.2
Sep-66				Oct-66				Nov-66															
Lot	Pu	Beta	Gamma	Lot	Pu	Beta	Gamma	Lot	Pu	Beta	Gamma												
69-1	2	2.01	23.6	610-1	2	1.68	20.8	611-1	2	3.75	58.65												
69-2	2	0.31	3.9	610-2	3	1.56	21.49	611-2	1	3.96	60.7												
69-3	1	1.72	22.6	610-3	6	1.68	23	611-3	2	4.23	60.94												
69-4	1	1.7	24	610-4	4	1.84	25.5	611-4	3	4.09	58.4												
69-5	1	1.69	22.8	610-5	3	1.93	28.41	611-5	1	3.84	56.4												
69-6	1	1.45	19.3	610-6	2	2.2	32.01	611-6	1	4.37	69.41												
69-7	1	1.41	19.4	610-7	1	2.09	31.03	611-7	1	4.2	66.75												
69-8	2	1.59	20.5	610-8	2	2.08	30.16	611-8	2	3.61	52.12												
69-9	2	1.52	20.4	610-9	2	2.18	32.28	611-9	1	3.75	60.39												
69-10	2	1.6	21.4	610-10	2	2.42	36.68	611-10	2	2.94	43.6												
69-11	3	1.49	20.03	610-11	2	2.84	42.83	611-11	1	2.79	40.71												
				610-12	2	2.79	42.13	611-12	2	2.57	38.17												
				610-13	1	2.63	39.68	611-13	1	2.86	46.72												
				610-14	2	2.9	43.14	611-14	1	2.73	39.08												
				610-15	2	3.52	55.2	611-15	1	2.57	33.8												
Average	1.6	1.5	19.8		2.4	2.3	33.6		1.5	3.5	52.4												

<sup>1</sup>From Analytical Data Reports

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**Table 4-3 Detailed Analysis of Drummed UO<sub>3</sub> Product (Cont.)**

Jan-67						Feb-67					
Lot No.	Beta <sup>(1)</sup>	Gamma	<sup>95</sup> ZrNb	<sup>103</sup> Ru	<sup>106</sup> RuRh	Lot No.	Beta	Gamma	<sup>95</sup> ZrNb	<sup>103</sup> Ru	<sup>106</sup> RuRh
71-1	2.98	34.3	2.61	0.449	1.78	72-1	2.5	41.3	3.9	0.066	Off page
71-2	2.09	35.6	3.43	0	0	72-2	2.34	38.7	3.64	0.0789	Off page
71-3	2.31	33.4	2.73	0.403	0.604	72-3	2.18	30.7	2.51	0.358	Off page
71-4	2.53	34.6	2.83	0.381	0.888	72-4	2.25	32.8	2.75	0.336	0.558
71-5	2.37	39.7	3.77	0.0401	0.0615	72-5	2.18	31.7	2.67	0.302	0.562
71-6	2.73	38.6	2.94	0.663	0.801	72-6	2.11	30.9	2.6	0.301	0.52
71-7	2.46	36.2	3.02	0.387	0.585	72-7	2.47	38.5	3.58	0.0742	0.38
71-8	2.39	35.9	3.07	0.492	0.318	72-8	<sup>(2)</sup>	<sup>(2)</sup>	2.72	0.461	1.7
71-9	2.46	36.7	3.1	0.533	0.362	72-9			2.88	0.368	0.775
71-10	2.66	44.5	4.26	0.0157	Off page						
71-11	2.58	42	3.96	0.0608	Off page						
<b>Ave.</b>	<b>2.51</b>	<b>37.4</b>	<b>3.25</b>	<b>0.311</b>	<b>0.491</b>	<b>Ave.</b>	<b>2.29</b>	<b>34.9</b>	<b>3.03</b>	<b>0.261</b>	<b>0.499</b>
Apr-67						May-67					
Lot No.	Beta	Gamma	<sup>95</sup> ZrNb	<sup>103</sup> Ru	<sup>106</sup> RuRh	Lot No.	Beta	Gamma	<sup>95</sup> ZrNb	<sup>103</sup> Ru	<sup>106</sup> RuRh
74-1			2.97	0.307	0.528	75-1			1.250	2.790	0.737
74-2			4.09	0.053	0.082	75-2			1.230	0.354	0.756
74-3			2.37	0.027	0.055	75-3			1.340	0.371	0.813
74-4			4.80	0.088	0.125	75-4			1.340	0.338	0.738
74-5			4.64	0.297	0.566	75-5			2.260	0.327	0.001
74-6			4.95	0.357	0.461	75-6			4.270	0.092	0.242
74-7			7.04	0.052	0.120	75-7			5.410	0.000	0.000
74-8			5.01	0.330	0.095	75-8			6.770	0.129	0.165
74-9			2.72	0.254	0.506	75-9			6.250	0.284	0.386
74-10			2.32	0.245	0.468	75-10			5.660	0.298	0.423
74-11			2.42	0.222	0.603	75-11			4.910	0.382	0.783
74-12			38.76	0.005	0.116	75-12			5.580	0.353	0.618
74-13			2.91	0.097	0.138						
74-14			20.18	0.001	0.166						
74-15			1.51	0.043	0.442						
74-16			1.54	0.015	0.197						
<b>Ave.<sup>(3)</sup></b>			<b>6.764</b>	<b>0.149</b>	<b>0.292</b>	<b>Ave.</b>			<b>3.856</b>	<b>0.477</b>	<b>0.472</b>

(1) Units for beta and gamma are % of activity of aged natural uranium.

For others it is micro Curies per pound of uranium.

(2) Gross beta-gamma readings discontinued.

(3) (3) <sup>95</sup>ZrNb values appear incorrect by a factor of 10. If corrected, average is 3.45.

**APPENDIX C**  
**Section 4 Supplemental Information**

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**Table 4-3 Detailed Analysis of Drummed UO<sub>3</sub> Product (Cont.)**

Month	Lot No.	Pu (ppb)	<sup>103</sup> Ru <sup>(1)</sup>	<sup>106</sup> RuRh	<sup>95</sup> ZrNb	<sup>234</sup> Th(Pa)
May-71	D1-5-1	<1	0.000	0.211	3.46	118.0
May-71	D1-5-2	<2	0.000	0.190	4.34	98.1
May-71	D1-5-3	<1	0.000	0.117	4.40	90.8
Jun-71	D1-5-4	<1	0.000	0.154	4.32	84.3
Jun-71	D1-5-5	<1	0.000	0.187	4.91	84.4
Jun-71	D1-5-6	<5	0.000	0.770	8.16	72.5
Jun-71	D1-5-7	<6	0.000	0.893	7.90	58.4
Jun-71	D1-5-8	<2	0.000	0.954	6.43	59.4
Jun-71	D1-5-9	<2	0.000	0.934	6.60	59.8
Jun-71	D1-5-10	<7	0.000	0.793	6.85	47.6
Jun-71	D1-5-11	<6	0.000	0.754	6.20	33.4
Jun-71	D1-5-12	<7	0.000	0.247	5.93	60.0
Jun-71	D1-5-13	<9	0.000	0.317	5.82	57.6
Jul-71	D1-6-1	<3	0.000	0.634	5.86	40.4
Jul-71	D1-6-2	<sup>(2)</sup>	0.000	0.104	5.90	31.4
Jul-71	D1-6-3	<3	0.214	1.320	6.15	65.0
Jul-71	D1-6-4	<3	0.212	0.652	6.24	68.0
Jul-71	D1-6-5	<2	0.038	0.412	5.88	58.8
Jul-71	D1-6-6	<3	0.085	0.172	5.55	56.0
Jul-71	D1-6-7	<4	0.013	0.547	5.52	56.0
Aug-71	D1-6-13	<3	0.171	1.130	3.63	78.3
Aug-71	D1-6-14	<2	0.157	1.220	3.71	82.4
Aug-71	D1-6-15	<1	0.163	0.926	3.44	83.6
Aug-71	D1-7-1	<5	0.158	0.891	3.38	78.7
Aug-71	D1-7-2	<1	0.154	0.847	3.24	79.5
Aug-71	D1-7-3	<1	0.151	0.798	2.97	83.9
Aug-71	D1-7-4	<1	0.136	<0.175	2.32	86.6
Aug-71	D1-7-5	<1	0.129	<0.163	2.05	84.1
Aug-71	D1-7-6	<1	0.126	<0.179	2.05	82.9
Aug-71	D1-7-7	<1	0.130	<0.170	2.05	81.1
Aug-71	D1-7-8	<4	0.113	<1.650	1.79	73.0
Aug-71	D1-7-9	<4	0.104	<1.430	1.25	70.5
Aug-71	D1-7-10	<4	0.104	<1.480	1.30	74.9
Aug-71	D1-7-11	<1	0.103	<1.450	1.19	74.8
Sep-71	D1-7-12	6	0.110	1.220	1.49	78.0
Apr-72	D2-3-1	4	0.185	0.960	2.08	64.6
Apr-72	D2-3-2	3	0.193	1.520	2.33	59.3
Apr-72	D2-4-1 <sup>(3)</sup>	2	0.197	0.515	1.68	96.8
Jun-72	D2-4-2	2	0.200	5.340	1.67	103.0
May-72	D2-4-3	2	0.181	0.247	2.13	66.5
May-72	D2-4-4	2	0.178	0.736	1.97	61.9
May-72	D2-4-5	2	0.174	0.290	2.01	62.2
May-72	D2-4-6	2	0.174	0.871	1.90	62.2
May-72	D2-4-7	2	0.240	0.182	1.74	68.4
May-72	D2-4-8	2	0.187	6.760	2.35	80.9

(1) Units for isotopics are microCuries per pound of uranium.

(2) Data not recorded

(3) Insufficient documentation to determine whether enriched or depleted uranium in D2-4 series.

**Appendix D**  
**Section 5 Supplemental Information**

**APPENDIX D**

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**Section 5 Supplemental Information**

**Table 5.1.1 Current Inventory of Hanford In-Scope Uranium**

Fluor (HTA) Inventory as of March 31, 1999							
HANFORD LOCATION	MT	COEI	DESCRIPTION COEI	# ITEMS	Grams U Elem. Wt.	MTU Subtotals	<sup>235</sup> U%
UO3 Plant - uranium conversion	10	771	Samples and standards	1	607,000		0.275
			<i>location subtotal</i>	1	<b>607,000</b>	<b>0.607</b>	
Process control laboratory - 222S	10	771	Samples and standards	1	167		0.700
			<i>location subtotal</i>		<b>167</b>	<b>0.000</b>	
3712, Scrap in Drum Storage	10	A18	Uranium clad metal recastable after hydrofluoric and nitrate	2	303,583		0.210
			<i>location subtotal</i>		<b>303,583</b>	<b>0.304</b>	
<b>MTU Depleted U Subtotal</b>						<b>0.91</b>	
3712S Billet Storage	20	254	Unalloyed Finish Machined Items Product	129	24,021,340		1.250
			<i>location subtotal</i>		<b>24,021,340</b>	<b>24.021</b>	
UO3 Plant - uranium conversion	20	455	Other oxides product	1	4,491		0.807
UO3 Plant - uranium conversion	20	455	Other oxides product	1	8,255		0.827
UO3 Plant - uranium conversion	20	455	Other oxides product	4	13,563		0.828
UO3 Plant - uranium conversion	20	455	Other oxides product	10	46,300,099		0.842
UO3 Plant - uranium conversion	20	455	Other oxides product	42	45,853,335		0.845
UO3 Plant - uranium conversion	20	455	Other oxides product	10	45,845,907		0.850
UO3 Plant - uranium conversion	20	455	Other oxides product	10	44,900,257		0.852
UO3 Plant - uranium conversion	20	455	Other oxides product	10	46,022,949		0.858
UO3 Plant - uranium conversion	20	455	Other oxides product	10	45,856,140		0.869
UO3 Plant - uranium conversion	20	455	Other oxides product	10	46,002,479		0.870
UO3 Plant - uranium conversion	20	455	Other oxides product	10	45,846,755		0.883
UO3 Plant - uranium conversion	20	455	Other oxides product	10	43,228,833		0.892
UO3 Plant - uranium conversion	20	455	Other oxides product	10	46,066,735		0.896
UO3 Plant - uranium conversion	20	455	Other oxides product	10	44,367,244		0.910
UO3 Plant - uranium conversion	20	455	Other oxides product	2	11,249		0.914
UO3 Plant - uranium conversion	20	455	Other oxides product	10	46,012,506		0.923
UO3 Plant - uranium conversion	20	455	Other oxides product	10	45,711,419		0.928



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**Section 5 Supplemental Information**

**Table 5.1.1 Current Inventory of Hanford In-Scope Uranium**

Fluor (HTA) Inventory as of March 31, 1999							
HANFORD LOCATION	MT	COEI	DESCRIPTION COEI	# ITEMS	Grams U Elem. Wt.	MTU Subtotals	<sup>235</sup> U%
UO3 Plant - uranium conversion	20	455	Other oxides product	9	29,590,740		0.938
UO3 Plant - uranium conversion	20	455	Other oxides product	10	45,588,547		0.945
UO3 Plant - uranium conversion	20	771	Samples and standards	5	984,727		0.845
UO3 Plant - uranium conversion	20	771	Samples and standards	4	221,456		0.920
<i>location subtotal</i>					<b>668,437,686</b>	<b>668.438</b>	
303A, Fuel Assembly Rtn. from N	20	257	Canned and Clad Items Product	145	113,684,170		0.950
303B, Billet Storage	20	257	Canned and Clad Items Product	18	10,030,721		0.950
303B, Billet Storage	20	257	Canned and Clad Items Product	72	39,192,209		1.150
303G, Billet Storage	20	254	Unalloyed Finish Machined Items Product	1126	209,584,186		1.250
<i>location subtotal</i>					<b>372,491,286</b>	<b>372.491</b>	
3712, Assembly Storage	20	257	Canned and Clad Items Product	628	488,194,369		0.950
3712, Assembly Storage	20	257	Canned and Clad Items Product	6	3,588,949		0.980
3712, Assembly Storage	20	257	Canned and Clad Items Product	6	3,551,564		1.050
3712, Assembly Storage	20	257	Canned and Clad Items Product	5	2,635,634		1.080
3712, Assembly Storage	20	257	Canned and Clad Items Product	178	94,503,268		1.150
3712, Scrap in Drum Storage	20	780	Alloyed Archive &/or Retained Sample Items	4	1,106,623		0.950
3712, Scrap in Drum Storage	20	780	Alloyed Archive &/or Retained Sample Items	2	407,369		1.250
3712, Scrap in Drum Storage	20	A18	Uranium clad metal recastable after hydrofluoric and nitrate	1	13,286		0.720
3712, Scrap in Drum Storage	20	A18	Uranium clad metal recastable after hydrofluoric and nitrate	2	390,872		0.950
<i>location subtotal</i>					<b>594,391,934</b>	<b>594.392</b>	
3716, Inner/Outer Unfin. Elmt. Stg.	20	256	In Canning & Cladding Process	299	113,372,011		0.950
3716, Inner/Outer Unfin. Elmt. Stg.	20	256	In Canning & Cladding Process	55	14,634,186		1.250
<i>location subtotal</i>					<b>128,006,197</b>	<b>128.006</b>	

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**Section 5 Supplemental Information**

**Table 5.1.1 Current Inventory of Hanford In-Scope Uranium**

Fluor (HTA) Inventory as of March 31, 1999							
<b>HANFORD LOCATION</b>	<b>MT</b>	<b>COEI</b>	<b>DESCRIPTION COEI</b>	<b># ITEMS</b>	<b>Grams U Elem. Wt.</b>	<b>MTU Subtotals</b>	<b><sup>235</sup>U%</b>
<b><i>MTU Low Enriched U Subtotal</i></b>						<b>1,787.348</b>	
UO3 Plant - uranium conversion	81	771	Samples and standards	1	733	0.001	0.000
303A, Fuel Assembly Rtn. from N	81	257	Canned and Clad Items Product	10	8,425,890	8.426	0.000
303B, Billet Storage	81	257	Canned and Clad Items Product	6	2,903,375	2.903	0.000
3712, Assembly Storage	81	257	Canned and Clad Items Product	67	53,871,446		0.000
3712, Scrap in Drum Storage	81	780	Alloyed Archive &/or Retained Sample Items	3	440,526		0.000
3712, Scrap in Drum Storage	81	A18	Uranium clad metal recastable after hydrofluoric and nitrate	1	13,082		0.000
3716, Inner/Outer Unfin. Elmt. Stg.	81	256	In Canning & Cladding Process	24	8,672,340		0.000
<i>location subtotal</i>					<b>62,997,394</b>	<b>62.997</b>	
<b><i>MTU Normal U Subtotal</i></b>						<b>74.3</b>	
<b><i>Hanford In-Scope MTU Total - All U Types</i></b>						<b>1,862.6</b>	
<b><i>Hanford Out-of-Scope MTU Total - All U Types</i></b>						<b>2,137.4</b>	
<b>Hanford March 30, 1999 Total U Inv. - All Types</b>						<b>3999.986</b>	

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**Section 5 Supplemental Information****Table 5.1.2 Pacific Northwest National Laboratory (PNNL)  
Recycled Uranium Inventory as of March 31, 1999**

<b>Uranium Type</b>	<b># of Items</b>	<b>Isotopic Weight</b>	<b>U Elem. Weight</b>	<b>Units</b>
<b>Depleted Uranium</b>	18	10	4,940	Kilograms
<b>Normal Uranium</b>	18	Not Applicable	50	Kilograms
<b>Enriched Uranium</b>	194	48	1,446	Kilograms
<b>PNNL Total</b>	<b>230</b>	<b>58</b>	<b>6,436</b>	<b>Kilograms</b>

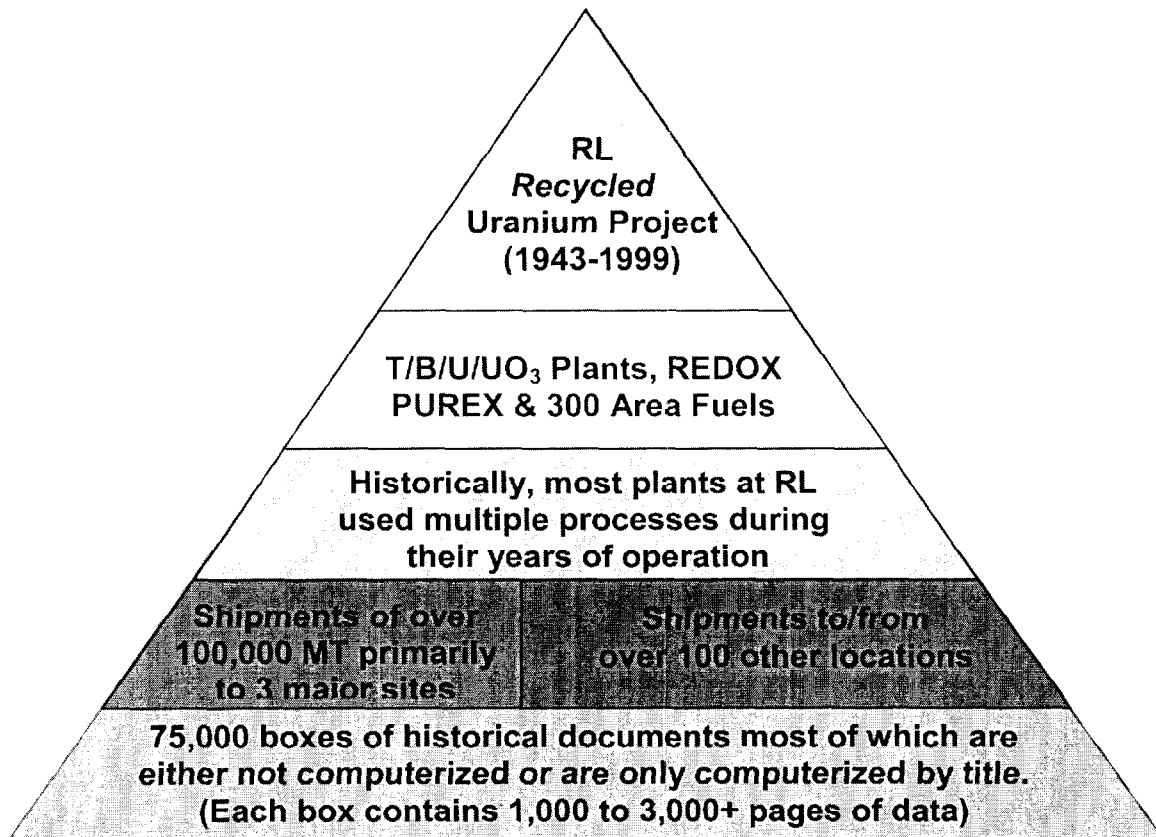
**Appendix E**

**Description of Research Strategies  
Used in Study**

**Description of Research Strategies Used in Study**

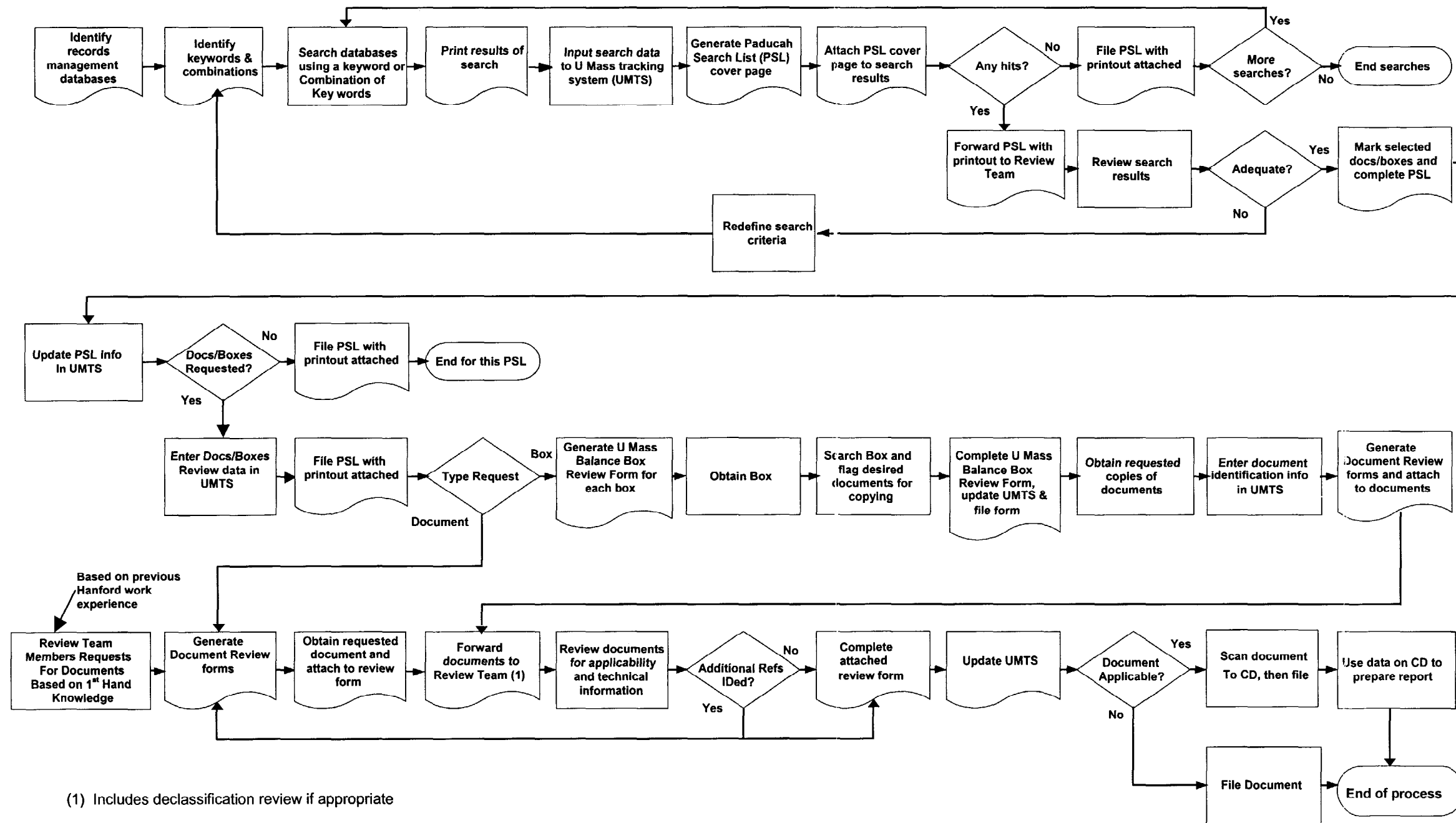
**E.0 Uranium Mass Balance Project Document Retrieval And Review Process**

Due to the time available, complexity and range of information to be researched at Hanford (see Figure E-1), the Uranium Mass Balance Project Team decided to use existing processes and computer software where ever practical. This appendix describes adaptation and use of those resources for this project. A flowchart of the overall retrieval and document review process is provided in Figure E-2.



**Figure E-1 Complexity and Range of Information to be Researched at Hanford**

**APPENDIX E**      DOE/RL-2000-43  
**Description of Research Strategies Used in Study**



**Figure E-2 Uranium Mass Balance Project Document Identification/Review Process**

## Description of Research Strategies Used in Study

### E.1 Databases Used

The Technical Review Team members were selected based on their previous experience at Hanford, in most cases including experience directly related to one or more of the facilities involved in the uranium recovery program. Once the team was assembled, the members, based on their past experience, identified the types of records that would be needed to respond to the four specific points in the Deputy Secretary of Energy's letter of direction dated September 15, 1999 [Glauthier, 1999]. Several existing databases were identified that catalogued various types of documentation that might be applicable to this project were searched. These were:

- *Human Radiation Experiments Information Management System (HREX)* – This publicly accessible database was created in 1994 and contains approximately 392,000 pages of historical documents related to radiation experiments on human subjects performed by or for the Departments of Defense, Energy, Health and Human Services, and Veterans Affairs, as well as the Nuclear Regulatory Commission, the National Aeronautical and Space Administration, the Central Intelligence Agency, and their predecessor organizations.
- *OpenNet* – This database includes references to Department of Energy (DOE) documents that were declassified and made publicly available after October 1, 1994, in compliance with former Secretary Hazel O'Leary's Openness Initiative. It presently contains approximately 400,000 documents; however, the declassification process is still in progress.
- *Records Holding Task Group* – This collection of approximately 102,000 classified documents is held in the records holding area of the DOE's Oak Ridge Operations Office. In the summer of 1998, the Hanford "Downwinders" Litigation staff reviewed the entire collection and indexed all Hanford-related documents, which resulted in a listing of approximately 14,000 Hanford related documents. This Hanford-related listing was searched as part of the U-Mass study.
- *Hanford Site Historian Database* – This database contains documents gathered by the Site Historian in generating several publicly available publications related to various aspects of the Hanford site history.
- *Document Declassification Tracking System (DDTS)* – This is a site database created in 1995 with approximately 61,000 classified and formerly classified Hanford documents.
- *Record Holding Area Management Information System (RHA-MIS)* – This database was developed in the mid-1970s as the Hanford Site master database for managing RL and its contractors' archived boxes of records in storage. The system currently tracks the location and general content of approximately 75,000 boxes of records

# APPENDIX E

## Description of Research Strategies Used in Study

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from the field to various storage locations, including the Federal Records Center in Seattle, WA.

- *Document Tracking Application (DTA)* – Created in the mid-1970s, this system contains approximately 41,000 classified documents.
- *Master* – This system was created in the mid-1970s and contains approximately 750,000 engineering documents related to the Fast Flux Test Facility. Other contractor documents were added to the system between 1982 and 1993, when this system was replaced with the Records Management Information System (RMIS).
- *Records Management Information System* – This system was created in 1993 and consists of 14 different subsystems with over 1,700,000 documents. The system was not retrofitted to capture documents issued prior to its startup; however, some older documents have been added to the system from time-to-time in special cases. Only the following subsystems were of interest to the Project:
  - *Records* – This subsystem contains over 640,000 documents, including ALARA records, correspondence, declassified documents, engineering drawings, legacy/historical information, media highlights, management system documents, radiological survey records, technical documents, publications, and work packages.
  - *Tank Farms Information Center (TFIC)* – This subsystem contains primarily older Westinghouse Hanford Company and Rockwell Hanford Company documents related to the tank farms.
  - *Solid Waste* – This subsystem contains hazardous waste manifests.
  - *RL* – This subsystem contains RL correspondence.
  - *Administrative Record (AR)* – This subsystem contains documents relied on or considered in order to arrive at a final decision for remedial action for hazardous waste management.

Although, three additional RMIS subsystems were identified and searched, later analyses verified these files could have been eliminated because the information they contained was not germane to the Project.

### E.2 Database Keyword Searches

The Technical Review Team identified keywords or combinations of keywords that related to the facilities, materials, and types of documents that would be used in the database searches in an attempt to identify documents relevant to the Team's



**Description of Research Strategies Used in Study**

evaluation. Table E-1 shows the primary keywords that were used, normally in combination, in the searches. The team also identified variations in the way in which the keywords might appear in the titles or documents identified in the databases. Combining the keywords into meaningful logical expressions resulted in identifying several hundred queries/combinations of queries to be run on each of the various databases.

Each specific query was assigned a unique identification number (Paducah Search List or PSL number) and was logged into a Project database along with:

- Keywords and logic used in the search
- Name of the database searched
- Date of the search
- Name of the researcher
- Number of documents matching the search criteria (or "hits")
- Date the search results were provided to the Technical Review Team

The above information was reflected on a database generated cover sheet that was then attached to the search results printout. The printout identified the documents or boxes of records that satisfied the search criteria. The cover sheet and printout were then delivered to the Technical Review Team for review.

If the number of hits on a particular query exceeded 200, only the first two pages of the results were printed and provided for review. The problem of a high number of hits was generally caused by one of two things:

- 1) The search criterion was too general.
- 2) In some databases documents have been scanned and digitized and full text searches using optical character recognition (OCR) software is available; however both the lack of quality of the original documents and the numerous different fonts used in them caused the OCR software to register many false hits.

In those cases, a Technical Review Team member would evaluate the first two pages of hits and determine whether to ask for the rest of the results or to narrow the search criteria and have the search performed again.

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## Description of Research Strategies Used in Study

**Table E-1 Keywords Used in Searching Databases**

Type	Primary Keyword	Variations of Keyword
Hanford Facilities	T-PLANT	T PLANT, 221-T, 221 T, 221T
	B-PLANT	B PLANT, 221-B, 221 B, 221B
	U-PLANT	TBP PLANT, TBP-PLANT, 221-U, 221 U, 221U
	REDOX	S-PLANT, S PLANT, 202S, 202-S, 202 S
	PUREX	A-PLANT, A PLANT, 202A, 202-A, 202 A
	UO <sub>3</sub> PLANT	UO3-PLANT, UO3 PLANT, UO3-PLANT, UD3 PLANT, UD3-PLANT, 224-U, 224 U, 224U, 224-UA, 224 UA, 224UA
	FUEL FABRICATION	307, 308, 313, 333
Materials	URANIUM	U3O8, U308, DEPLETED URANIUM, DU, D.U., D. U., ENRICHED URANIUM, EU, E.U., E. U., URANIUM SCRAP, URANIUM WASTE; URANIUM TRIOXIDE, UO <sub>3</sub> , UO3, UD3
	NEPTUNIUM	NP-237, NP237, NP 237
	URANYL NITRATE HEXAHYDRATE	UNH, U.N.H., U. N. H.
Activities/ Documents	MAT* BALANCE	
	SEP* FACTOR	
	FLOW SHEET	FLOW-SHEET, FLOWSHEET
	DECON* FACTOR	
	SPEC*	PRODUCT, UO <sub>3</sub> , UO3, UD3, URANIUM, ENRICHED URANIUM, URANIUM SCRAP
	ANALYTICAL REPORT	
	SHIP*	
	RECEI*	
	REPORT	WEEKLY, MONTHLY, QUARTERLY, SEMI
Other Facilities & Sites	K-25	K25, K 25
	Y-12	Y12, Y 12
	FERNALD	NATL LEAD OF OHIO, NATIONAL LEAD, NAT'L LEAD, NATL LEAD, NLO, N.L.O., N. L. O.
	RMI	R.M.I., R. M. I.
	GASEOUS DIFFUSION	
	UNION CARBIDE	
	PORTSMOUTH	
	PADUCAH	

\* Indicates use of a wildcard

### E.3 Technical Review of Keyword Search Results

Upon receipt of the Key Word search results, one or more Technical Review Team members reviewed the computer printout associated with each PSL and, based on the

**Description of Research Strategies Used in Study**

titles of the documents listed, determined whether copies of any of the documents should be obtained for Team review. Where appropriate, document titles were flagged to indicate that they were being requested for review. In the case of the RHA-MIS database, the computer printouts provided box numbers, storage locations, and a general description of the types of documents in each box. Again, one or more Review Team members reviewed the list of boxes and flagged those that might contain records related to the Project. The reviewer(s) completed the PSL cover sheet to include the reviewer's name, date of review, whether any documents or boxes were selected and, if so, the number of documents or boxes selected, along with any comments the reviewer wished to make.

**E.4 Obtaining Documents and Boxes of Records**

After review by the Technical Review Team the PSL cover sheet and its associated list were used to update the Project database with the information provided from the reviewers. For each document requested by the Technical Review Team, the following information was entered into the Project database:

- A unique document tracking number (for the request)
- The unique PSL number that resulted in the request
- Document identification number (if any)
- Document revision
- Document alias number(s) (if any)
- Document date
- Document Title
- Document source
- Box number
- File folder title (if any)
- Name of requestor

The requested document was then either printed out the document (if it was available online) or a copy was ordered from the appropriate source. When the document became available, the database generated a Document Review/Production Order containing the above information as well as the date the document was delivered to the requestor and the number of pages in the document. In those cases where the requests were for entire boxes of records, arrangements were made to retrieve the boxes from offsite storage if necessary and made available for review in the RL Records Holding Area (RL-RHA). Once the boxes were available in the RL-RHA, the Technical Review Team members who had requested them were notified via Box Review Tracking forms which identified the box number, the box owner, security classification of the box content, and whether the box had been completely scanned. The form also provided the box tracking history.

**Description of Research Strategies Used in Study****E.5 Additional Document Searches**

Because of their previous work experience at Hanford, many of the Technical Review Team members were aware of the existence and location of specific documents that would be relevant to the Team's efforts. In such cases the Team member would obtain a copy of a document. A Document Review/Production Order form was initiated for each document obtained in this manner and it was entered into and tracked in the Project database.

**E.6 Technical Review of Documents**

One or more members of the Technical Review Team reviewed each document requested to determine whether it contained information relevant to the Team's efforts. If a document contained no relevant information, the reviewer marked the Document Review/Production Order form to indicate that the document was not relevant and then signed and dated the form and returned both to to be used to update the Project database. If a document did contain relevant information, the reviewer also indicated the security classification status, and whether declassification in whole or part was needed. The reviewer also marked the form to identify keywords to be associated with the document in the Project database to assist in future searches by the Project Team or others.

In the case of boxes of records, a Review Team member (normally, the requestor, but not always) examined the contents of a box and flagged any relevant documents for copying. The RL-RHA staff made copies upon request and a Document Review/Production Order was initiated for each document copied. The information was then entered into the previously described Project database.

**E.7 Project Records**

The Project records for this project include:

- Documentation (completed Paducah Search List or PSL) for each query run on each database and the marked up computer printouts indicating the documents requested.
- A completed Document Review/Production Order for each of the documents requested showing the results of the Teams review.
- A completed Box Review Tracking form for each box requested showing the results of the box review.

**Description of Research Strategies Used in Study**

- A computer database that cross-links the queries to the PSLs, the PSLs to the document requests, and the keywords assigned to a document by the Technical Review Team.

In preparing its report, the Technical Review Team cited references to the sources of information used in the report. Copies of the source documents will be retained by RL until it is determined they are no longer needed. It is the Project's intent to scan these documents onto CD-ROMs and catalog them in a database to minimize future search and duplicating time and expense.

**E.8 References**

Glauthier 1999

Memorandum, T. J. Glauthier, Deputy Secretary of Energy, to All Departmental Elements, *Paducah Gaseous Diffusion Plant – Follow-Up Activities*, U.S. Department of Energy, Washington, DC, September 15, 1999

**Appendix F**

**Supplemental Information on Hanford  
Fuel Fabrication**

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## Supplemental Information on Hanford Fuel Fabrication

### F.1 Single Pass Reactor Fuel Fabrication

#### F.1.1 Fuel Canning

The original fuel canning process implemented at Hanford involved the use of an electric heater press, known by workers as the "whiz-bang," to heat and bond the uranium fuel cores to their aluminum jackets. However, the heaters burned out frequently, did not heat the elements and cans to consistent temperatures, and did not produce a uniform bonding. This problem was serious because non-uniform bonding caused thin places in the jacketing which were subject to localized heating during irradiation. These "hot spots" could cause fuel element ruptures in the reactors. By August 1944, the uranium fuel cores were being jacketed in a triple-dip method that consisted of bathing them in molten bronze, tin, and then a molten aluminum-silicon mixture. The bronze used in this process at Hanford was relatively high in tin content (53% tin and 47% copper), and the bronze bath itself had a flux cover composed of barium chloride, potassium chloride, and sodium chloride. As fuel cores were dipped into this mixture, they acquired trace coverings of all of these substances.

Initially, the bare uranium cores were cleaned by passing them through a trichloroethylene vapor degreaser. They were then passed through a nitric acid pickling tank, two rinse tanks, and a hot air dryer. Meanwhile, a steel "sleeve" that would surround each can during the dipping process was cleaned in sodium hydroxide; and aluminum end caps and cans were cleaned in a sodium dichromate solution followed by a methanol rinse. The bare uranium cores were dipped in a bronze bath to heat them to a uniform temperature within the uranium beta phase (660 °C to 770 °C). Then they were placed in a tin bath to: (1) cool them into the uranium alpha phase (less than 660 °C) and (2) to remove any excess bronze. Next they were centrifuged to throw off excess tin. Then the cores were immersed quickly in an aluminum-silicon brazing bath while in the uranium alpha phase, and water quenched. The various heating and cooling procedures were done to randomize the uranium grains, thus inhibiting the uranium "growth" (expansion under irradiation) problem. After water quenching, the steel sleeve was pulled away and cleaned with sodium hydroxide and soap to remove any remaining aluminum-silicon. The sleeve then could be reused many times. The thickness of the residual end cap on the element was then measured with a fluoroscope and marked with a punch to indicate the amount that needed to be removed in subsequent end machining. Identification numbers were stamped on the can base end, and the braze line on the end cap was tungsten inert gas welded to seal the porous braze to the end cap and can. A final etching in nitric acid completed the procedures.

Three tests followed the canning process. The first, was the frost test, which consisted of spraying the can with acenaphthene mixed with carbon tetrachloride ( $\text{CCl}_4$ ). The canned element was then placed into an induction coil to heat its surface. If there was a gas bubble or a non-bonded spot, this spot would become shiny, and the element then would be rejected and sent back through a recycling process. If the bond was good, the acenaphthene was removed with trichloroethylene, and the element was heated in one



## Supplemental Information on Hanford Fuel Fabrication

of several autoclaves located in the 314 Building. In that step, the canned element was placed into a steam autoclave, which operated at about 100 pounds per square inch gauge (psig) and 175 °C for more than 20 hours, to reveal any pinholes or incomplete welds. Water from the steam would be conducted through any such openings, and the uranium core would expand rapidly, resulting from the formation of a uranium oxide compound known as  $U_3O_8$ , and split the aluminum can. If an element passed the autoclave test it then underwent a final radiograph (X-ray) test in the 314 Building, to detect porosity in the end weld bead. Any porosity could have become a pathway for water to contact the uranium fuel and cause the element to rupture during irradiation.

### F.1.2 Single Pass Fuel Fabrication Changes

In 1948, the extrusion press in the 314 Building was exceeded, and Hanford began receiving rolled uranium rods from an offsite commercial mill. The rolling process seemed to offer metallurgical advantages, because the uranium could be processed at lower temperatures, which induced less oxidization and produced smaller and more random grains within the metal. From 1950 to 1951, a rolling mill was procured and installed in the 314 Building, to save the costs of shipment to offsite mills. However, this mill was relatively small, and the rolling operation was transferred to a large facility constructed at the Feed Materials Production Center (FMPC), an Atomic Energy Commission (AEC) site in Fernald, Ohio, in 1952. Thereafter, no extruding or rolling operations were conducted at Hanford in connection with the fabrication of fuel elements for single-pass reactors. The 314 Building process continued to operate for the purposes of straightening uranium rods, providing autoclave and radiograph testing of canned elements, and providing uranium scrap processing operations.

In 1954, the 313 Building underwent a major remodeling and expansion, reaching a total size of 182.5 feet by 486 feet, with a total area of 76,633 square feet. At that time, much contaminated equipment and other solid wastes from this building and its immediate surrounding area and from the 303 fresh fuel warehouses were buried. The remodeling occurred at the time that fuel canning technology in the 313 Building switched from the triple-dip process to the new lead-dip process. Lead-dip consisted of immersing the uranium fuel cores in a duplex bath (molten lead covered with molten aluminum-silicon) to preheat the cores in the uranium alpha phase. This step formed an intermetallic compound of uranium and lead ( $UPb$  or  $UPb_3$ ) on the core. It was followed by a molten aluminum-silicon bath (also in the uranium alpha phase) to braze and bond the cores to the aluminum cans and caps. This process allowed the first canning bath to occur at a lower temperature (lower than 660 °C) because the uranium cores already had been beta heat treated in a molten salt bath at the FMPC. However, the new method introduced a great deal more lead and other heavy metals into 313 Building waste streams. At about the same time that the lead-dip process replaced the triple-dip method, an ultrasonic test replaced the frost test, which eliminated the use of acenaphthene and  $CCl_4$ . Concurrently, the majority of testing autoclaves were removed from the 314 Building and placed in the north end of the 313 Building.

## Supplemental Information on Hanford Fuel Fabrication

In the early 1960's, just before the eight single-pass reactors at Hanford began to close, experiments were under way in the 304, 3716, and 313 Buildings with a new canning procedure known as the Hot Die Size Process. Also termed the "nickel-plate" procedure, this operation plated uranium fuel cores with nickel, using nickel sulfate, nickel chloride, and boric acid. It included standard fuel fabrication cleaning, degreasing, etching, and testing chemicals and processes. Although the Hot Die Size method was tested successfully, it was not implemented on a large scale because of the impending closures of Hanford's eight original reactors.

### F.2 N-Reactor Fuel Fabrication Processing

Fuel element preparation activities for the single-pass reactors ended in the 313 and 314 Buildings in 1971, when the last of these reactors closed. The 314 Building was modified in the 1970's and was used for a variety of research projects and crafts services. The majority of the fabrication equipment for single-pass reactor fuel elements was removed from the 313 Building between the mid-1970's and the mid-1980's. However, the south end of the 313 Building continued to house major functions in support of N-Reactor fuel production. Among these functions were: (1) the receiving and inspection of uranium billets and other components used to make N Reactor fuel elements, (2) the chemical passivation of spacers from N-Reactor, (3) the casting and machining of copper-silicon pre-shape components used in N-Reactor fuel elements (beginning in 1973), and, (4) the neutralization and handling of non-uranium-bearing acid wastes from N-Reactor fuel fabrication processes in the 333 Building. Finished N-Reactor fuels and fabrication components, tools, and miscellaneous supplies were stored in the north end of the 313 Building from 1971 to 1987, and an Engineering Development Laboratory, including facilities for working with uranium, was established in this structure in the 1970's.

#### F.2.1 N-Reactor Fuel Fabrication

The fuel-making process for the New Production Reactor (N-Reactor) was very different from that used to make fuel for single-pass reactors. Soon after funding was secured for N-Reactor in 1958, a high-pressure heat transfer apparatus was emplaced in the 189/190-D Building, a converted World War II pumphouse in the Site's 100-D Area. Its purpose was to test a new, N-Reactor fuel concept being developed in the 306 Metallurgical Pilot Plant, a 300 Area building dedicated to fuel manufacturing experimentation. The concept first tried for N-Reactor fuel was a wire-wrapped, seven-element cluster of long, thin fuel rods spaced together in a horizontal flow tube. Each individual element was only 0.625 to 0.704 inches in diameter, and was 35 to 45 inches long. However, attention soon turned to yet another new concept developed in the 306 Building. This idea, of a co-extruded tube-in-tube fuel element design, eventually was adopted for N-Reactor.

**Supplemental Information on Hanford Fuel Fabrication****F.2.2 Co-Extrusion Process**

The co-extrusion process began with inspection and cleaning of copper and copper-silicon pre-shapes and backing plates used in the process. The cleansing agents were nitric acid, nitric hydrofluoric, and chromic nitric sulfuric acid. Next, cladding components made from Zircaloy-2<sup>TM</sup> were degreased, rinsed in nitric and hydrofluoric acid, and dried with forced-air heating. In the meantime, uranium billets were degreased with perchloroethylene, etched with nitric acid, rinsed, dried and inspected. Next, the copper, copper-silicon, Zircaloy-2<sup>TM</sup>, and uranium components were assembled and welded into a billet assembly. This assembly was evacuated of air, leak tested, sealed preheated, and then co-extruded (squeezed together) in the Loewry Press. As the process specifications for this step emphasized: "The quality of the extruded tube is dependent upon many things, not the least of which is skill, care, effort, and precision that are put into the co-extrusion operation."

The process of cleaning, degreasing, etching and drying components, then assembling and pressing them, was repeated for both the outer (larger) and inner (smaller) tubes that made up the tube-in-tube configuration. The extruded tubes then exited the press to a roll-out table where they were rolled continuously for at least six minutes to prevent tube deformation and non-uniform cooling. Next they were sectioned to the specified length, and the ends were machined to create fuel sections or elements. Nitric acid was used to remove copper silicon residues, and nitric sulfuric acid was used to chemically mill (i.e., dissolve away) excess uranium on fuel element ends. Elements then were etched with nitric hydrofluoric and nitric acid, and brazed with an etched braze ring material consisting of Zircaloy-2<sup>TM</sup> alloyed with about five percent beryllium. (This braze material previously had been degreased and etched.) The brazed elements were heat-treated in a molten salt bath to randomize the uranium grain structure to prevent preferential grain growth that could rupture the elements in the reactor.

The next step in the process was to weld projections or supports onto the fuel elements. Eight lengthwise protrusions were attached to the outer surface of each fuel element, evenly spaced around its diameter. This configuration allowed cooling water to circulate optimally around the elements, without creating hot spots where the sides of elements rested too close to the inner walls of the process tubes. After projections were welded onto the elements, the two tubes (inner and outer) had to be attached together. Support hardware was attached to the outer surface of the inner tube, and locking hardware was affixed to the inner surface of the outer tube. The two tubes were then given a final nitric hydrofluoric acid etch, separately tested in autoclaves, inspected, assembled and interlocked, and stored as finished fuel. The co-extrusion process was carried out continuously in the 333 Building from 1960 until December 1986, reaching a peak volume of approximately 250 finished fuel elements per week in the mid-1980s.

Worker exposure to uranium was controlled. Machining and other fines-producing fabrication activities were conducted within ventilated enclosures. Air exhausted from these enclosures was filtered. Uranium scrap recovery activities such as burning in a controlled atmosphere incinerator, while providing a higher potential for worker uranium

## Supplemental Information on Hanford Fuel Fabrication

uptake, were limited in scope. Additionally, due to transportation issues with untreated scrap, much of the scrap was processed to a recoverable wet sodium diuranate cake before shipment offsite. Some low concentration liquid wastes were discharged to ponds and cribs for disposal. Dry wastes were packaged and sent to the Hanford waste burial sites for disposal.

### F.3 Material Sources

A number of private contractors were involved with the early fuel fabrication operations. B&T Metals of Columbus, Ohio, extruded a large quantity of uranium metal rods for Hanford from April through August 1943. Copperweld Steel Company of Warren, Ohio out-gassed and straightened a large quantity of uranium rods for the reactors between May and August 1943. Revere Copper & Brass also out-gassed and straightened rods in Detroit. Hanford began out-gassing and straightening its own uranium fuel rods in September, 1944. Baker Brothers of Toledo, Ohio, manufactured unbonded uranium slugs for Hanford from early 1944 through July, 1944. The William E. Pratt Manufacturing Company turned and ground unbonded slugs in the spring of 1944. Between May and August of 1944, McKinney Tool and Manufacturing in Cleveland, Ohio turned and ground unbonded slugs. During the late 1940s and early 1950s, uranium rods were rolled or extruded by Vulcan Crucible Steel Company in Aliquippa, PA, Revere Copper and Brass, and the Brush Beryllium Company in Detroit, Joslyn Manufacturing & Supply Company in Fort Wayne, Indiana, Allegheny-Ludlum Steel Corporation in Waterville, New York, and Simonds Saw & Steel Co. of Lockport, NY.

Hanford stopped extruding uranium rods in 1948, switching to rolled rods on site. The AEC shifted the rolling work to the Fernald, Ohio Feed Materials Production Center and its supporting contractors in 1952.

Uranium slug machining was taken over by FMPC at Fernald Ohio, which opened in 1952, and the Weldon Spring plant which opened in 1956. FMPC and Weldon Spring produced ingots of natural, low enriched and depleted uranium to be extruded offsite into tubes and billets for further machining into uranium cores. The cores were then shipped to Hanford for cladding and assembly. The ingots were extruded into tubular billets by Bridgeport Brass Company in Adrian, MI from 1954 to 1961 and later by its corporate successor, Reactive Metals, Inc., in Ashtabula, Ohio. Fernald then shipped the billets to Hanford.

**Supplemental Information on Hanford Fuel Fabrication**

F.4 References (This entire Appendix is supported by one or more of the following general references.)

DOE/EM-0319 1997

DOE/EM-0319, *Linking Legacies*, January 1997

Gerber 1992

WHC-MR-0388, M. S. Gerber, *Past Practices Technical Characterization Study, 300 Area*, December 1992

Gerber 1996

WHC-MR-0521, Rev 0, M. S. Gerber, *The Plutonium Production Story at the Hanford Site, Process and Facilities History*, June 1996

**Appendix G**

**Supplemental Information  
on the UO<sub>3</sub> Plant**

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# APPENDIX G

## Supplemental Information On The UO<sub>3</sub> Plant

DOE/RL-2000-43

### G.1 Operating History Uranium Trioxide (UO<sub>3</sub>) Plant [Gerber 1993]

The original Uranium Trioxide (UO<sub>3</sub>) Plant was located in a World War II facility known as the 224-U Bulk Reduction Building. This three-story, frame and concrete block structure had just under 12,000 square feet, and had been constructed to house a part of the plutonium separation and concentration process used at Hanford in the 1940s. However, process improvements as early as 1945 demonstrated that the 224-U Building was not needed. Rather than contaminate it with plutonium, Hanford management decided to utilize the building as a training facility until another use was found. The 224-U Building was modified in 1951 to accomplish conversion of Uranyl Nitrate Hexahydrate (UNH) to UO<sub>3</sub>. This facility subsequently became known as the UO<sub>3</sub> Plant.

The facility began test runs in January 1952, and full operations the following month. The first UO<sub>3</sub> calciners simply were large pots that heated the UNH in batches. An early difficulty concerned the UNH feed from REDOX, which contained impurities sufficient that much of Hanford's UO<sub>3</sub> product "proved to be inadequate for successful processing in the continuous UF<sub>6</sub> conversion process at Oak Ridge." Process improvements in the REDOX Plant were made during 1952-1953, to correct this situation. The first feed supplies of UNH received from the U-Plant in 1953 also proved to be problematic. Metallic impurities, as well as the nitric acid content and the presence of Tri-butyl Phosphate (TBP) and its decomposition products required that the UO<sub>3</sub> produced from initial U-Plant product UNH had to be sent to an intermediate metallurgy facility in Cleveland, Ohio further purification before shipment to Oak Ridge. Additionally, the U-Plant UNH foamed, caked and stuck in the pots during the calcining process, so that the UO<sub>3</sub> would have to be vacuumed and even chopped out. This condition was undesirable from the standpoints of efficiency, operator safety, and contamination control. However, changes made in the U-Plant rendered the UNH so pure that the UO<sub>3</sub> Plant product, by the end of 1953, did not have to be sent offsite for further purification, and was suitable to be shipped and used directly at Oak Ridge. That year, the UO<sub>3</sub> Plant processed more than 1.5 times the total fuel inventory of uranium that was received at Hanford.

During 1954, UO<sub>3</sub> Plant capacity increased to 18 tons per day with the addition of two gas-fired calciners. The unit cost per ton also dropped to 79 percent that of 1953. Overall production in 1954 was limited, however, by the quantity of feed available from the REDOX and U plants. REDOX experienced many shutdowns caused by equipment failures that year, and the U-Plant was closed for much of the autumn to allow for system modifications that would allow it to process wastes aged only one year (instead of usual three years). Several problems were encountered and overcome during 1954, including high radiation fields around the calciner pots caused by the processing of newer UNH (higher in zirconium, niobium, and ruthenium) from the two Hanford feed plants. This problem was solved by the addition of special shielding to protect operators during pot unloading. Also, sulfamic acid added to the UNH prior to calcination caused some caking in the calciner pots, and renewed foaming occurred due to the presence of organic decomposition products in the UNH. Silicon anti-foaming agents, as well as



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other sulfur-based additives were used to control these situations. A key improvement that year was the use of vacuum cleaning techniques that enabled the plant to recover 90-95 percent of the oxide powder associated with failed filter bags. A large backlog of such bags that had accumulated since startup, were cleaned and discarded. By year's end, plans were underway to expand the UO<sub>3</sub> Plant.

During 1955, monthly UO<sub>3</sub> production averaged 106 percent that of 1954, while the unit costs per metric ton dropped to 92 percent of that for the previous year. The plant had to shut down for portions of the summer due to contamination problems resulting from high gamma feed from the U-Plant. More persistent problems resulted from the gradual corrosion and mechanical wear of equipment and calciner seals and gaskets to the point where a vacuum could not be maintained in the pots. Airborne contamination around the pots increased until operators had to wear masks for respiratory protection. In 1956, equipment modifications, including new pot agitators, shafts, seals, bearings and supports, as well as new pot cover assemblies, off-gas systems and gasketing, were installed to address these problems.

In the meantime, plans went forward to construct the 224-UA Building, a major addition to the UO<sub>3</sub> Plant. The plant was equipped with six large, new, continuous action calciners. These calciners were developed and designed at Hanford, and had large troughs with paddle agitators that essentially turned and mixed the UNH/UO<sub>3</sub> bed throughout the process. The caking and clogging problems that had plagued the pots was obviated by the below-grade valving of the continuous calciners. The new valves used air as an agitator, and maintained a seal between the calciner and the powder pickup bin, while passing a continuous stream of UO<sub>3</sub>. The new calciners also produced a pebbly product that consisted of spheres with an average diameter of 200 microns (about 1/100th of an inch), as opposed to the granular oxide product of the pot.

The first three of the continuous calciners began operations in the last quarter of 1956, and, despite mechanical difficulties with their powder handling systems during the earliest months, they soon demonstrated their production potential. That December, UO<sub>3</sub> Plant throughput exceeded that of any previous month by 27 percent. Overall, the 1956 plant production exceeded that of 1955 by 57 percent.

Another salient improvement made during 1956 was the replacement of the old, 900-pound drums used for offsite shipping of the UO<sub>3</sub> powder with new T-Hoppers. These containers left the site on specially fitted rail flat cars and served as feed hoppers for the Oak Ridge plant customer.

Installation of the last three of the continuous calciners was completed at the UO<sub>3</sub> Plant in early 1957. At that time, the 18 pot units were retired from service, and all processing was done through the continuous calciners. Late that year, design scoping was begun for new facilities needed to segregate regular UNH feed from that generated by the processing of E-Metal in the REDOX Plant. The UO<sub>3</sub> powder that resulted from processing the two types of UNH streams had significantly different nuclear reactivity levels, and separation was needed by the customer at Oak Ridge.

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During 1958, two new tanks with associated piping and instrumentation were installed and fitted to receive the enriched UNH from the stainless steel, overhead pipeline that brought the UNH from the REDOX Plant. Routine transfers of enriched UO<sub>3</sub> from Hanford to Oak Ridge began in early 1959. Meanwhile, in 1958, the UO<sub>3</sub> Plant established another high production record that was 5.5 percent higher than that of 1957, and almost double that of 1954. Metallurgical examination of the two-year old continuous calciners showed their condition to be excellent.

In 1958, the U-Plant finished its mission and was shut down. However, PUREX's UNH feed to the UO<sub>3</sub> Plant far surpassed that which had been coming from U-Plant. Together, the UO<sub>3</sub> and PUREX Plants went on to set and surpass production records almost continually, while the REDOX Plant continued to supply a small stream of enriched UNH until its shutdown in 1967. During 1959, the concentration equipment and the acid recovery system at the UO<sub>3</sub> Plant were automated, and in 1960, for the first time, the calciners were automated so that they could be operated and shut down remotely. Programming of the calciners included preliminary air blowing and steam heating of the feed points, admission and regulation of the feed, and control of the UO<sub>3</sub> bed temperature. Steep production climbs at the plant continued through 1961, but dropped off slightly in 1962 due to mechanical and process difficulties at the feed plants (PUREX and REDOX). By 1963, production again was so high that serious consideration was given to constructing a pipeline, or converting an existing one, to carry UNH from PUREX to the UO<sub>3</sub> Plant. However, the project did not go forward, and transfers by tanker truck continued. That same year, production of UO<sub>3</sub> shipped offsite rose to about 12,000 tons per year, and the capability was added to process UNH derived from "125 Metal." During 1965-1966, an experimental process of conversion of thorium nitrate into thorium oxide powder was carried out in the UO<sub>3</sub> Plant, using the old electric pots. The goal of this work was to produce thorium oxide powder suitable for fabrication into reactor target elements for <sup>233</sup>U production. However, for reasons unrelated to the UO<sub>3</sub> Plant, the use of thorium oxide powder was abandoned, in favor of experiments with thorium wafer targets.

Beginning in 1967, UO<sub>3</sub> Plant operations were tied exclusively to those of the PUREX Plant. That year, UNH concentrator modifications in the UO<sub>3</sub> Plant improved heat distribution and allowed the calciner feed to maintain a uniformly higher specific gravity, thus producing more powder in the same operating time. Both the UO<sub>3</sub> and PUREX plants closed in 1972. However, PUREX resumed operations in late 1983 -- closely followed by UO<sub>3</sub> Plant in early 1984. Since that time, there have been 17 startups at the UO<sub>3</sub> Plant, averaging about eight days each, as the plant could calcine UNH at a much faster rate than the PUREX Plant could produce it. Final deactivation orders came for both plants in 1992. In April 1993, the UO<sub>3</sub> Plant resumed operations to convert the final 200,000 gallons of remaining UNH to UO<sub>3</sub> powder. That run was the plant's last.

In general, waste management was handled very simply and efficiently at the UO<sub>3</sub> Plant. Radiation levels in the UNH were relatively low, as compared with levels in the chemical processing feed plants, as there was no high-level waste generated or processed by the UO<sub>3</sub> process. Process condensate was sent to various U-Plant cribs

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over the years, specifically the 216-U-12 crib in the 1980s and the 216-U-17 crib for later operations. Various ditches and swamps received equipment cooling water and the steam condensate, previously the U-Pond and more recently the 214-U Ditch. Airborne UO<sub>3</sub> powder was trapped in primary bag filters, with secondary bag filters and then HEPA (High Efficiency Particulate Air) filters added during the 1972 - 1984 shutdown. That period also witnessed the addition of fire protection improvements, a backup power supply for instrumentation, an open faced hood and associated exhaust and filtration equipment for the UO<sub>3</sub> loadout, and a nitrous oxide (NO<sub>x</sub>) monitor for the 296-U-4 stack. Beginning in the late 1950s, the main off-gas from the UO<sub>3</sub> process (NO<sub>x</sub>), was routed through "wet scrubbers," which sprayed the gas with nitric acid to capture the NO<sub>x</sub> vapors and dissolve any entrained solid oxide particulates. The acid mixture was then routed through an acid absorber (bubble-cap tower) and stored in chemical tanks awaiting transfer to PUREX. In the late 1980s, a Fiber Mist Eliminator was added to scrub acid vapors from the UNH concentrator to minimize entrained solution and particulates.

### G.2 Process Operations

The major unit operations performed at the UO<sub>3</sub> Plant were concentration of UNH, calcination of UNH to UO<sub>3</sub>, packaging of the UO<sub>3</sub> product, and nitric acid recovery. Uranium containing wastes were generated during routine operation. The primary waste streams were the liquid effluents discharged to the ground and gaseous effluents released to the atmosphere.

The UNH solution was transferred to the UO<sub>3</sub> Plant and stored in Tank C-1 in C-Cell. During operation the UNH solution was accumulated in storage tanks and then transferred to the concentrators in D-Cell. The UNH was concentrated to approximately 100 weight per cent UNH in thermosiphon evaporators. The optimum operating temperature was 125°C to 127°C. The concentrated UNH was stored in a steam heated tank. Off-gas from the concentrator knockout pot was routed through a catch tank to a fiber mist eliminator. The mist eliminator captured UNH droplets entrained from the concentrators and the recycle unit concentrator. The recovered UNH was eventually recycled to PUREX. Part of the condensate, was used as reflux water in the acid absorber tower, and the balance of the condensate was neutralized and pumped to the U-17 crib [Raab 1978; Harmon 1979; Strickland 1993] .

Concentrated UNH was pumped to the 224-U building where the calcination process was conducted and UNH converted to UO<sub>3</sub> powder. Initially calcination was performed using pot calciners. The UO<sub>3</sub> product from the pot calciners was unloaded using a pneumatic unloading system, which conveys uranium oxide from the pots and conveys it to bulk storage. The system consisted of an exhauster, a bag filter, a cyclone collector, a rotary valve, a hammer mill, and various pipe and fittings. The pot calciners were replaced by 1956 with continuous calciners. The UO<sub>3</sub> particle bed in the calciner was maintained at 270°C. The shell temperature was maintained at about 500°C for optimal efficiency.

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The UO<sub>3</sub> powder was collected from the calciners in ground-level pickup bins and then transferred by the pneumatic transfer system, using air, to the fourth floor of the UA tower to the cyclone separator. From there it flowed by gravity through a hammer mill (not normally used) on the third floor of the tower, then to a storage hopper on the second floor, and was unloaded from the hopper into T-Hopper shipping containers in the powder loadout room. The exhaust air from this operation was routed through primary and secondary bag filters in series, a prefilter, and HEPA filter before discharge to the environment, via a roof exhauster. Powder from the cyclone and primary bag filter was collected in the powder hopper. Powder from the secondary bag filter was also collected.

As the UNH was thermally decomposed, oxides, of nitrogen and water were driven off and drawn through the vent piping to the Acid Recovery Tower where they were converted to nitric acid. The system consisted of calciner off-gas scrubbers that remove fine particles of entrained UO<sub>3</sub>, a vapor cooler, an absorber tower and a system of reflux water addition. The acid was collected and pumped to the 211-U Tank Farm for storage and return to the processing plants. Net acid recovery was about 92 percent of that represented by the incoming UNH solution. The nitric acid had a low residual level (0.043 molar) of UNH.

### G.3 Waste Generation [Harmon 1979]

The processing of 1,000 MTU at the UO<sub>3</sub> Plant typically resulted in the generation of ~15 million gallons of cooling water, plus steam condensate from the acid recovery and uranium nitrate concentration steps, and chemical sewer waste. Total radionuclide content of this water which totaled 120 million gallons in 1972 was less than 2 Ci of combined fission products and alpha-emitting nuclides. This stream was sent to 216-U-10 Pond.

Process condensate, largely from the UNH concentrators in the 224-U Building, averaged about 300,000 gallons annually, containing about 0.01 Ci of total mixed fission products. It was sent to the 216-U-12 Crib.

Approximately  $1.2 \times 10^9$  ft<sup>3</sup> of gases were discharged to the atmosphere from the UO<sub>3</sub> Plant annually, containing an average (total) of  $6 \times 10^{-3}$  Ci of fission products and  $9 \times 10^{-5}$  of alpha emitting radionuclides. The radionuclides were essentially all <sup>106</sup>Ru and uranium, respectively.

Solid uranium waste was generated from failed and replaced equipment and normal line-generated process waste. About 120 to 140 ft<sup>3</sup> (total) was generated during a six week campaign mode of operation. This represented approximately 0.01 Ci of total beta emitters; 0.01 Ci of combined <sup>90</sup>Sr, <sup>137</sup>Cs and <sup>106</sup>Ru nuclides; and less than 0.2 kg of total uranium. The solid wastes were buried in the 200 Area waste burial grounds.

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## Supplemental Information On The UO<sub>3</sub> Plant

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### G.4 Radiation Exposure

The early years of UO<sub>3</sub> Plant operations were plagued with dusting and radiation problems around the calcination pots and during bag filter changes. Gustavson mentioned [Gustavson 1950] that “the dust problem in the pot room was one of the greatest obstacles in designing the UO<sub>3</sub> Building.” Gerber cited [Gerber 1993] that Annual Reports reported occasions when “airborne contamination around the pots increased until operators had to wear assault masks.” Two separate ventilation systems were installed to address the dust problems [Gustavson 1950]. Manual unloading of the calciner pots and high levels of maintenance were also reported. Radiation fields around the pot calciners resulted in the addition of special shielding in 1954 to protect the operators during pot unloading. The installation of continuous calciners greatly reduced exposure and dusting problems associated with the calcination process. Exposure during bag filter changes was also a concern in the early years of operation due to dusting problems. As a result, protective clothing and respiratory protection were used at these locations.

After many modifications and improvements to process operations, the total complement of workers when the UO<sub>3</sub> Plant was in full operation was approximately 30, including operations, maintenance and supervision during the latter years of UO<sub>3</sub> Plant operations. In 1971 to 1972, the average annual whole body occupational radiation dose of the UO<sub>3</sub> workers was approximately 1 rem; the maximum was 2.3 rem and the minimum was 0.09 rem. However, because this plant operated only part time, the process operations workers were assigned elsewhere for more than half of the operating year [Harmon 1979].

### G.5 Contaminate Partitioning

The major unit operations performed at the UO<sub>3</sub> Plant were concentration of UNH, calcination of UNH to UO<sub>3</sub>, packaging of the UO<sub>3</sub> product, and nitric acid recovery. None of these unit operations would preferentially concentrate or decontaminate the plutonium or neptunium from the uranium. The chemical and physical properties of the actinides are similar under the concentration and calcination operating conditions used at the UO<sub>3</sub> Plant such that there was no separation of one transuranic radionuclide from another. The ratio of transuranic constituents to uranium in the UO<sub>3</sub> product, residual uranium in waste streams, and uranium in any recovery streams, would have been the same as that in the UNH feed to the UO<sub>3</sub> Plant.

There is some evidence, however, of fission product partitioning during calcination. There is a statement in the UO<sub>3</sub> Fission Product Specifications [Knights 1966] that “<sup>95</sup>ZrNb and <sup>99</sup>Tc are carried almost quantitatively through the concentration and denitration processes, whereas ruthenium concentration is reduced by a factor of 2 to 5. An early report indicated an average decontamination factor (DF) of 6 across the UO<sub>3</sub> Plant from U Plant UNH. This was attributed to volatilization of ruthenium during the calcination operation. The acid specific fission product analyses indicated that 95

## APPENDIX G

### Supplemental Information On The UO<sub>3</sub> Plant

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percent was ruthenium. [Abrams 1955]. In contrast, the DF from REDOX UNH was less than one, indicating that the ruthenium concentration was significantly lower.

Some technetium heptoxide (Tc<sub>2</sub>O<sub>7</sub> – pertechnetate), which has a boiling point of 310°C, could be expected to be volatilized during the uranium calcination step, which operated at < 300°C. The off-gas from the calciners was driven off and drawn through vent piping to the Acid Recovery Tower. This system consisted of calciner off-gas scrubbers that remove fine particles of entrained UO<sub>3</sub>, a vapor cooler, an absorber tower and a system of reflux water addition. Any <sup>99</sup>Tc that would have been volatilized would have been recovered along with the NO<sub>2</sub>, entrained uranium and fission products and been recycled as nitric acid to the reprocessing plants. There is no evidence that any <sup>99</sup>Tc reached the final exhaust filters. The presence of other beta-gamma fission products would have masked any radiation from the soft beta of the <sup>99</sup>Tc.

#### G.6 UO<sub>3</sub> Related Incidents

One incident involving UO<sub>3</sub> powder occurred April 12, 1960 when the flexible hose used to load powder into a large shipping container broke and spilled about 1.5 tons of powder in the loadout room, of which 2 to 5 Kg escaped to the loadout pad. This powder spread over the asphalt loading ramp and to the road around the UO<sub>3</sub> Plant. Most of the powder was swept up and put in drums for recovery, but the rest of the powder was washed off the asphalt and onto the ground surface. Contaminated soil was removed and buried. The contamination was limited to the immediate areas of the spill. There was no general spread in the 200 West Area, no detectable contamination offsite, and no personnel contamination problems of concern were encountered [HW-64898 1960].

There were several incidents involving UNH and liquid effluents. On December 30, 1954 2,000 gallons of UNH were spilled on the main roadway just east of the 200-East Area hill. No external exposure in excess of permissible limits is known to have resulted from this incident. All individuals involved in this incident were surveyed and found to be free of contamination, and an analysis of the bioassay result indicated no detectable deposition of soluble uranium [HW-34494-DEL 1955].

The most serious radiation event identified during this study involving personnel exposure at the UO<sub>3</sub> Plant occurred in December 1960, when the fresh air mask hose being used by an employee was blocked by condensate in the line and the mask was improperly adjusted. The employee inhaled/ingested 7-12 mg of uranium [DOE/AD-0015 1991]. Up to that time, this was the highest recorded deposition at the plant. Within 24 hours, 80% of the uptake had been eliminated, reducing the body burden to 10% of the permissible level. Subsequent whole body counter examinations a week after exposure showed no detectable uranium.

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## Supplemental Information On The UO<sub>3</sub> Plant

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# **Appendix H**

## **Timeframe of Events at Hanford**



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**APPENDIX H**  
**Timeframe of Events at Hanford**

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Date	Event	Source
Dec-42	Pacific NW and California surveyed for possible production sites	DOE/MA-0001
December 21, 1942	Dupont signed to construct/operate atomic plants under Manhattan Engineer District	DOE/AD-0015
January-43	Dupont begins reactor design at Wilmington	DOE/AD-0015
Feb-43	Temporary office established and land purchases initiated	DOE/MA-0001
Mar-43	Construction initiated at HEW to build facilities to produce plutonium for the first atomic bombs.	Draft DOE/RL-97-Internet-1047 Building Periods, pg 1 of 6 and WHC-MR-0293, Rev 2
Jun-43	Construction began on B-Reactor	DOE/EM/0319
Autumn 1943	Completion of 313 Building	WHC-MR-0521, Rev. 0
November 4, 1943	X-10 Reactor at Oak Ridge went critical (0500am Local time)	DOE/EM-0319
Dec-43	First uranium fuel fabrication operation at HEW - Hanford began machining natural uranium (0.711 wt% U235) rods	WHC-MR-0521, Rev. 0 and DOE/EM-0319, Linking Legacies, January 1997
December 19, 1943	Bismuth Phosphate process demonstrated at Oak Ridge	DOE/EM-0319
Late 1943	Calutrons at Oak Ridge became operational	DOE/EM-0319
Jan-44	300 Area connected to rail service	WHC-MR-0521, Rev. 0
Mar-44	313 Building - Core canning operations initiated	WHC-MR-0521, Rev. 0
Summer 1944	Hanford population reaches 50,000	DOE/MA-0001
Late summer 1944	FDR discusses potential for future use of nuclear energy for commercial power production	New Fuels Cladding Facility by Holly K. Chamberlain, Washington State Historical Society, Sept. 24, 1996
June 8, 1944	Dupont engineers in Wilmington, DE chose the bismuth phosphate process for the full scale plants	DOE/EM-0319

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<b>Date</b>	<b>Event</b>	<b>Source</b>
Jul-44	314 Building - Started fuel element testing	WHC-MR-0521, Rev. 0
Aug-44	314 Building scrap recovery process started	WHC-MR-0521, Rev. 0
Sep 26-27, 1944	B-Reactor - First reactor on-line (beginning of plutonium production)	DOE/EM-0319
Oct-44	T-Plant completed	DOE/AD-0015
Nov-44	Uranium ingots began arriving at Hanford	DOE/EM-0319
Dec-44	U-Plant completed	DOE/AD-0015
December 17, 1944	D-Reactor on-line	DOE-EM-0319
December 26, 1944	T-Plant - Batch processing of irradiated uranium fuel material commenced	DOE-EM-0319
Jan-45	314 Building- Extrusion press begins operations	WHC-MR-0521, Rev. 0
Feb-45	F-Reactor on-line	DOE-EM-0319
February 5, 1945	First Shipment of Plutonium to Los Alamos, NM	DOE/AD-015
1945	U-Plant constructed but used as a training facility until 1952	WHC-MR-0521, Rev. 0
Apr-45	B-Plant started processing irradiated uranium on April 13, 1945	WHC-MR-0521, Rev. 0
July 16, 1945	Trinity test in New Mexico	DOE/EM-0319
Aug-45	K-25 Plant at Oak Ridge fully operational	DOE/EM-0319
August 6, 1945	"Little Boy" Hiroshima	DOE/EM-0319
August 9, 1945	"FAT MAN" Nagasaki	DOE/EM-0319
September 1, 1946	GE assumes control as overall Site Contractor	Draft DOE/RL-97-Internet-1047, Primary ontractors/Subcontractors, pg 2 of 4 and WHC-MR-0293, Rev 2
1947	Atomic Energy Commission (AEC) takes charge of Hanford Site	DOE/EM-0319
January 1, 1947	New AEC takes control of US Atomic weapons complex	DOE/EM-0319

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Date	Event	Source
Apr-47	Decision to explore enriching depleted uranium back to normal concentrations	Ltr. RE: Meeting with Dr. CW Greenwalt on use of K-25 in connection with Hanford Operations, BS626100, 04/21/1947
1949	Hanford began manufacturing of lithium targets for Tritium production	DOE/EM-0319
Jul-49	Hanford begins manufacture of Plutonium Pits	DOE/EM-0319
September 23, 1949	President Truman announces explosion of first Soviet atomic bomb	The American Experience, "Race for the Superbomb," PBS Online
Oct-49	H-Reactor comes on-line	DOE/EM-0319
Late 1949	REDOX Plant construction begins	WHC-MR-0521, Rev. 0
May-50	First shipment of HEU "J" slugs to Y-12	Material Balance Report 15-1415
Oct-50	DR-Reactor comes on-line	DOE/EM-0319
1951	Rocky Flats begins operations	DOE/EM-0319
1951	AEC establishes the Savannah River site near Aiken, SC	DOE/EM-0319
1951	Rolling mill installed in 314 Building	WHC-MR-0521, Rev. 0
November 10, 1951	Uranium Recovery Technical Manual provided an estimate that trace plutonium in recycled UO <sub>3</sub> would be 100 parts of plutonium per billion parts of uranium	HW19140
1952	Feed Materials Production Center at Fernald, OH begins refining uranium	DOE/EM-0319
1952	Construction of the Portsmouth Gaseous Diffusion Plant at Piketon, OH begins	WHC-MR-0293, Rev 2
1952	U Plant refitted for uranium recovery	WHC-MR-0293, Rev 2
1952	Rolling operation transferred to FMPC	WHC-MR-0521, Rev. 0
Jan-52	REDOX (S-Plant) commenced operations	WHC-MR-0521, Rev. 0
Jan-52	First recorded shipments of irradiated EU slugs to Idaho ICPP	HAN-53121, dated 12/2/53

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Date	Event	Source
Feb-52	UO <sub>3</sub> Plant begins operations	DOE/EM-0319
Mar-52	First recorded shipment of UO <sub>3</sub> product to K-25 GDP with fission products UO <sub>3</sub> trial production lots 007, 008, and 009)	March 11, 1952 Shipping document from R.B. Richards, Mgr. Separations Technology Unit to Dr. Frank Hurd, Carbide and Carbon Chemicals Corporation, K-25 Plant, Oak Ridge (Hanford 43666)
Mar-52	Second recorded shipment of 32 drums and 4 boxes of UO <sub>3</sub> product from Hanford to K-25 Plant at Oak Ridge	March 19, 1952 Shipping document from R.B. Richards, Mgr. Separations Technology Unit to Dr. Frank Hurd, Carbide and Carbon Chemicals Corporation, K-25 Plant, Oak Ridge (Hanford 43786)
Jul-52	TBP Plant (U-Plant) begins "mining" uranium from tank wastes	DOE/EM-0319
September 18, 1952	Oak Ridge communicated preliminary specifications to Hanford on UO <sub>3</sub> that listed "Plutonium: Not to exceed 10 ppb,"	Ref KLI-1681
Nov-52	C-Reactor comes on-line	DOE/EM-0319
Jan-53	Construction of the 1812 enrichment stages at the Paducah Plant begins	WHC-MR-0293, Rev 2
May-53	Standard established for off-site shipment of Hanford Uranium Trioxide (UO <sub>3</sub> ) established as "10 parts of plutonium per billion parts of uranium"	R.E. Smith, Summary of Oak Ridge Discussions Relative to Hanford Uranium Trioxide Specifications, 5/7/53, HW-27990
Dec-53	D.D. Eisenhower's "Atoms for Peace" encouraged use of atomic power for electrical production	New Fuels Cladding Facility by Holly K. Chamberlain, Washington State Historical Society, Sept. 24, 1996
May-54	313 Building major expansion	WHC-MR-0521, Rev. 0

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Date	Event	Source
Dec-54	Construction of the 1812 enrichment stages at the Paducah Plant is completed	DOE/EM-0319
Jan-55	KW-Reactor comes on-line	WHC-MR-0293, Rev 2
Apr-55	KE-Reactor comes on-line	
1956	Begin using T-Hoppers for offsite shipments in addition to drums	WHC-MR-0437, page 37
1956	Weldon Spring Plant near St. Louis begins refining uranium	DOE/EM-0319
Jan-56	PUREX (A-Plant) startup	DOE/EM-0319
Mar-56	T Plant was shut down in March 1956 following startup of the PUREX plant in January 1956.	DOE/EM-0319
1958	REDOX begins processing enriched irradiated uranium fuel assemblies ("E-Metal")	WHC-MR-0521, Rev. 0
1958	TBP Plant (U-Plant) shuts down	DOE/EM-0319
Mar-59	First shipments of Hanford low enriched (0.94% <sup>235</sup> U) UO <sub>3</sub> to K-25 Facility approved by AEC	HAN-71497, dated 3/3/59
May-59	N-Reactor construction began	Draft DOE/RL-97-Internet-1047 Table 2.3-6
1960	Plutonium Recycle Test Reactor (PRTR) constructed in 300 Area	WHC-MR-0440
1960	333 Building (N-Reactor Fuels Cladding Facility) completed	WHC-MR-0440
1962	PUREX "Q Cell" equipped for continuous neptunium purification	WHC-MR-0521, Rev. 0
1963	Modifications begin to allow PUREX to process various fuel types including N-Reactor fuel	WHC-MR-0521, Rev. 0
1963	WPPS begins construction of Hanford Electrical Generating Plant to be supplied by N-Reactor	New Fuels Cladding Facility by Holly K. Chamberlain, Washington State Historical Society, Sept. 24, 1996
Nov-63	Fire destroyed REDOX anion exchange concentrator	WHC-MR-0521, Rev. 0

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Date	Event	Source
Dec-63	N-Reactor (multi-pass, dual-purpose) reactor comes on-line (without power generating capability)	New Fuels Cladding Facility by Holly K. Chamberlain, Washington State Historical Society, Sept. 24, 1996
Dec-64	DR-Reactor Shutdown	DOE/EM-0319
1965	GE Replaced by Multiple Contractors	Draft DOE/RL-97-Internet-1047
Apr-65	H-Reactor Shutdown	DOE/EM-0319
Jun-65	F-Reactor Shutdown	DOE/EM-0319
1966	N-Reactor (multi-pass, dual-purpose) reactor begins producing steam for WPPS Hanford Electrical Generating Plant	New Fuels Cladding Facility by Holly K. Chamberlain, Washington State Historical Society, Sept. 24, 1996
1966	Weldon Spring Plant near St. Louis closed down	DOE/EM-0319
1967	PUREX began N-Reactor fuel separation processing	WHC-MR-0521, Rev. 0
Jun-67	D-Reactor Shutdown	DOE/EM-0319
1967	PUREX began processing "125 Metal"	WHC-MR-0521, Rev. 0
1967	REDOX (S-Plant) shut down	DOE/EM-0319
1968	PUREX began processing "210 Metal"	WHC-MR-0521, Rev. 0
1968	B-Plant converted to a waste fractionation plant to extract & encapsulate 137CS & 90Sr from high level tank wastes.	DOE/EM-0319
Feb-68	B-Reactor shut down	DOE/EM-0319
Apr-69	C-Reactor Shutdown	DOE/EM-0319
Feb-70	KW-Reactor Shutdown	DOE/EM-0319
Jan-71	KE-Reactor Shutdown	DOE/EM-0319
1972	Fernald Refinery closes	DOE/EM-0319
1972	PUREX temporary shutdown	WHC-MR-0521, Rev. 0
Sep-72	UO <sub>3</sub> Plant shutdown	DOE/EM-0319

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Date	Event	Source
1974	Atomic Energy Commission (AEC) turns management of Hanford over to Energy Research and Development Administration (ERDA)	DOE/EM-0319
1977	U. S. Department of Energy (DOE) assumes management of Hanford Site	DOE/EM-0319
1983	PUREX Plant reopened with operating limit to process N-Reactor fuel	WHC-MR-0521, Rev. 0
1987	Fuel & Target Fabrication at Hanford's 300 Area ceased permanently	DOE/EM-0319
Feb-87	N-Reactor shuts down	DOE/EM-0319
Early 1990	PUREX (A-Plant) shuts down	WHC-MR-0521, Rev. 0
Oct-90	PUREX placed in "Standby " status	WHC-MR-0521, Rev. 0
Dec-92	DOE issues final closure order for PUREX	WHC-MR-0521, Rev. 0
1993	PUREX starts 5-year deactivation plan	WHC-MR-0521, Rev. 0



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## **APPENDIX I**

### **Estimates of Annual Recycled Uranium Constituents Shipped Offsite**

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**Estimates of Annual Recycled Uranium Constituents Shipped Offsite**

I.1 This appendix contains engineering estimates of annual quantities of constituents (Pu, Np, and Tc) contained in shipments of recycled uranium shipped to/from the Hanford site. Tables I-1 and I-2 summarize the annual receipts and shipments of recycled uranium to and from the Hanford site during the last fifty years. These tables contain summaries of annual receipt and shipment based upon data presented in Section 3 and Appendix B of this report. Analytical data on the amount of Pu, Np, and Tc in recycled uranium received at Hanford is not available since there were no requirements for these measurements. Limited analytical data has been identified which indicates that the recycled uranium shipped offsite from Hanford typically contained Pu in the range of one to five ppb, Np in the range of 20 to 500 ppb, and Tc in the range of 3 to 12 ppb. Data supporting these constituent concentration ranges is given in Section 4 and Appendix C of this report. Data on the concentration of Np and Tc in Hanford recycled uranium is minimal, since there were specification requirements for these elements,

Since it is not possible to provide a complete historical assessment of the constituent levels in all recycled uranium shipped each year, rough estimates of annual quantities of constituents in recycled uranium were made assuming that the constituent levels during the years where analytical data is not available are the same as the constituent levels for years when analytical data is available. These estimates are based upon the constituent levels mentioned above and were done for the bounding minimum and maximum values, and the mean value of the constituent concentration range. Tables I-3, I-4, and I-5 illustrate the estimated quantities of Pu contained in the recycled uranium shipped. Tables I-6, I-7, and I-8 illustrate the estimated quantities of neptunium in the recycled uranium shipped. Tables I-9, I-10, and I-11 illustrate the estimated quantities of technetium contained in the recycled uranium shipped. Tables I-12, I-13, and I-14 present estimates of the Pu, Tc, and Np constituents in recycled uranium received at Hanford, shipped from Hanford, contained in waste at Hanford, released to the environment at Hanford, or in the current inventory at Hanford.

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**Estimates of Annual Recycled Uranium Constituents Shipped Offsite**

**Table I-1 Historical Hanford Recycled Uranium Receipts (MTU)**

	Site	Recycled Uranium Received (MTU) All Types										Decade Subtotal
		FY 1950	FY 1951	FY 1952	FY 1953	FY 1954	FY 1955	FY 1956	FY 1957	FY 1958	FY 1959	
1950s	Paducah GDP	NA	NA	NA	0.00	0.00	0.00	0.00	2.93	2.23	3.91	9.1
	Fernald	NA	NA	NA	0.84	2,735.15	4,550.42	4,631.75	5,893.45	7,255.88	5,314.39	30,381.9
	Oak Ridge	NA	NA	NA	0.61	2.09	0.39	0.03	0.00	0.04	0.11	3.3
	Other	NA	NA	NA	2,347.64	19.58	16.08	6.73	4.95	34.59	25.27	2,454.8
1960s		FY 1960	FY 1961	FY 1962	FY 1963	FY 1964	FY 1965	FY 1966	FY 1967	FY 1968	FY 1969	
	Paducah GDP	1.96	2.86	4.08	4.13	2.36	0.00	0.00	0.00	0.00	0.00	15.4
	Fernald	7,146.63	6,615.23	6,361.70	7,504.02	6,727.71	8,103.47	5,604.66	5,057.25	3,422.20	2,581.94	59,124.8
	Oak Ridge	0.45	0.45	0.06	0.08	0.00	0.01	0.00	0.06	0.13	0.05	1.3
	Other	615.88	715.46	885.91	9.22	48.57	5.05	7.64	11.44	2.12	0.60	2,301.9
1970s		FY 1970	FY 1971	FY 1972	FY 1973	FY 1974	FY 1975	FY 1976	FY 1977	FY 1978	FY 1979	
	Paducah GDP	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
	Fernald	2,444.00	730.59	28.21	0.00	0.00	1.17	1.60	0.80	0.55	0.27	3,207.2
	Oak Ridge	0.05	0.63	0.04	0.00	0.67	0.03	0.00	0.14	0.08	0.01	1.7
	Other	0.28	2.53	432.26	351.21	676.91	447.95	479.45	330.09	488.68	473.01	3,682.4
1980s		FY 1980	FY 1981	FY 1982	FY 1983	FY 1984	FY 1985	FY 1986	FY 1987	FY 1988	FY 1989	
	Paducah GDP	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
	Fernald	1.26	0.96	0.00	0.04	1.86	2.25	1.77	0.79	0.63	0.11	9.7
	Oak Ridge	0.02	0.02	0.00	0.00	0.01	0.94	0.00	0.00	0.00	0.04	1.0
	Other	322.98	512.28	813.94	1,301.93	1,348.65	1,454.73	1,581.71	532.44	8.22	20.06	7,896.9
1990s		FY 1990	FY 1991	FY 1992	FY 1993	FY 1994	FY 1995	FY 1996	FY 1997	FY 1998	FY1999	
	Paducah GDP	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
	Fernald	0.31	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.3
	Oak Ridge	1.03	8.96	1.32	0.18	0.00	0.00	0.00	0.00	0.00	0.00	11.5
	Other	19.58	3.40	6.32	0.00	0.22	0.95	0.49	9.43	0.08	0.00	40.5
Explanatory Notes:												
											Total From Paducah GDP = 24	
											Total From Fernald = 92,724	
											Total From Oak Ridge = 19	
											Total From Other = 16,377	
											<b>Grand Total Received = 109,144</b>	

# APPENDIX I

DOE/RL-2000-43

## Estimates of Annual Recycled Uranium Constituents Shipped Offsite

Table I-2 Historical Hanford Recycled Uranium Shipments (MTU)

	Site	Recycled Uranium Shipped (MTU), All Types										Decade Subtotals
		FY 1950	FY 1951	FY 1952	FY 1953	FY 1954	FY 1955	FY 1956	FY 1957	FY 1958	FY 1959	
<b>1950s</b>	Paducah GDP	NA	NA	0.00	0.00	2,233.02	2,586.71	4,105.04	5,385.91	6,056.42	5,202.42	25,569.5
	Fernald	NA	NA	0.00	0.12	0.00	266.21	411.53	348.85	365.21	508.99	1,900.9
	Oak Ridge	NA	NA	154.39	603.57	1,176.09	499.41	289.19	98.76	9.10	288.29	3,118.8
	Other	NA	NA	0.00	2,309.07	706.60	36.59	3.79	1.69	9.15	16.11	3,083.0
<b>1960s</b>		<b>FY 1960</b>	<b>FY 1961</b>	<b>FY 1962</b>	<b>FY 1963</b>	<b>FY 1964</b>	<b>FY 1965</b>	<b>FY 1966</b>	<b>FY 1967</b>	<b>FY 1968</b>	<b>FY 1969</b>	
	Paducah GDP	5,148.06	6,093.78	5,491.82	5,771.94	4,087.37	0.00	0.00	14,432.88	0.00	3,537.14	44,563.0
	Fernald	382.68	333.89	429.41	1,443.75	1,511.07	2,036.13	2,242.30	1,568.16	1,900.48	2,139.00	13,986.9
	Oak Ridge	610.60	614.92	46.80	1.57	0.01	0.00	0.09	0.00	0.00	0.00	1,274.0
	Other	22.73	31.31	3.23	2.96	3.09	3.84	6.20	1.52	0.04	0.64	75.6
<b>1970s</b>		<b>FY 1970</b>	<b>FY 1971</b>	<b>FY 1972</b>	<b>FY 1973</b>	<b>FY 1974</b>	<b>FY 1975</b>	<b>FY 1976</b>	<b>FY 1977</b>	<b>FY 1978</b>	<b>FY 1979</b>	
	Paducah GDP	0.00	721.58	3,078.50	558.12	0.00	0.00	0.00	0.00	0.00	0.00	4,358.2
	Fernald	2,479.34	576.37	94.86	368.40	1,216.33	55.62	28.94	147.34	92.92	61.68	5,121.8
	Oak Ridge	0.00	0.01	0.17	0.00	1.92	0.00	0.00	0.36	0.21	0.29	3.0
	Other	0.53	587.40	4.91	0.51	1,019.98	3.55	3.92	4.04	96.87	8.25	1,730.0
<b>1980s</b>		<b>FY 1980</b>	<b>FY 1981</b>	<b>FY 1982</b>	<b>FY 1983</b>	<b>FY 1984</b>	<b>FY 1985</b>	<b>FY 1986</b>	<b>FY 1987</b>	<b>FY 1988</b>	<b>FY 1989</b>	
	Paducah GDP	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
	Fernald	58.49	91.36	77.74	160.13	942.91	1,093.02	1,319.60	374.37	123.81	0.21	4,241.6
	Oak Ridge	0.01	0.02	0.00	0.00	0.00	0.03	0.05	0.00	0.02	0.03	0.1
	Other	9.46	25.79	18.11	6.60	12.83	9.91	18.52	8.20	26.62	18.25	154.3
<b>1990s</b>		<b>FY 1990</b>	<b>FY 1991</b>	<b>FY 1992</b>	<b>FY 1993</b>	<b>FY 1994</b>	<b>FY 1995</b>	<b>FY 1996</b>	<b>FY 1997</b>	<b>FY 1998</b>	<b>FY 1999</b>	
	Paducah GDP	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
	Fernald	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
	Oak Ridge	0.00	0.00	0.00	8.51	0.00	0.00	0.00	0.00	0.00	0.01	8.5
	Other	12.81	16.72	12.58	246.69	17.25	19.37	247.97	29.91	0.00	0.01	603.3
<b>Explanatory Notes:</b>								Total To Paducah GDP = 74,491				
								Total To Fernald = 25,251				
								Total To Oak Ridge = 4,404				
								Total To Other = 5,646				
								<b>Grand Total Shipped = 109,792</b>				

# APPENDIX I

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## Estimates of Annual Recycled Uranium Constituents Shipped Offsite

Table I-3 Estimated Minimum Pu In Hanford Recycled Uranium Shipments (Gm)

	Site	Plutonium Shipped In Recycled Uranium (Gm)										Decade Subtotal
		FY 1950	FY 1951	FY 1952	FY 1953	FY 1954	FY 1955	FY 1956	FY 1957	FY 1958	FY 1959	
1950	Paducah GDP	NA	NA	0.000	0.000	2.233	2.587	4.105	5.386	6.056	5.202	25.57
	Fernald	NA	NA	0.000	0.000	0.000	0.266	0.412	0.349	0.365	0.509	1.90
	Oak Ridge	NA	NA	0.154	0.604	1.176	0.499	0.289	0.099	0.009	0.288	3.12
	Other	NA	NA	0.000	2.309	0.707	0.037	0.004	0.002	0.009	0.016	3.08
1960s		FY 1960	FY 1961	FY 1962	FY 1963	FY 1964	FY 1965	FY 1966	FY 1967	FY 1968	FY 1969	
	Paducah GDP	5.148	6.094	5.492	5.772	4.087	0.000	0.000	14.433	0.000	3.537	44.56
	Fernald	0.383	0.334	0.429	1.444	1.511	2.036	2.242	1.568	1.900	2.139	13.99
	Oak Ridge	0.611	0.615	0.047	0.002	0.000	0.000	0.000	0.000	0.000	0.000	1.27
	Other	0.023	0.031	0.003	0.003	0.003	0.004	0.006	0.002	0.000	0.001	0.08
1970s		FY 1970	FY 1971	FY 1972	FY 1973	FY 1974	FY 1975	FY 1976	FY 1977	FY 1978	FY 1979	
	Paducah GDP	0.000	0.722	3.078	0.558	0.000	0.000	0.000	0.000	0.000	0.000	4.36
	Fernald	2.479	0.576	0.095	0.368	1.216	0.056	0.029	0.147	0.093	0.062	5.12
	Oak Ridge	0.000	0.000	0.000	0.000	0.002	0.000	0.000	0.000	0.000	0.000	0.00
	Other	0.001	0.587	0.005	0.001	1.020	0.004	0.004	0.004	0.097	0.008	1.73
1980s		FY 1980	FY 1981	FY 1982	FY 1983	FY 1984	FY 1985	FY 1986	FY 1987	FY 1988	FY 1989	
	Paducah GDP	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.00
	Fernald	0.058	0.091	0.078	0.160	0.943	1.093	1.320	0.374	0.124	0.000	4.24
	Oak Ridge	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.00
	Other	0.009	0.026	0.018	0.007	0.013	0.010	0.019	0.008	0.027	0.018	0.15
1990s		FY 1990	FY 1991	FY 1992	FY 1993	FY 1994	FY 1995	FY 1996	FY 1997	FY 1998	FY1999	
	Paducah GDP	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.00
	Fernald	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.00
	Oak Ridge	0.000	0.000	0.000	0.009	0.000	0.000	0.000	0.000	0.000	0.000	0.01
	Other	0.013	0.017	0.013	0.247	0.017	0.019	0.248	0.030	0.000	0.000	0.60
Explanatory Notes: NA = Not Applicable Identified Hanford historical data indicates typical Pu concentrations ranged from 1 - 5 ppb Estimates based on an average minimum Pu concentration for all shipments (ppb) = 1 Conversion factor (g/MT per 1ppb) = 0.001 Analytical data was only found for a limited number of years. All other years were assumed similar.								Total To Paducah GDP = 74.5 Total To Fernald = 25.3 Total To Oak Ridge = 4.4 Total To Other = 5.6 <b>Grand Total Shipped = 109.8</b>				



# APPENDIX I

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## Estimates of Annual Recycled Uranium Constituents Shipped Offsite

**Table I-4 Estimated Mean Pu In Hanford Recycled Uranium Shipments (Gm)**

	Site	Plutonium Shipped In Recycled Uranium (Gm)										Decade Subtotal
		FY 1950	FY 1951	FY 1952	FY 1953	FY 1954	FY 1955	FY 1956	FY 1957	FY 1958	FY 1959	
<b>1950</b>	Paducah GDP	NA	NA	0.000	0.000	6.699	7.760	12.315	16.158	18.169	15.607	76.71
	Fernald	NA	NA	0.000	0.000	0.000	0.799	1.235	1.047	1.096	1.527	5.70
	Oak Ridge	NA	NA	0.463	1.811	3.528	1.498	0.868	0.296	0.027	0.865	9.36
	Other	NA	NA	0.000	6.927	1.120	0.110	0.011	0.005	0.027	0.048	9.25
<b>1960s</b>		<b>FY 1960</b>	<b>FY 1961</b>	<b>FY 1962</b>	<b>FY 1963</b>	<b>FY 1964</b>	<b>FY 1965</b>	<b>FY 1966</b>	<b>FY 1967</b>	<b>FY 1968</b>	<b>FY 1969</b>	
	Paducah GDP	15.444	18.281	16.475	17.316	12.262	0.000	0.000	43.299	0.000	10.611	133.69
	Fernald	1.148	1.002	1.288	4.331	4.533	6.108	6.727	4.704	5.701	6.417	41.96
	Oak Ridge	1.832	1.845	0.140	0.005	0.000	0.000	0.000	0.000	0.000	0.000	3.82
	Other	0.068	0.094	0.010	0.009	0.009	0.012	0.019	0.005	0.000	0.002	0.23
<b>1970s</b>		<b>FY 1970</b>	<b>FY 1971</b>	<b>FY 1972</b>	<b>FY 1973</b>	<b>FY 1974</b>	<b>FY 1975</b>	<b>FY 1976</b>	<b>FY 1977</b>	<b>FY 1978</b>	<b>FY 1979</b>	
	Paducah GDP	0.000	2.165	9.235	1.674	0.000	0.000	0.000	0.000	0.000	0.000	13.07
	Fernald	7.438	1.729	0.285	1.105	3.649	0.167	0.087	0.442	0.279	0.185	15.37
	Oak Ridge	0.000	0.000	0.001	0.000	0.006	0.000	0.000	0.001	0.001	0.001	0.01
	Other	0.002	1.762	0.015	0.002	3.060	0.011	0.012	0.012	0.291	0.025	5.19
<b>1980s</b>		<b>FY 1980</b>	<b>FY 1981</b>	<b>FY 1982</b>	<b>FY 1983</b>	<b>FY 1984</b>	<b>FY 1985</b>	<b>FY 1986</b>	<b>FY 1987</b>	<b>FY 1988</b>	<b>FY 1989</b>	
	Paducah GDP	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.00
	Fernald	0.175	0.274	0.233	0.480	2.829	3.279	3.959	1.123	0.371	0.001	12.72
	Oak Ridge	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.00
	Other	0.028	0.077	0.054	0.020	0.038	0.030	0.056	0.025	0.080	0.055	0.46
<b>1990s</b>		<b>FY 1990</b>	<b>FY 1991</b>	<b>FY 1992</b>	<b>FY 1993</b>	<b>FY 1994</b>	<b>FY 1995</b>	<b>FY 1996</b>	<b>FY 1997</b>	<b>FY 1998</b>	<b>FY 1999</b>	
	Paducah GDP	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.00
	Fernald	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.00
	Oak Ridge	0.000	0.000	0.000	0.026	0.000	0.000	0.000	0.000	0.000	0.000	0.03
	Other	0.038	0.050	0.038	0.740	0.052	0.058	0.744	0.090	0.000	0.000	1.81

**Explanatory Notes:**

NA = Not Applicable

Identified Hanford historical data indicates typical Pu concentrations ranged from 1 - 5 ppb

Estimates based on an average mean Pu concentration for all shipments (ppb) = 3.0

Conversion factor (g/MT per 1ppb) = 0.001

Analytical data was only found for a limited number of years, all other years were assumed similar.

Total To Paducah GDP = 223.5

Total To Fernald = 75.8

Total To Oak Ridge = 13.2

Total To Other = 16.9

**Grand Total Shipped = 329.4**

# APPENDIX I

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## Estimates of Annual Recycled Uranium Constituents Shipped Offsite

**Table I-5 Estimated Maximum Pu In Hanford Recycled Uranium Shipments (Gm)**

	Site	Plutonium Shipped In Recycled Uranium (Gm)										Decade Subtotal
		FY 1950	FY 1951	FY 1952	FY 1953	FY 1954	FY 1955	FY 1956	FY 1957	FY 1958	FY 1959	
<b>1950s</b>	Paducah GDP	NA	NA	0.000	0.000	11.165	12.934	20.525	26.930	30.282	26.012	127.85
	Fernald	NA	NA	0.000	0.001	0.000	1.331	2.058	1.744	1.826	2.545	9.50
	Oak Ridge	NA	NA	0.772	3.018	5.880	2.497	1.446	0.494	0.046	1.441	15.59
	Other	NA	NA	0.000	11.545	3.533	0.183	0.019	0.008	0.046	0.081	15.41
<b>1960s</b>		FY 1960	FY 1961	FY 1962	FY 1963	FY 1964	FY 1965	FY 1966	FY 1967	FY 1968	FY 1969	
	Paducah GDP	25.740	30.469	27.459	28.860	20.437	0.000	0.000	72.164	0.000	17.686	222.81
	Fernald	1.913	1.669	2.147	7.219	7.555	10.181	11.211	7.841	9.502	10.695	69.93
	Oak Ridge	3.053	3.075	0.234	0.008	0.000	0.000	0.000	0.000	0.000	0.000	6.37
	Other	0.114	0.157	0.016	0.015	0.015	0.019	0.031	0.008	0.000	0.003	0.38
<b>1970s</b>		FY 1970	FY 1971	FY 1972	FY 1973	FY 1974	FY 1975	FY 1976	FY 1977	FY 1978	FY 1979	
	Paducah GDP	0.000	3.608	15.392	2.791	0.000	0.000	0.000	0.000	0.000	0.000	21.79
	Fernald	12.397	2.882	0.474	1.842	6.082	0.278	0.145	0.737	0.465	0.308	25.61
	Oak Ridge	0.000	0.000	0.001	0.000	0.010	0.000	0.000	0.002	0.001	0.001	0.01
	Other	0.003	2.937	0.025	0.003	5.100	0.018	0.020	0.020	0.484	0.041	8.65
<b>1980s</b>		FY 1980	FY 1981	FY 1982	FY 1983	FY 1984	FY 1985	FY 1986	FY 1987	FY 1988	FY 1989	
	Paducah GDP	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.00
	Fernald	0.292	0.457	0.389	0.801	4.715	5.465	6.598	1.872	0.619	0.001	21.21
	Oak Ridge	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.00
	Other	0.047	0.129	0.091	0.033	0.064	0.050	0.093	0.041	0.133	0.091	0.77
<b>1990s</b>		FY 1990	FY 1991	FY 1992	FY 1993	FY 1994	FY 1995	FY 1996	FY 1997	FY 1998	FY 1999	
	Paducah GDP	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.00
	Fernald	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.00
	Oak Ridge	0.000	0.000	0.000	0.043	0.000	0.000	0.000	0.000	0.000	0.000	0.04
	Other	0.064	0.084	0.063	1.233	0.086	0.097	1.240	0.150	0.000	0.000	3.02

<p>Explanatory Notes:                  NA = Not Applicable</p> <p>Identified Hanford historical data indicates typical Pu concentrations ranged from 1 - 5 ppb</p> <p>Estimates based on an average maximum Pu concentration for all shipments (ppb) = 5</p> <p style="padding-left: 40px;">Conversion factor (g/MT per 1ppb) = 0.001</p> <p>Analytical data was only found for a limited number of years, all other years were assumed similar.</p>	Total To Paducah GDP =	372.5
	Total To Fernald =	126.3
	Total To Oak Ridge =	22.0
	Total To Other =	28.2
	<b>Grand Total Shipped =</b>	<b>549.0</b>

**APPENDIX I**

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**Estimates of Annual Recycled Uranium Constituents Shipped Offsite**

**Table I-6 Estimated Minimum Np In Hanford Recycled Uranium Shipments (Kg)**

	Site	Neptunium Shipped In Recycle Uranium (Kg)										Decade Subtotal
		FY 1950	FY 1951	FY 1952	FY 1953	FY 1954	FY 1955	FY 1956	FY 1957	FY 1958	FY 1959	
<b>1950s</b>	Paducah GDP	NA	NA	0.000	0.000	0.045	0.052	0.082	0.108	0.121	0.104	0.51
	Fernald	NA	NA	0.000	0.000	0.000	0.005	0.008	0.007	0.007	0.010	0.04
	Oak Ridge	NA	NA	0.003	0.012	0.024	0.010	0.006	0.002	0.000	0.006	0.06
	Other	NA	NA	0.000	0.046	0.014	0.001	0.000	0.000	0.000	0.000	0.06
<b>1960s</b>		<b>FY 1960</b>	<b>FY 1961</b>	<b>FY 1962</b>	<b>FY 1963</b>	<b>FY 1964</b>	<b>FY 1965</b>	<b>FY 1966</b>	<b>FY 1967</b>	<b>FY 1968</b>	<b>FY 1969</b>	
	Paducah GDP	0.103	0.122	0.110	0.115	0.082	0.000	0.000	0.289	0.000	0.071	0.89
	Fernald	0.008	0.007	0.009	0.029	0.030	0.041	0.045	0.031	0.038	0.043	0.28
	Oak Ridge	0.012	0.012	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.03
	Other	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.00
<b>1970s</b>		<b>FY 1970</b>	<b>FY 1971</b>	<b>FY 1972</b>	<b>FY 1973</b>	<b>FY 1974</b>	<b>FY 1975</b>	<b>FY 1976</b>	<b>FY 1977</b>	<b>FY 1978</b>	<b>FY 1979</b>	
	Paducah GDP	0.000	0.014	0.062	0.011	0.000	0.000	0.000	0.000	0.000	0.000	0.09
	Fernald	0.050	0.012	0.002	0.007	0.024	0.001	0.001	0.003	0.002	0.001	0.10
	Oak Ridge	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.00
	Other	0.000	0.012	0.000	0.000	0.020	0.000	0.000	0.000	0.002	0.000	0.03
<b>1980s</b>		<b>FY 1980</b>	<b>FY 1981</b>	<b>FY 1982</b>	<b>FY 1983</b>	<b>FY 1984</b>	<b>FY 1985</b>	<b>FY 1986</b>	<b>FY 1987</b>	<b>FY 1988</b>	<b>FY 1989</b>	
	Paducah GDP	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.00
	Fernald	0.001	0.002	0.002	0.003	0.019	0.022	0.026	0.007	0.002	0.000	0.08
	Oak Ridge	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.00
	Other	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.00
<b>1990s</b>		<b>FY 1990</b>	<b>FY 1991</b>	<b>FY 1992</b>	<b>FY 1993</b>	<b>FY 1994</b>	<b>FY 1995</b>	<b>FY 1996</b>	<b>FY 1997</b>	<b>FY 1998</b>	<b>FY 1999</b>	
	Paducah GDP	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.00
	Fernald	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.00
	Oak Ridge	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.00
	Other	0.000	0.000	0.000	0.005	0.000	0.000	0.005	0.001	0.000	0.000	0.01
Explanatory Notes: NA = Not Applicable Identified Hanford historical data indicates typical Np concentrations ranged from 20 - 500 ppb Estimates based on an average minimum Np concentration for all shipments (ppb) = 20 Conversion factor (Kg/MT per 1ppb) = 0.000001 Analytical data was only found for a limited number of years, all other years were assumed similar.								Total To Paducah GDP = 1.5 Total To Fernald = 0.5 Total To Oak Ridge = 0.1 Total To Other = 0.1 <b>Grand Total Shipped = 2.2</b>				

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## Estimates of Annual Recycled Uranium Constituents Shipped Offsite

**Table I-7 Estimated Mean Np In Hanford Recycled Uranium Shipments (Kg)**

	Site	Neptunium Shipped In Recycle Uranium (Kg)										Decade Subtotal
		FY 1950	FY 1951	FY 1952	FY 1953	FY 1954	FY 1955	FY 1956	FY 1957	FY 1958	FY 1959	
<b>1950s</b>	Paducah GDP	NA	NA	0.000	0.000	0.581	0.673	1.067	1.400	1.575	1.353	6.65
	Fernald	NA	NA	0.000	0.000	0.000	0.069	0.107	0.091	0.095	0.132	0.49
	Oak Ridge	NA	NA	0.040	0.157	0.306	0.130	0.075	0.026	0.002	0.075	0.81
	Other	NA	NA	0.000	0.600	0.184	0.010	0.001	0.000	0.002	0.004	0.80
<b>1960s</b>		<b>FY 1960</b>	<b>FY 1961</b>	<b>FY 1962</b>	<b>FY 1963</b>	<b>FY 1964</b>	<b>FY 1965</b>	<b>FY 1966</b>	<b>FY 1967</b>	<b>FY 1968</b>	<b>FY 1969</b>	
	Paducah GDP	1.338	1.584	1.428	1.501	1.063	0.000	0.000	3.753	0.000	0.920	11.59
	Fernald	0.099	0.087	0.112	0.375	0.393	0.529	0.583	0.408	0.494	0.556	3.64
	Oak Ridge	0.159	0.160	0.012	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.33
	Other	0.006	0.008	0.001	0.001	0.001	0.001	0.002	0.000	0.000	0.000	0.02
<b>1970s</b>		<b>FY 1970</b>	<b>FY 1971</b>	<b>FY 1972</b>	<b>FY 1973</b>	<b>FY 1974</b>	<b>FY 1975</b>	<b>FY 1976</b>	<b>FY 1977</b>	<b>FY 1978</b>	<b>FY 1979</b>	
	Paducah GDP	0.000	0.188	0.800	0.145	0.000	0.000	0.000	0.000	0.000	0.000	1.13
	Fernald	0.645	0.150	0.025	0.096	0.316	0.014	0.008	0.038	0.024	0.016	1.33
	Oak Ridge	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.00
	Other	0.000	0.153	0.001	0.000	0.265	0.001	0.001	0.001	0.025	0.002	0.45
<b>1980s</b>		<b>FY 1980</b>	<b>FY 1981</b>	<b>FY 1982</b>	<b>FY 1983</b>	<b>FY 1984</b>	<b>FY 1985</b>	<b>FY 1986</b>	<b>FY 1987</b>	<b>FY 1988</b>	<b>FY 1989</b>	
	Paducah GDP	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.00
	Fernald	0.015	0.024	0.020	0.042	0.245	0.284	0.343	0.097	0.032	0.000	1.10
	Oak Ridge	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.00
	Other	0.002	0.007	0.005	0.002	0.003	0.003	0.005	0.002	0.007	0.005	0.04
<b>1990s</b>		<b>FY 1990</b>	<b>FY 1991</b>	<b>FY 1992</b>	<b>FY 1993</b>	<b>FY 1994</b>	<b>FY 1995</b>	<b>FY 1996</b>	<b>FY 1997</b>	<b>FY 1998</b>	<b>FY 1999</b>	
	Paducah GDP	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.00
	Fernald	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.00
	Oak Ridge	0.000	0.000	0.000	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.00
	Other	0.003	0.004	0.003	0.064	0.004	0.005	0.064	0.008	0.000	0.000	0.16

Explanatory Notes:  
NA = Not Applicable

Identified Hanford historical data indicates typical Np concentrations ranged from 20 - 500 ppb  
 Estimates based on an average mean Np concentration for all shipments (ppb) = 260  
 Conversion factor (Kg/MT per 1ppb) = 0.000001

Analytical data was only found for a limited number of years, all other years were assumed similar.

Total To Paducah GDP =	19.4
Total To Fernald =	6.6
Total To Oak Ridge =	1.1
Total To Other =	1.5
<b>Grand Total Shipped =</b>	<b>28.5</b>

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## Estimates of Annual Recycled Uranium Constituents Shipped Offsite

**Table I-8 Estimated Maximum Np In Hanford Recycled Uranium Shipments (Kg)**

	Site	Neptunium Shipped In Recycle Uranium (Kg)										Decade
		FY 1950	FY 1951	FY 1952	FY 1953	FY 1954	FY 1955	FY 1956	FY 1957	FY 1958	FY 1959	Subtotal
<b>1950s</b>	Paducah GDP	NA	NA	0.000	0.000	1.117	1.293	2.053	2.693	3.028	2.601	12.78
	Fernald	NA	NA	0.000	0.000	0.000	0.133	0.206	0.174	0.183	0.254	0.95
	Oak Ridge	NA	NA	0.077	0.302	0.588	0.250	0.145	0.049	0.005	0.144	1.56
	Other	NA	NA	0.000	1.155	0.353	0.018	0.002	0.001	0.005	0.008	1.54
<b>1960s</b>		<b>FY 1960</b>	<b>FY 1961</b>	<b>FY 1962</b>	<b>FY 1963</b>	<b>FY 1964</b>	<b>FY 1965</b>	<b>FY 1966</b>	<b>FY 1967</b>	<b>FY 1968</b>	<b>FY 1969</b>	
	Paducah GDP	2.574	3.047	2.746	2.886	2.044	0.000	0.000	7.216	0.000	1.769	22.28
	Fernald	0.191	0.167	0.215	0.722	0.756	1.018	1.121	0.784	0.950	1.070	6.99
	Oak Ridge	0.305	0.307	0.023	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.64
	Other	0.011	0.016	0.002	0.001	0.002	0.002	0.003	0.001	0.000	0.000	0.04
<b>1970s</b>		<b>FY 1970</b>	<b>FY 1971</b>	<b>FY 1972</b>	<b>FY 1973</b>	<b>FY 1974</b>	<b>FY 1975</b>	<b>FY 1976</b>	<b>FY 1977</b>	<b>FY 1978</b>	<b>FY 1979</b>	
	Paducah GDP	0.000	0.361	1.539	0.279	0.000	0.000	0.000	0.000	0.000	0.000	2.18
	Fernald	1.240	0.288	0.047	0.184	0.608	0.028	0.014	0.074	0.046	0.031	2.56
	Oak Ridge	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.00
	Other	0.000	0.294	0.002	0.000	0.510	0.002	0.002	0.002	0.048	0.004	0.86
<b>1980s</b>		<b>FY 1980</b>	<b>FY 1981</b>	<b>FY 1982</b>	<b>FY 1983</b>	<b>FY 1984</b>	<b>FY 1985</b>	<b>FY 1986</b>	<b>FY 1987</b>	<b>FY 1988</b>	<b>FY 1989</b>	
	Paducah GDP	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.00
	Fernald	0.029	0.046	0.039	0.080	0.471	0.547	0.660	0.187	0.062	0.000	2.12
	Oak Ridge	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.00
	Other	0.005	0.013	0.009	0.003	0.006	0.005	0.009	0.004	0.013	0.009	0.08
<b>1990s</b>		<b>FY 1990</b>	<b>FY 1991</b>	<b>FY 1992</b>	<b>FY 1993</b>	<b>FY 1994</b>	<b>FY 1995</b>	<b>FY 1996</b>	<b>FY 1997</b>	<b>FY 1998</b>	<b>FY 1999</b>	
	Paducah GDP	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.00
	Fernald	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.00
	Oak Ridge	0.000	0.000	0.000	0.004	0.000	0.000	0.000	0.000	0.000	0.000	0.00
	Other	0.006	0.008	0.006	0.123	0.009	0.010	0.124	0.015	0.000	0.000	0.30
<b>Explanatory Notes:</b>												
NA = Not Applicable												
Identified Hanford historical data indicates typical Np concentrations ranged from 20 - 500 ppb												
Estimates based on an average maximum Np concentration for all shipments (ppb) = 500												
Conversion factor (Kg/MT per 1ppb) = 0.000001												
Analytical data was only found for a limited number of years, all other years were assumed similar.												
								Total To Paducah GDP =				37.2
								Total To Fernald =				12.6
								Total To Oak Ridge =				2.2
								Total To Other =				2.8
								<b>Grand Total Shipped =</b>				<b>54.9</b>

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Estimates of Annual Recycled Uranium Constituents Shipped Offsite

Table I-9 Estimated Minimum Tc In Hanford Recycled Uranium Shipments (Kg)

	Site	Technetium Shipped In Recycle Uranium (Kg)										Decade Subtotal
		FY 1950	FY 1951	FY 1952	FY 1953	FY 1954	FY 1955	FY 1956	FY 1957	FY 1958	FY 1959	
1950	Paducah GDP	NA	NA	0.000	0.000	6.699	7.760	12.315	16.158	18.169	15.607	76.71
	Fernald	NA	NA	0.000	0.000	0.000	0.799	1.235	1.047	1.096	1.527	5.70
	Oak Ridge	NA	NA	0.463	1.811	3.528	1.498	0.868	0.296	0.027	0.865	9.36
	Other	NA	NA	0.000	6.927	2.120	0.110	0.011	0.005	0.027	0.048	9.25
1960s		FY 1960	FY 1961	FY 1962	FY 1963	FY 1964	FY 1965	FY 1966	FY 1967	FY 1968	FY 1969	
	Paducah GDP	15.444	18.281	16.475	17.316	12.262	0.000	0.000	43.299	0.000	10.611	133.69
	Fernald	1.148	1.002	1.288	4.331	4.533	6.108	6.727	4.704	5.701	6.417	41.96
	Oak Ridge	1.832	1.845	0.140	0.005	0.000	0.000	0.000	0.000	0.000	0.000	3.82
Other	0.068	0.094	0.010	0.009	0.009	0.012	0.019	0.005	0.000	0.002	0.23	
1970s		FY 1970	FY 1971	FY 1972	FY 1973	FY 1974	FY 1975	FY 1976	FY 1977	FY 1978	FY 1979	
	Paducah GDP	0.000	2.165	9.235	1.674	0.000	0.000	0.000	0.000	0.000	0.000	13.07
	Fernald	7.438	1.729	0.285	1.105	3.649	0.167	0.087	0.442	0.279	0.185	15.37
	Oak Ridge	0.000	0.000	0.001	0.000	0.006	0.000	0.000	0.001	0.001	0.001	0.01
Other	0.002	1.762	0.015	0.002	3.060	0.011	0.012	0.012	0.291	0.025	5.19	
1980s		FY 1980	FY 1981	FY 1982	FY 1983	FY 1984	FY 1985	FY 1986	FY 1987	FY 1988	FY 1989	
	Paducah GDP	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.00
	Fernald	0.175	0.274	0.233	0.480	2.829	3.279	3.959	1.123	0.371	0.001	12.72
	Oak Ridge	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.00
Other	0.028	0.077	0.054	0.020	0.038	0.030	0.056	0.025	0.080	0.055	0.46	
1990s		FY 1990	FY 1991	FY 1992	FY 1993	FY 1994	FY 1995	FY 1996	FY 1997	FY 1998	FY 1999	
	Paducah GDP	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.00
	Fernald	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.00
	Oak Ridge	0.000	0.000	0.000	0.026	0.000	0.000	0.000	0.000	0.000	0.000	0.03
Other	0.038	0.050	0.038	0.740	0.052	0.058	0.744	0.090	0.000	0.000	1.81	

Explanatory Notes:  
NA = Not Applicable

Identified Hanford historical data indicates typical Tc concentrations ranged from 3 -12 ppm

Estimates based on an average minimum Tc concentration for all shipments (ppm) = 3

Conversion factor (Kg/MT per 1ppm) = 0.001

Analytical data was only found for a limited number of years, all other years were assumed similar.

Total To Paducah GDP =	223.5
Total To Fernald =	75.8
Total To Oak Ridge =	13.2
Total To Other =	16.9
<b>Grand Total Shipped =</b>	<b>329.4</b>

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## Estimates of Annual Recycled Uranium Constituents Shipped Offsite

**Table I-10 Estimated Mean Tc In Hanford Recycled Uranium Shipments (Kg)**

	Site	Technetium Shipped In Recycle Uranium (Kg)										Decade Subtotal
		FY 1950	FY 1951	FY 1952	FY 1953	FY 1954	FY 1955	FY 1956	FY 1957	FY 1958	FY 1959	
<b>1950</b>	Paducah GDP	NA	NA	0.000	0.000	16.748	19.400	30.788	40.394	45.423	39.018	191.77
	Fernald	NA	NA	0.000	0.001	0.000	1.997	3.086	2.616	2.739	3.817	14.26
	Oak Ridge	NA	NA	1.158	4.527	8.821	3.746	2.169	0.741	0.068	2.162	23.39
	Other	NA	NA	0.000	17.318	5.300	0.274	0.028	0.013	0.069	0.121	23.12
<b>1960s</b>		<b>FY 1960</b>	<b>FY 1961</b>	<b>FY 1962</b>	<b>FY 1963</b>	<b>FY 1964</b>	<b>FY 1965</b>	<b>FY 1966</b>	<b>FY 1967</b>	<b>FY 1968</b>	<b>FY 1969</b>	
	Paducah GDP	38.610	45.703	41.189	43.290	30.655	0.000	0.000	108.247	0.000	26.529	334.22
	Fernald	2.870	2.504	3.221	10.828	11.333	15.271	16.817	11.761	14.254	16.043	104.90
	Oak Ridge	4.580	4.612	0.351	0.012	0.000	0.000	0.001	0.000	0.000	0.000	9.55
	Other	0.170	0.235	0.024	0.022	0.023	0.029	0.046	0.011	0.000	0.005	0.57
<b>1970s</b>		<b>FY 1970</b>	<b>FY 1971</b>	<b>FY 1972</b>	<b>FY 1973</b>	<b>FY 1974</b>	<b>FY 1975</b>	<b>FY 1976</b>	<b>FY 1977</b>	<b>FY 1978</b>	<b>FY 1979</b>	
	Paducah GDP	0.000	5.412	23.089	4.186	0.000	0.000	0.000	0.000	0.000	0.000	32.69
	Fernald	18.595	4.323	0.711	2.763	9.122	0.417	0.217	1.105	0.697	0.463	38.41
	Oak Ridge	0.000	0.000	0.001	0.000	0.014	0.000	0.000	0.003	0.002	0.002	0.02
	Other	0.004	4.406	0.037	0.004	7.650	0.027	0.029	0.030	0.727	0.062	12.97
<b>1980s</b>		<b>FY 1980</b>	<b>FY 1981</b>	<b>FY 1982</b>	<b>FY 1983</b>	<b>FY 1984</b>	<b>FY 1985</b>	<b>FY 1986</b>	<b>FY 1987</b>	<b>FY 1988</b>	<b>FY 1989</b>	
	Paducah GDP	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.00
	Fernald	0.439	0.685	0.583	1.201	7.072	8.198	9.897	2.808	0.929	0.002	31.81
	Oak Ridge	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.00
	Other	0.071	0.193	0.136	0.049	0.096	0.074	0.139	0.061	0.200	0.137	1.16
<b>1990s</b>		<b>FY 1990</b>	<b>FY 1991</b>	<b>FY 1992</b>	<b>FY 1993</b>	<b>FY 1994</b>	<b>FY 1995</b>	<b>FY 1996</b>	<b>FY 1997</b>	<b>FY 1998</b>	<b>FY 1999</b>	
	Paducah GDP	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.00
	Fernald	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.00
	Oak Ridge	0.000	0.000	0.000	0.064	0.000	0.000	0.000	0.000	0.000	0.000	0.06
	Other	0.096	0.125	0.094	1.850	0.129	0.145	1.860	0.224	0.000	0.000	4.52

<p>Explanatory Notes:                  NA = Not Applicable                  Identified Hanford historical data indicates typical Tc concentrations ranged from 3 - 12 ppm                  Estimates based on an average mean Tc concentration for all shipments (ppm) = 7.5                  Conversion factor (Kg/MT per 1ppm) = 0.001                  Analytical data was only found for a limited number of years, all other years were assumed similar.</p>	<p>Total To Paducah GDP = 558.7                  Total To Fernald = 189.4                  Total To Oak Ridge = 33.0                  Total To Other = 42.3  <b>Grand Total Shipped = 823.4</b></p>
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Estimates of Annual Recycled Uranium Constituents Shipped Offsite

Table I-11 Estimated Maximum Tc In Hanford Recycled Uranium Shipments (Kg)

	Site	Technetium Shipped In Recycle Uranium										Decade
		FY 1950	FY 1951	FY 1952	FY 1953	FY 1954	FY 1955	FY 1956	FY 1957	FY 1958	FY 1959	Subtotal
1950s	Paducah GDP	NA	NA	0.000	0.000	26.796	31.041	49.260	64.631	72.677	62.429	306.83
	Fernald	NA	NA	0.000	0.001	0.000	3.194	4.938	4.186	4.382	6.108	22.81
	Oak Ridge	NA	NA	1.853	7.243	14.113	5.993	3.470	1.185	0.109	3.459	37.43
	Other	NA	NA	0.000	27.709	8.479	0.439	0.045	0.020	0.110	0.193	37.00
1960s		<b>FY 1960</b>	<b>FY 1961</b>	<b>FY 1962</b>	<b>FY 1963</b>	<b>FY 1964</b>	<b>FY 1965</b>	<b>FY 1966</b>	<b>FY 1967</b>	<b>FY 1968</b>	<b>FY 1969</b>	
	Paducah GDP	61.777	73.125	65.902	69.263	49.048	0.000	0.000	173.195	0.000	42.446	534.76
	Fernald	4.592	4.007	5.153	17.325	18.133	24.434	26.908	18.818	22.806	25.668	167.84
	Oak Ridge	7.327	7.379	0.562	0.019	0.000	0.000	0.001	0.000	0.000	0.000	15.29
	Other	0.273	0.376	0.039	0.036	0.037	0.046	0.074	0.018	0.000	0.008	0.91
1970s		<b>FY 1970</b>	<b>FY 1971</b>	<b>FY 1972</b>	<b>FY 1973</b>	<b>FY 1974</b>	<b>FY 1975</b>	<b>FY 1976</b>	<b>FY 1977</b>	<b>FY 1978</b>	<b>FY 1979</b>	
	Paducah GDP	0.000	8.659	36.942	6.697	0.000	0.000	0.000	0.000	0.000	0.000	52.30
	Fernald	29.752	6.916	1.138	4.421	14.596	0.667	0.347	1.768	1.115	0.740	61.46
	Oak Ridge	0.000	0.000	0.002	0.000	0.023	0.000	0.000	0.004	0.002	0.004	0.04
	Other	0.006	7.049	0.059	0.006	12.240	0.043	0.047	0.048	1.162	0.099	20.76
1980s		<b>FY 1980</b>	<b>FY 1981</b>	<b>FY 1982</b>	<b>FY 1983</b>	<b>FY 1984</b>	<b>FY 1985</b>	<b>FY 1986</b>	<b>FY 1987</b>	<b>FY 1988</b>	<b>FY 1989</b>	
	Paducah GDP	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.00
	Fernald	0.702	1.096	0.933	1.922	11.315	13.116	15.835	4.492	1.486	0.003	50.90
	Oak Ridge	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.00
	Other	0.114	0.309	0.217	0.079	0.154	0.119	0.222	0.098	0.319	0.219	1.85
1990s		<b>FY 1990</b>	<b>FY 1991</b>	<b>FY 1992</b>	<b>FY 1993</b>	<b>FY 1994</b>	<b>FY 1995</b>	<b>FY 1996</b>	<b>FY 1997</b>	<b>FY 1998</b>	<b>FY 1999</b>	
	Paducah GDP	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.00
	Fernald	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.00
	Oak Ridge	0.000	0.000	0.000	0.102	0.000	0.000	0.000	0.000	0.000	0.000	0.10
	Other	0.154	0.201	0.151	2.960	0.207	0.232	2.976	0.359	0.000	0.000	7.24

Explanatory Notes:  
 NA = Not Applicable  
 Identified Hanford historical data indicates typical Tc concentrations ranged from 3 - 12 ppm  
 Estimates based on an average maximum Tc concentration for all shipments (ppm) = 12  
 Conversion factor (Kg/MT per 1ppm) = 0.001000  
 Analytical data was only found for a limited number of years, all other years were assumed similar.

Total To Paducah GDP =	893.9
Total To Fernald =	303.0
Total To Oak Ridge =	52.9
Total To Other =	67.8
<b>Grand Total Shipped =</b>	<b>1,317.5</b>



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**Estimates of Annual Recycled Uranium Constituents Shipped Offsite**

**Table I-12 Estimated Constituents Based On  
Low Value Of Constituent Boundary Range**

Recycle Uranium Category	Recycle Uranium (MTU)	Constituents		
		Pu (g)	Np (Kg)	Tc (Kg)
Receipts	109,144	1.1	0.3274	1.1
Shipments	109,792	109.8	2.20	329.4
On-Site Wastes				
Tank Waste	958	0.96	0.0192	2.87
Solid Waste	1,054	1.05	0.0211	3.16
Total In Waste	2,012	2.01	0.040	6.0
Environmental Releases	162	0.16	0.0032	0.49
Current Inventory				
UO <sub>3</sub> and Metal	1,863	1.9	0.0373	5.6
Spent Fuel	2,137	NA	NA	NA
PNNL Inventory	6	0.006	0.0001	0.018
Total In Scope Inventory	1,869	1.9	0.0374	5.6
<b>Notes:</b>				
	Estimated Constituents	Pu (ppb)	Np (ppb)	Tc (ppm)
	Low Concentration In Shipments	1	20	3
	Low Concentration In Receipts*	0.01	3	0.01
*See Section 4.8.4				
	Conversion Factor (g/MT per ppb)	1.00E-03		
	Conversion Factor (Kg/MTU per ppb)	1.00E-06		
	Conversion Factor (Kg/MTU per ppm)	1.00E-03		

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## Estimates of Annual Recycled Uranium Constituents Shipped Offsite

**Table I-13 Estimated Constituents Based On Mean Value Of Constituent Boundary Range**

Recycle Uranium Category	Recycle Uranium (MTU)	Constituents		
		Pu (g)	Np (Kg)	Tc (Kg)
Receipts	109,144	327.4	0.71	327.4
Shipments	109,792	329.4	28.5	823.4
On-Site Wastes				
Tank Waste	958	2.87	0.25	7.19
Solid Waste	1,054	3.16	0.27	7.91
Total In Waste	2,012	6.0	0.52	15.1
Environmental Releases	162	0.49	0.042	1.22
Current Inventory				
UO <sub>3</sub> and Metal	1,863	5.6	0.48	14.0
Spent Fuel	2,137	NA	NA	NA
PNNL Inventory	6	0.018	0.002	0.045
Total In Scope Inventory	1,869	5.6	0.49	14.0
<b>Notes:</b>				
Estimated Constituents		Pu (ppb)	Np (ppb)	Tc (ppm)
Mean Concentration In Shipments		3	260	7.5
Mean Concentration In Receipts*		3	6.5	3
*See Section 4.8.4				
Conversion Factor (g/MT per ppb)		1.00E-03		
Conversion Factor (Kg/MTU per ppb)		1.00E-06		
Conversion Factor (Kg/MTU per ppm)		1.00E-03		

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## Estimates of Annual Recycled Uranium Constituents Shipped Offsite

**Table I-14 Estimated Constituents Based On High Value Of Constituent Boundary Range**

Recycle Uranium Category	Recycle Uranium (MTU)	Constituents		
		Pu (g)	Np (Kg)	Tc (Kg)
Receipts	109,144	654.9	1.09	654.9
Shipments	109,792	549.0	54.9	1,317.5
On-Site Wastes				
Tank Waste	958	4.8	0.48	11.5
Solid Waste	1,054	5.3	0.53	12.6
Total In Waste	2,012	10.1	1.0	24.1
Environmental Releases	162	0.81	0.08	1.9
Current Inventory				
UO <sub>3</sub> and Metal	1,863	9.3	0.93	22.4
Spent Fuel	2,137	NA	NA	NA
PNNL Inventory	6	0.030	0.003	0.072
Total In Scope Inventory	1,869	9.3	0.93	22.4
<b>Notes:</b>				
	Estimated Constituents	Pu (ppb)	Np (ppb)	Tc (ppm)
	High Concentration In Shipments	5	500	12
	High Concentration In Receipts*	6	10	6
*See Section 4.8.4				
	Conversion Factor (g/MT per ppb)	1.00E-03		
	Conversion Factor (Kg/MTU per ppb)	1.00E-06		
	Conversion Factor (Kg/MTU per ppm)	1.00E-03		

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