Dr. Weyzen

712401

March 20, 1973

James L. Liverman, Director
Division of Biomedical and
Environmental Research

REPORT OF COMMITTEE

Attached for your review and evaluation is a copy of the report which has been prepared by the Plutonium Program Plan Committee. This report very briefly reviews each area of concern and provides a plan to involve the DBER staff in a more thorough and critical review of the current status and future needs of DBER in plutonium research to insure that this Division is responsive to RDT needs.

N. F. Barr, Assistant Director
for Measurement & Evaluation, DBER

C. W. Edington
Chief, Biology Branch, DBER

J. Harley, Director
Health and Safety Laboratory

C. L. Osterberg, Assistant Director
for Environmental Sciences, DBER

Attachment:
Report

J. Harley
3/ /73

OFFICE ▶	BER:BB	ADME	ADES	ADBS	DEP DIR	~~XXX~~
SURNAME ▶	Edington/bel	Barr	Osterberg	Kirby-Smith	Burr	~~XXXXXXX~~
DATE ▶	3/20/73	3/2?/73	3/20/73	3/ /73	3/ /73	

INTRODUCTION

In response to your charge for the development of a plan concerning the hazards of plutonium that would insure that DBER is more responsive to the needs of RDT, this Committee has had two meetings (March 2 and March 13) with staff of RDT and has attempted, in the short time available, to determine the major biomedical and environmental problems facing RDT in the development and implementation of their fast breeder reactor program. It has also attempted to review broadly the information that is already available on plutonium as to its distribution in the biosphere, its transport through the environment from source to man, and its toxicity on experimental animals. As a consequence of this review the Committee has tried to identify areas in which new or increased research effort should be emphasized.

In view of the complex and diversified nature of the research effort that is aimed at resolving problems related to the biomedical and environmental effects of plutonium and other important transuranium radionuclides, a more concentrated, in-depth, review of specific problem areas must be conducted. In this way the Division can develop a program effort that is strong, balanced, and at the same time, responsive to the needs of RDT. To accomplish this, a plan has been developed which, in our opinion, will allow more effective use of DBER staff in such a program evaluation and planning exercise. It will allow the staff efforts to be concentrated on specific problem areas and thus make more efficient use of their time and research backgrounds. This plan is presented below for your consideration and as a basis for further discussion with you.

NEEDS AS DEFINED BY RDT

Criteria for the release of Pu and other transuranics have and will continue to strongly influence the timing and cost of developing advanced power reactors and their supporting facilities. Even though Pu^{239} is a very valuable material, control procedures developed against its value as a fuel, or for safeguard purposes, would permit release of quantities to the environment that are unacceptable from the standpoint of human health. Thus, systems for control and containment of Pu and other transuranics are established in response to bioenvironmental criteria.

The principal requirements RDT has for bioenvironmental information arise from their need to engineer against the release of quantities of plutonium which are environmentally not acceptable.

(1) RDT's most pressing need is for assurance that current MPC's are defensible. They are fearful that the use of current MPC's as criteria for engineering design of containment systems may be successfully attacked. The need to undertake design changes and retrofitting in connection with the upcoming LMFBR demonstration plant would be exceedingly expensive and could substantially delay LMFBR development.

(2) A longer range need is the requirement that MPC's not be unduly conservative.

(3) Important, but of less urgency, is the need for information on the dispersal, environmental transport and health consequences of environmental plutonium at concentrations substantially below MPC's.

The development of a plan which will evaluate how our current efforts and future research needs on the environmental and health effects of plutonium relate to these RDT requirements is essential and is proposed in this report.

ANALYSIS AND EVALUATION

Current MPC's are not based on explicit estimates of risks. Past experience demonstrates that when MPC's are challenged it is by making (unrealistically) high estimates of health consequences which might arise from releases at MPC. A cogent way to demonstrate the relevance of our current and future research is to identify how it provides information required for realistic and defensible risk estimates.

BIOMEDICAL EFFECTS

Shortly after the discovery of plutonium, it was recognized to be a potentially hazardous substance from a biological standpoint. The use of large quantities of plutonium in the weapons program of the Manhattan District made it essential that experimental animal studies be initiated to determine its biological effects. Because of the similarities of plutonium to radium, it was assumed that estimates of the biological effects of plutonium in man could be made if its effects in experimental animals were known. This assumption seemed reasonable in view of the fact that the biological effects of radium were known for experimental animals and considerable information was becoming available of the effects of radium in man. However, because of the difference subsequently discovered in the pattern of deposition of plutonium in the bone as compared to that of radium, this simple approach to estimating the potential hazards to man has been rejected.

Although work on rodents was carried out in the late forties, experimental work on the beagle dog was initiated at the University of Utah by DBM in 1952 to obtain data needed for evaluation of the biological effects of plutonium, radium and other transuranium elements.

Subsequently, considerable experimental work has been supported by DBM (DBER) in this country and by Atomic Energy Agencies of other countries (e.g., England, Russia, Canada, and Japan). Much important information has been obtained concerning the metabolism, translocation, deposition and toxicity of plutonium and related radionuclides as a result of these studies. The radionuclides have been administered to a variety of experimental animals in a number of different ways (inhalation, intravenous injection, subcutaneous injection, ingestion, intratracheal intubation, etc.). The results of these experiments have clearly established that the chemical and physical form of plutonium as well as its port of entry into the body is important with respect to its fate and the biological effects that it produces. In fact, it is apparent that isotopic effects (Pu^{238} vs. Pu^{239}) exist to confuse the issue. It has become relatively clear that the most probable source of exposure of importance to hazard evaluation in man is by inhalation. Exposure through the skin as a result of injury such as cuts or puncture wounds or by ingestion and absorption through the gastrointestinal epithelium are less important routes of entry for plutonium.

The first large scale experiments that were initiated with the dog to evaluate the biological effects of plutonium are now completed. In one of these experiments (Utah) it has been found that at the lowest level of plutonium citrate exposure (intravenous injection) approximately 35 percent of the animals died with osteosarcoma although, at this exposure level, the average life span of the dogs was not significantly different from the controls. In the other experiment (Battelle Northwest) in which plutonium oxide was administered by inhalation, it has been found that 20 of 21 exposed dogs that have lived longer than 1600 days have died of lung tumors. Because of these results, both experiments have been extended and lower levels of plutonium exposures are now being utilized. Data from these experiments will not become available for several years due to the long life-span of the dog.

Although information has been obtained with smaller experimental animals (rats, rabbits and mice), the different experimental techniques used have made it relatively difficult for comparison of effects. In addition, the amount of information that is available is not that extensive. It would seem that one of the more obvious weaknesses with our early experimental approach to this particular problem is that too little emphasis, for whatever reason, was placed on the use of smaller, short life-span experimental animals to obtain results for meaningful comparison with the dog, possible generalization of biological response and potential extrapolation to man. This deficiency in our program, if real, should be recognized and incorporated in our future program plans.

Another deficiency exists in our program to determine the late effects of plutonium in living organisms. To date all, or nearly all, experimental studies relate to effects produced as a result of acute exposure (accident-related episodes) as compared to chronic exposure to low levels of plutonium (occupational or individual exposure experience). It seems that experiments designed to determine the late effects produced by such exposures should be an important part of our research program and necessary for adequate evaluation of the potential hazards of plutonium to man.

To be more responsive to RDT or other AEC groups, it is important that our future research efforts in this area be directed at obtaining information on the biological effects of selected, but relevant, transuranium elements or mixtures of such elements as opposed to collecting data on any or all such elements because of their intrinsic scientific interest. I do not want to convey the idea that information of interest from a scientific standpoint, other than application to RDT needs, should not be pursued. If, however, information is needed for future reactor planning and development, a reasonable share of our current budget in this research area should be utilized for this purpose. To accomplish this objective effectively, economically and on a scientifically sound basis, current and future experimental programs must be planned carefully to insure that the data obtained will be meaningful and directly applicable to potential exposure conditions that are anticipated.

ENVIRONMENTAL

One of the least known phases of the plutonium picture is its transport in the environment, i.e., once dispersed, how does plutonium return to man? A first look indicates that the most important pathway is through the air, with the threat to man diminishing once the Pu is deposited on land or in water. However, the pathways to man are not yet well defined.

It is likely in the long term that these pathways will become more and more important in exposure of the world's population.

(1) Atmospheric

In the short term, the principal transport of Pu in the vicinity of a source is through the air. It is the primary route of exposure in both the accident and the non-accident cases.

(2) Terrestrial

The major long term concern to man appears to be Pu deposited on dry land. Airborne Pu is concentrated at the air - land interface, where for many years thereafter it is subject to resuspension. Terrestrial animals, including man, will be repeatedly exposed to Pu through inhalation whenever the winds are sufficiently strong to cause resuspension.

Of second order concern are deposition on plant material, foliar absorption and root uptake as entries into the food chains of man. Low absorption of Pu across the gut wall has been demonstrated for inorganic compounds but chelated Pu is more easily absorbed. More knowledge about the gut absorption of biologically chelated Pu is needed. Since most of our knowledge derives from Pu at NTS, Eniwetok, or Rocky Flats, we know little of the transport through foodstuffs grown on soil rich in humus.

(3) Aquatic

A. Freshwater

Drinking water appears to be an insignificant route of entry of Pu. Municipal water treatment will probably remove most Pu, and the low rate of absorption is a further safeguard.

The small fraction of our foodstuffs from lakes and rivers also is reassuring. The use of this water for irrigation may present a problem, but this will be revealed in work recommended under "Terrestrial."

B. Marine

The ocean presents a special problem because of its international aspects and existing legislation against dumping. In the long term, the present ban may be unwise. The deep ocean may well prove to be the proper deposition site for waste Pu.

Seven (7) metric tons of Pu^{239} are already in the ocean, or soon will be, from world fallout. Most is rapidly removed to deeper water, presumably away from man. However, the widely publicized ability of marine organisms to concentrate Ra will work against any efforts to use the ocean as a sink for Pu.

RECOMMENDATIONS

In order for the Division to determine the future course of action that it should adopt to be more responsive to RDT, it is recommended that the following task forces be appointed to consider the status of our current program efforts and to recommend future research directions in the proposed areas of concern if the situation warrants it:

TASK FORCE 1 - The objectives of this group are to develop quantitative estimates at MPC levels of health consequences arising from releases of Pu and other transuranics of priority interest to RDT.

The activity will require prediction of population exposures arising from realistic release situations (accidental Pu-U aerosal release, chronic ground, air and water contamination from continuous operating releases from

LMFBR and reprocessing plants) as well as prediction of health effects arising from these exposures.

These analyses will draw upon existing compilations (BEIR, UNSCEAR, NSIC, etc.), related analytical activities as results are available (TTG, NCRP, etc.), and continuing contact with designated RDT staff.

STAFF - Drs. Grahn, Cooper, Watters, Stapleton, Goldman

TASK FORCE 2 - The objectives of this group will be to summarize and to evaluate the major important information that is currently available on the biological effects of plutonium and related radionuclides and to recommend new experimental research efforts that might be needed to be responsive to RDT needs on a scientifically sound and timely basis and epidemiology.

STAFF - Drs. Goldman, Wachholz, Stapleton, Marks, Wood

TASK FORCE 3 - The objectives of this group will be to evaluate the current status, rationale and need for comparative radiobiological studies on different species of experimental animals. In view of the long term nature of experiments using dogs, it seems reasonable to assume that similar experiments on animals with shorter life spans may permit reasonable and more timely estimation of potential hazards to man. Possible methods for resolution of apparent species differences must be considered by this group. Comparative biological responses of experimental animals to radiation (regardless of source) should be considered by this group.

STAFF - Drs. Schulman, Persing, Still, Brooks

TASK FORCE 4 - The objectives of this group are to consider the feasibility of using simple in vivo or in vitro experimental systems and/or techniques (molecular, cellular and cytogenetic) for quick, reliable and economical assessment of the biological consequences of plutonium and related radionuclides.

SUBGROUP A - MOLECULAR AND BIOCHEMICAL TECHNIQUES

STAFF - Drs. Minthorn, Duda, Shepherd, Kornfeld

SUBGROUP B - CELLULAR AND CYTOGENETIC TECHNIQUES

STAFF - Drs. Bender, Shepherd, Matney, Harvey

TASK FORCE 5 - The objectives of this group are to consider the current status and need for additional work on techniques for reducing the body burden of individuals who have been exposed to plutonium or related radionuclides.

STAFF - Drs. Weyzen, Marks, Duda, Minthorn

TASK FORCE 6 - The objectives of this group are to examine resuspension as a mode of transfer of plutonium from the environment to man and animals, to assess our current work in the area, and determine its adequacy.

STAFF - Drs. Watters, Wachholz, Still, Mr. Slade, Myers

TASK FORCE 7 - This group should examine the importance of transport of Pu through terrestrial food chains as a hazard to man or constituents in the chain. Attention should be given to deposition on plant material, foliar uptake and root uptake, particularly from rich humic soils, from which most foodstuffs are derived.

STAFF - Drs. Franklin, Fraley, Rabson, Brooks

TASK FORCE 8 - This group should examine the aquatic food chains, particularly marine, to assess the extent of the return of Pu to man from the ocean. Special attention should be given to the prospective role of the Eniwetok Marine Biological Laboratory in future studies.

STAFF - Drs. Forster, Saunders, Harvey, Rabson

Dr. Marks

UNITED STATES
ATOMIC ENERGY COMMISSION
WASHINGTON, D.C. 20545

March 21, 1973

Plutonium Task Force Members

MEETING DATES FOR PLUTONIUM TASK FORCES

A special meeting of the individual plutonium task force groups will be held Friday, March 23. The first meeting will be largely to organize and distribute background reading material. Scheduling of Friday's meeting should be by the Task Force leaders.

However, future meetings will have to be scheduled to conform with Dr. Harley's presence.

Beginning Monday and Tuesday, March 26 and 27, and continuing every Monday and Tuesday until further notice, meetings will be as follows:

Monday,	1 p.m.	Task Force 1
"	2 p.m.	Task Force 2
"	3 p.m.	Task Force 3
"	4 p.m.	Task Force 4
Tuesday,	9 a.m.	Task Force 5
"	10 a.m.	Task Force 6
"	11 a.m.	Task Force 7
"	12 noon	Task Force 8

Travel should be reduced to a minimum until the work of the groups is completed.

Charles Osterberg
Charles L. Osterberg
Assistant Director for
Environmental Sciences
Division of Biomedical and
Environmental Research

UNITED STATES
ATOMIC ENERGY COMMISSION
WASHINGTON, D.C. 20545

March 21, 1973

D. Grahn
M. Goldman
M. Schulman
M. Minthorn
M. Bender
W. Weyzen
R. Watters
R. Franklin
W. Forster

SPECIFIC GUIDELINES FOR TASK FORCE OPERATION

To effectively coordinate activities of our plutonium research program evaluation, a few guidelines have been set up and should be followed by each Task Force. So that all of you will be equally informed, the following list of guidelines should indicate what is expected of you and to whom you should go with specific information requests.

1. Interaction with RDT: In our discussions with staff of RDT, it was apparent that they welcomed informal interaction with DBER staff on any matter related to this study. In view of the number of staff involved in our exercise, however, it is important that contact with RDT staff be controlled in part. Therefore, each Task Force Chairman or a person to be designated by him should be the point of contact between his group and RDT staff for informal question and answer problems. The individuals in RDT with whom we have had contact and to whom informal questions could be directed are:

Mr. Wallace Kornack, Technical Assistant to the Director
Mr. A. P. D'Zmura, Chief, Environmental Effects Branch
Dr. William H. McVey
Mr. Delbert F. Bunch

If any Task Force feels that it needs information that is detailed in nature or will require considerable involvement of RDT staff (for example, detailed information on source terms with respect to chemical or physical form, etc.), a request spelling out in detail what is wanted should be forwarded to Dr. Barr who will prepare a formal memo to the Director, RDT, for Dr. Liverman's signature. It is important that this aspect of our evaluation process be adhered to closely.

2. <u>Interaction with experts in the field</u>: To insure that the experts in plutonium research are not inundated with requests for information or assistance, each Task Force Chairman should make his group's needs known in writing to me. It will be my responsibility to coordinate the requests from all groups and contact the expert in question. In this way better communication and less confusion will occur.

3. <u>Use of the Oak Ridge Plutonium Data Bank</u>: It is conceivable that each Task Force will want to request information from the Environmental Information Center at Oak Ridge for use in their review and evaluation activities. If such information is required, please make your needs known to me so that a single, initial request can be made to the Information Center at Oak Ridge. If additional information is required, specific requests can be made through my office also.

Since Drs. Barr, Osterberg, Harley and I will want to be involved in the weekly information and planning meetings of each group, it would be appreciated if each Chairman would arrange the time that his group meeting will be held so that it does not conflict with other group meetings. This can best be done by working with Dr. Osterberg who will coordinate the schedule for the Task Force meetings. To accommodate Dr. Harley who will have to make special travel arrangements to participate in our program review, all such weekly meetings should be scheduled, if possible, for Monday afternoon, Tuesday morning or afternoon. Your cooperation in this matter will be greatly appreciated. It is not anticipated that the first meeting of each Task Force needs to meet this requirement. In fact all of the first meetings should be held before the end of this week.

It should be understood that members of any Task Force should feel free to call on members of any other Task Force for information or assistance in their review processes. Further, it is felt that each of you and each member of your Task Force should be impressed with the importance and priority of the evaluation of the current status and needs of our plutonium research efforts and how our research meets the needs of RDT.

It is anticipated that travel of the staff will be kept to a minimum over the next month so that this study can be completed within the time schedule that Dr. Liverman has given us.

Charles W. Edington
Chief, Biology Branch, DBER

cc: N. Barr
C. Osterberg
J. Harley
J. Liverman

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UNITED STATES
ATOMIC ENERGY COMMISSION
WASHINGTON, D.C. 20545

NOV 13 1972

James L. Liverman, Director
Division of Biomedical and Environmental Research

INFORMATION FOR USE BY TRANSURANIUM TECHNICAL GROUP (MEMORANDUM, JOHN R. TOTTER TO MILTON SHAW, DATED SEPTEMBER 29, 1972)

The reference memorandum and attachment requested information on current and predicted sources of transuranium elements and possible problem areas, for use by the Transuranium Technical Group in advising the Division of Biomedical and Environmental Research on the content and conduct of research into the possible hazards associated with the plutonium industry.

Information which may be useful to the Transuranium Technical Group is enclosed. Enclosure 1 is a brief examination of Light Water Reactor (LWR) and Liquid Metal-cooled Fast Breeder Reactor (LMFBR) fuel cycles, with emphasis on the quantities and distribution of plutonium throughout the fuel cycles. It is postulated that the most likely potential problem areas are those involving the preparation of fuel materials, the fabrication of fuels and the shipment of these materials.

Enclosure 2 presents an estimate of the total quantities of fissile plutonium expected to be recovered through the Year 2000.

Enclosure 3 is an estimate of the long-lived transuranium isotopes produced in LWRs and LMFBRs relative to the concentration of fissile plutonium produced by these reactor systems. By combining Enclosures 2 and 3 it is possible to estimate the cumulative quantities of transuranium elements present in the U.S. through the Year 2000. It should be noted that essentially all the transplutonic isotopes will be present in the high-level wastes from reprocessing and should present no additional hazard in the fabrication of plutonium containing fuel.

Enclosure 4 provides information on the isotopic composition of LWR-produced plutonium, and describes potential plutonium releases to the environment from LMFBRs and fuel cycle facilities. These releases are defined in terms of chemical form, particle size, and the presence of fission products. A number of uncertainties which must be resolved regarding plutonium in the environment are identified. The presence

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of uranium oxide in solid solution with plutonium oxide changes the solubility in mineral acids when compared with pure plutonium oxides. For example, studies at the Hanford Engineering Development Laboratory (HEDL-TME-72-67, "Dissolution of Unirradiated Mechanically Blended, Sol-Gel, and Coprecipitated Mixed Oxide Fuel") showed the fabrication history influenced the dissolution properties of the fuel in concentrated nitric acid. In particular, fuel sintering temperature, source of PuO_2 (i.e., oxalate, nitrate or burned metal derived PuO_2) and PuO_2 content of the fuel had major effects on fuel dissolution characteristics. The established Maximum Permissible Concentrations (MPC) for plutonium only discriminated between "soluble" and "insoluble" species. The extent to which the various fabrication parameters will affect the MPC has not been closely examined.

The physical and chemical characteristics of the various compounds of plutonium encountered in the course of recycling plutonium, in either LWR's or LMFBR's, are provided in Enclosures 1 & 4. Based on these characteristics, we would propose, for your consideration, the following course of action in biomedical and related research to provide a more thorough understanding for the requirements to contain plutonium during recycle, for both exposure to the general population and occupational exposures and for both normal operating and accident conditions.

1. Reevaluate and/or redetermine, as necessary, the body burden for plutonium as a function of the characteristics of plutonium for the several intake paths and for critical body organs.

2. Reevaluate and/or redetermine, as necessary, the MPC for airborne particulate plutonium as a function of the physical and chemical characteristics of the plutonium before and after environmental redistribution.

3. Identify, based on existing information, any significant departures from commonly used models for movement of radioactive materials through the biosphere that may be occasioned because of any unique characteristics of plutonium.

4. Develop insofar as appropriate, a rational basis for defining plutonium or alpha bearing wastes (those that require isolation from the biosphere for very long terms) and a rational basis for defining the acceptable residual Pu contamination - needed in determining decommissioning requirements of plutonium fuel cycle facilities.

   Note: The handling of the actual disposal of alpha bearing wastes is the responsibility of the Division of Waste Management and Transportation; the development of facility design and operating criteria (which depends on, among other things, the definition of alpha wastes and the definition of a decontaminated facility) are the responsibility of several divisions including this one.

5. Investigate emergency medical procedures for minimizing the effects of plutonium taken into the bodies of workers in the industry under accident conditions.

The acquisition of the information outlined in the suggested course of action is believed to be necessary to confirm that those limits, criteria and procedures are, in the light of more recent evidence, indeed as conservative as believed when established some years ago. Further, certain guidelines have not yet been provided in Regulations but have been handled on an ad hoc basis; e.g., intake limits under emergency conditions. A defensible basis is needed to set such limits.

We would be pleased to continue to work with you on the development of relevent plutonium biomedical and environmental programs.

Milton Shaw, Director
Division of Reactor Development
and Technology

Enclosures:
1. "Environmental Research Relating to Plutonium in the Civilian Power Industry" (2 copies)
2. Chart, "Available Recovered Plutonium & Requirements in the U.S." (2 copies)
3. Table, "Production of Transuranium Elements in LWRs & LMFBRs" (2 copies)
4. "Plutonium Source Terms," w/attachment (2 copies)

cc: L. Muntzing, Dir., REG, w/encl.
L. Rogers, Dir., DRS, w/encl.
J. H. Rubin, AGMES, w/encl.
J. J. Flaherty, AGMED, w/encl.
S. G. English, AGMR, w/encl.
M. B. Biles, Dir., OS, w/encl.

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ENCLOSURE 1

ENVIRONMENTAL RESEARCH RELATING TO PLUTONIUM IN THE CIVILIAN POWER INDUSTRY

Prepared by

Fuel Recycle Branch

Division of Reactor Development and Technology

October 1972

Environmental Research Relating to Plutonium in the Civilian Power Industry

Nature of the Problem

In order to establish the nature of the potential environmental problem of handling plutonium in the civilian power industry, it is first desireable to examine the fuel cycle with respect to operations carried out in the cycle and the quantities of material involved at various stages of the fuel cycle.

Simplified fuel cycles for typical PWR's without and with plutonium recycle and for an oxide fueled LMFBR are shown in Figures 1 through 5. The principle plutonium streams are shown in red, the minor scrap recycle and waste streams in blue. These diagrams obviously do not cover all the operations within each major facility in the cycle nor do they show the relative numbers of facilities.

The major operations in a plant for the fabrication of plutonium-containing fuel are shown in Table 1. It is in the conversion, preparation and fabrication plants that plutonium exists in the most dispersable and concentrated forms.

The projected nuclear capacity in 1980 is 150,000 MWe, and the numbers of each of the major facilities associated with the fuel cycle for a 150,000 LWR economy are shown in Table 2.

The total quantities of plutonium involved in the fuel cycle in 1980, with and without plutonium recycle in LWR's, are shown in Table 3 for an installed nuclear capacity of 150,000 MWe. Plutonium does not represent a major potential source of radiation exposure in the fuel cycle until it has been isolated in the fuel reprocessing plant. Prior to this, during reactor operation, fuel storage and shipment, and the fuel reprocessing operation itself, fission products are the critical nuclides from a health and safety standpoint.

The year 1980 was chosen as a basis for the overview of the nature of the problem since commerce in plutonium is not expected to reach reasonable levels until that time. The recycle of plutonium in LWR's is assumed to be relatively insignificant until at least 1980. The LMFBR cycle can reasonably be expected to become significant in the 1980's.

Identification of Potential Problem Areas

Potential problem areas involving plutonium in the fuel cycle occur after plutonium has been isolated. The routine release limits set by 10 CFR Part 20 for plutonium isotopes are, of course, extremely low. Routine releases probably will not constitute a potential problem, but accidental releases will. Nonetheless, it is probably desirable to eliminate the routine release of plutonium insofar as possible.

Based primarily on the quantities of plutonium, either pure or in plutonium bearing fuels, and the numbers of operations involving that plutonium, the most likely potential problem areas in the fuel cycle are those involving the preparation of fuel materials, the fabrication of fuels and the shipment of these materials.

Current Status

To date relatively small research and development quantities of plutonium have been shipped and fabricated into recycle fuel. Plutonium can be shipped as the nitrate though this practice has been questioned. Fuel fabrication for commercial power reactors has involved almost entirely slightly enriched uranium without plutonium. The plants in which these fuels have been fabricated have not been designed to contain or handle plutonium. However, firm orders are being taken for future recycle plutonium reloads for commercial power reactors, and plants to fabricate these fuels are being planned.

PWR - MATERIAL BALANCE FLOWSHEET

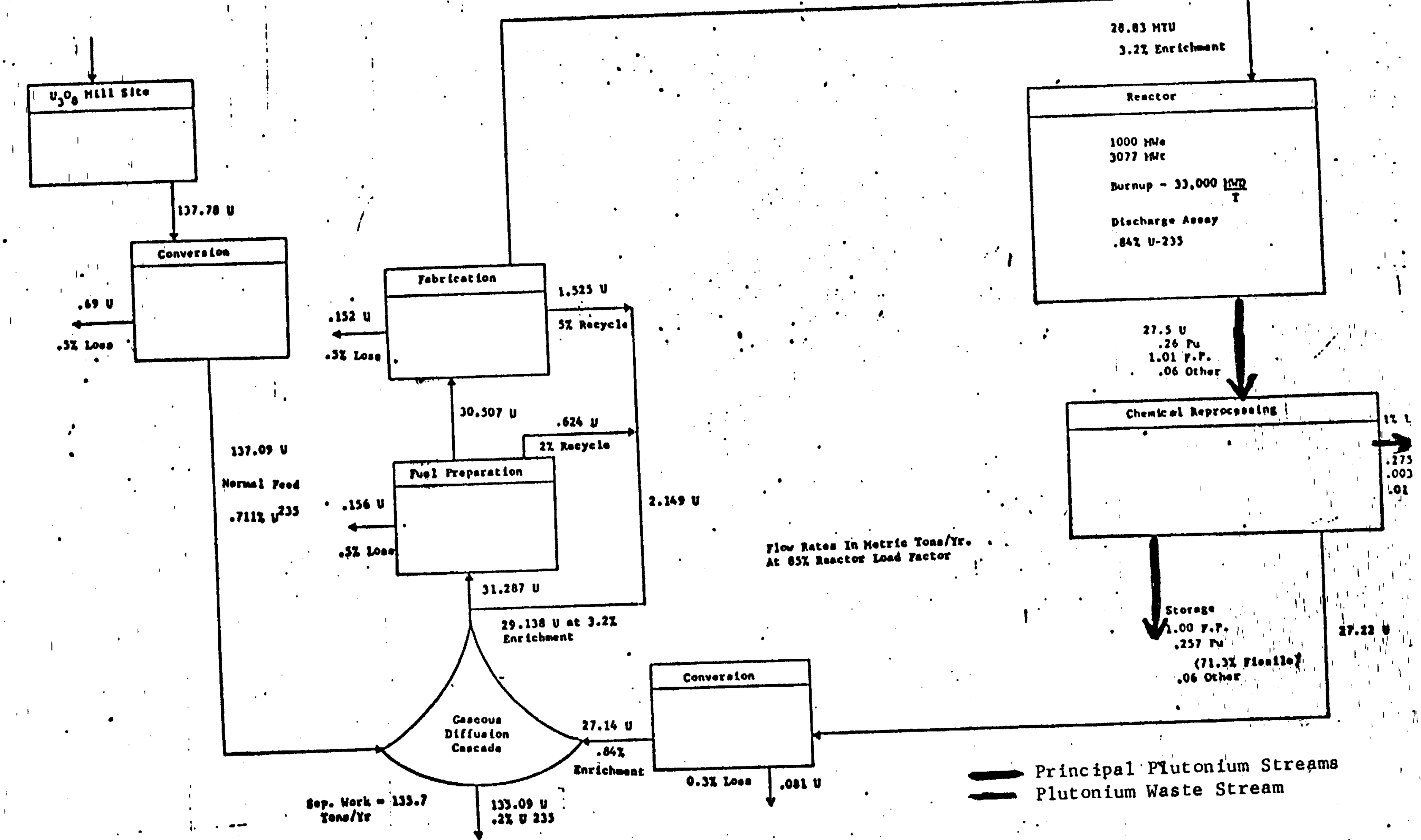

Figure 1

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PWR - PU RECYCLE - OVERALL FLOW DIAGRAM

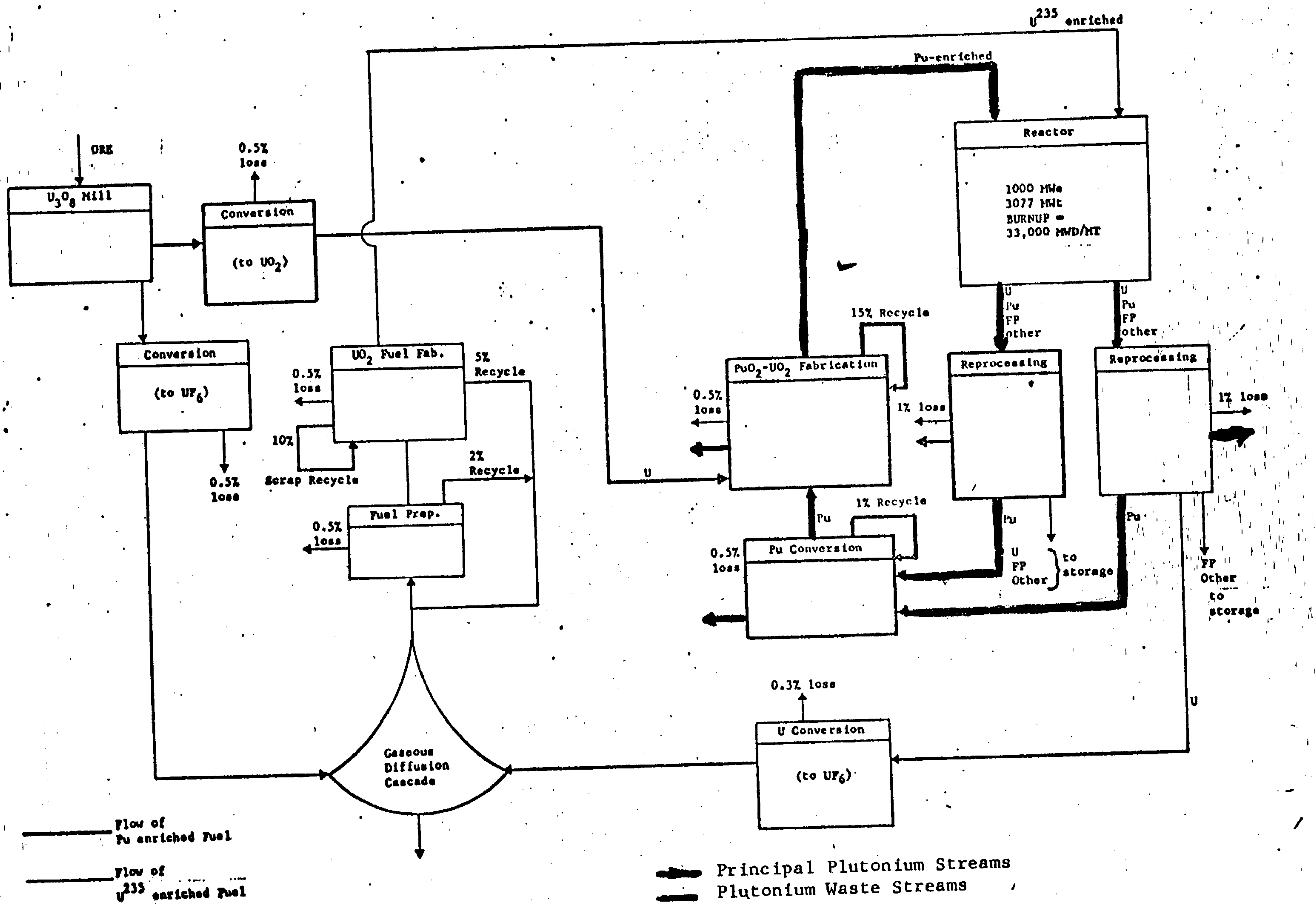

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Figure 2

PWR - PU RECYCLE - FLOW DIAGRAM AT EQUILIBRIUM

(U^{235} - ENRICHED COMPONENT)

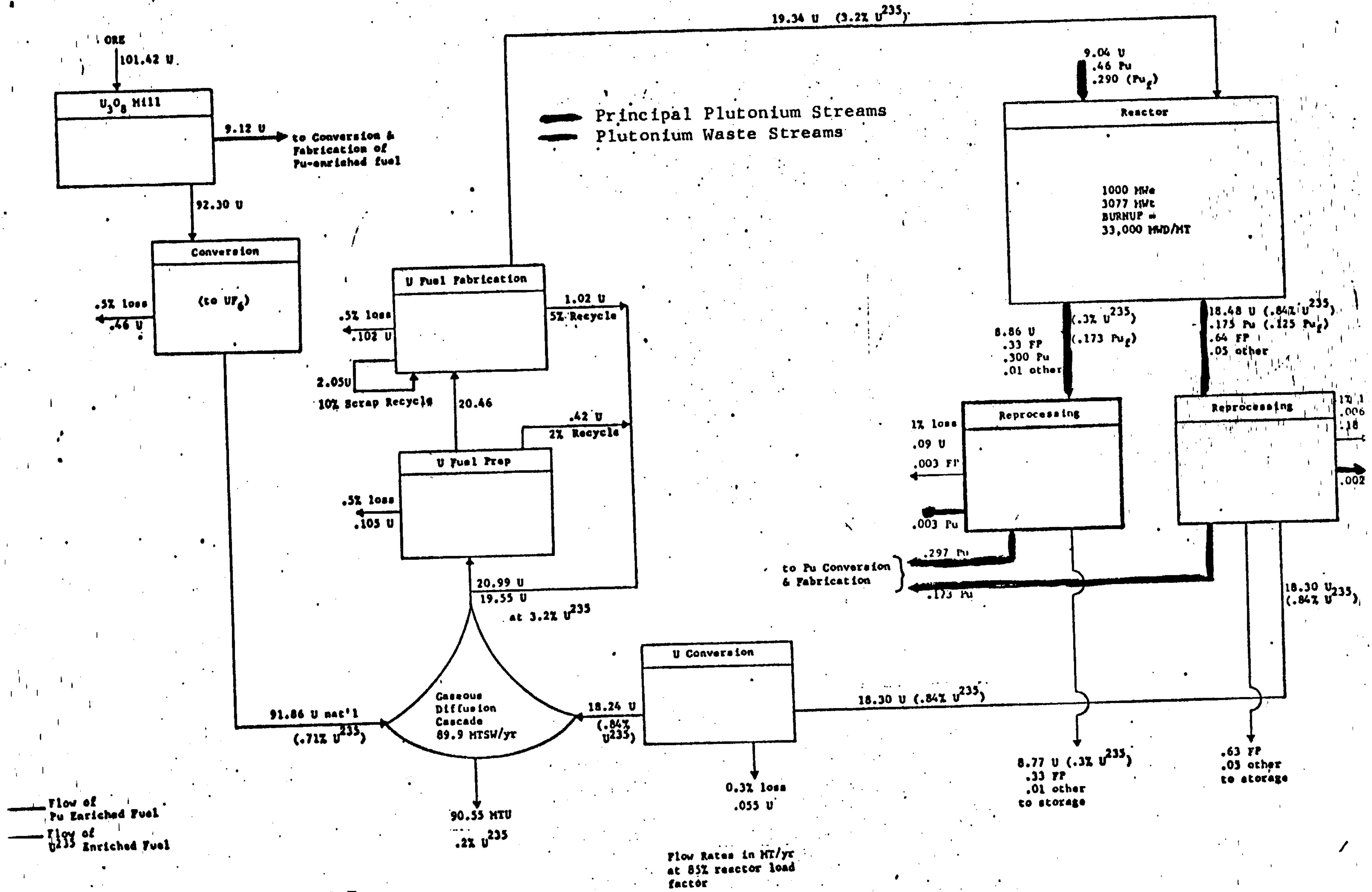

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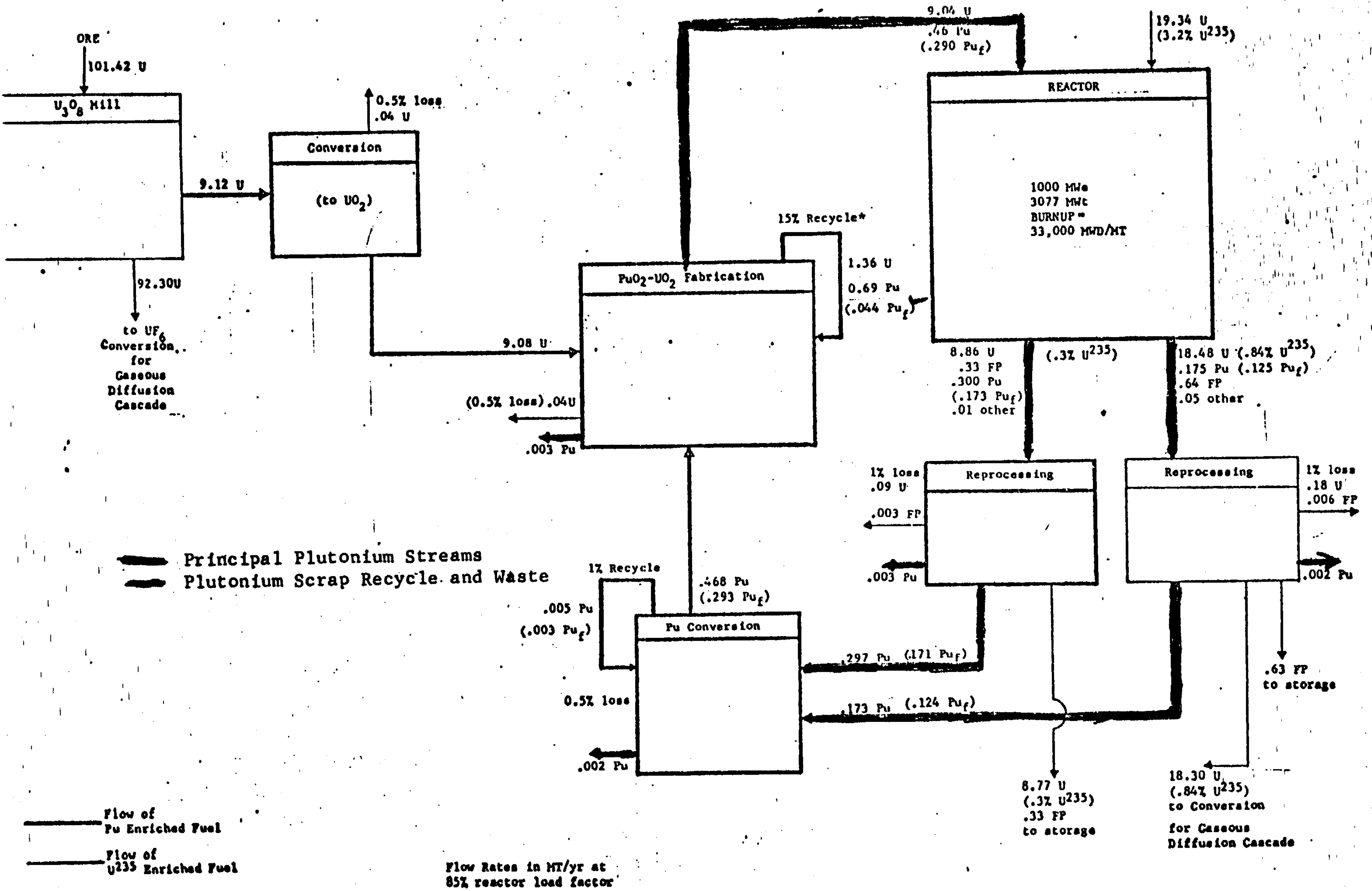
Figure 3

PWR - PU RECYCLE - FLOW DIAGRAM AT EQUILIBRIUM

(PLUTONIUM (APONENT)



*Comprises ~10% scrap that may be recycled without chemical processing (e.g. broken pellets) and 5% scrap that requires chemical processing.

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Typical LMFBR Fuel Cycle Oxide Fuel

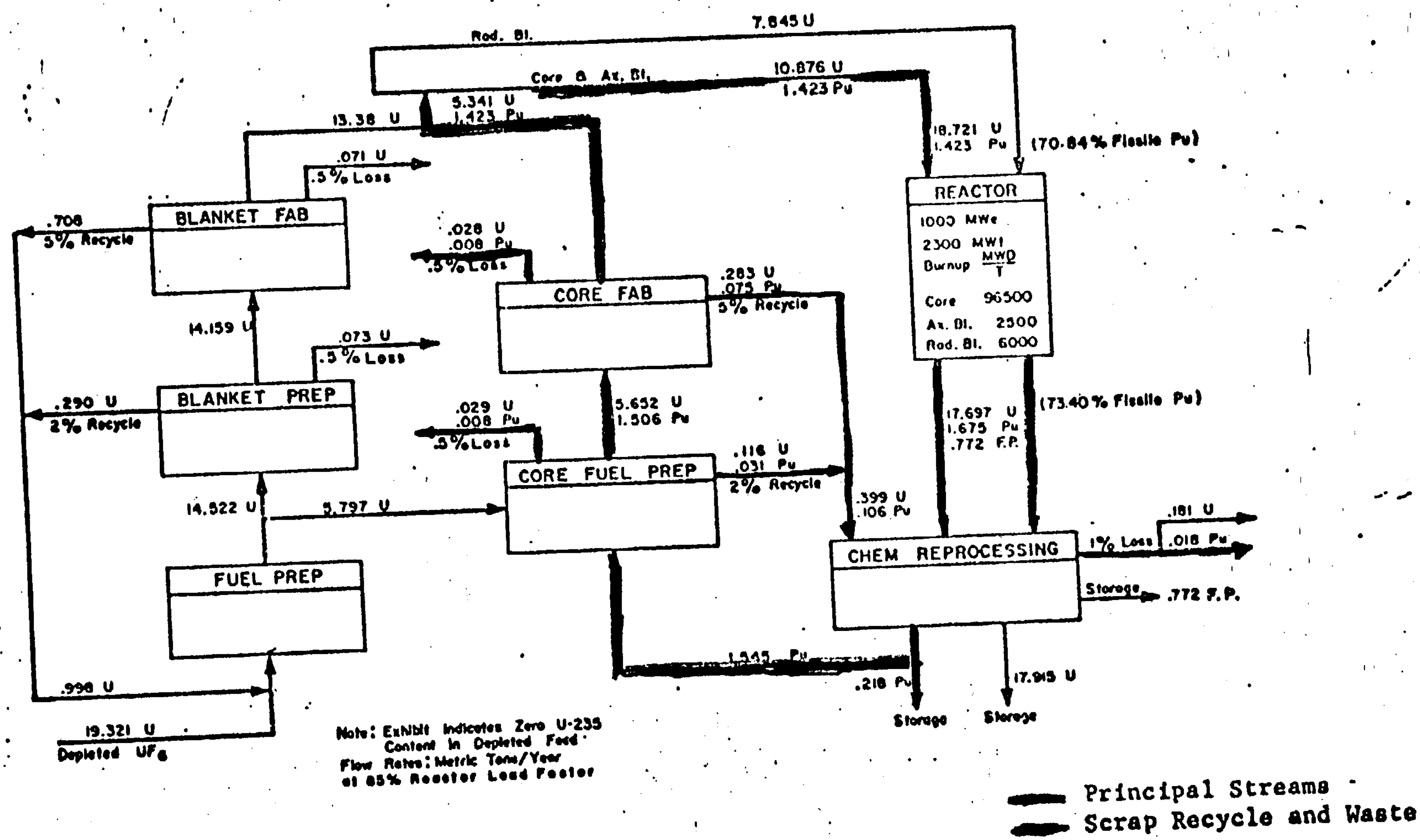

Figure 5

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TABLE 1

Major Operations in the Plutonium Fuel Fabrication Plant

<u>Operation</u>

<u>Operations with Fuel Materials</u>

Screening, weighing fuel powders
Mixing, blending
Slugging and granulation
Pressing
Sintering
Grinding
Inspection of pellets
Recycle rejected pellets
Conveying materials
Pellet loading
Inserting second end caps
Rod carriage
Welding second end caps
Cleaning and transferring fuel rods
Alpha monitoring fuel rods
Leak checking fuel rods
Transferring fuel rods to assembly area
Radiographic inspection of end cap welds
Dimensional inspection of end cap welds
Recycle rejected fuel rods
Fuel element assembly and inspection
Recycle rejected fuel assemblies
Fuel element preparation for shipping
Process and package wastes

<u>Operations with Clad & Hardware</u>

Ultrasonic inspection of cladding
Cutting to length and machining
Etching and rinsing of cladding
Assembly and welding of first end caps
Marking of cladding
Inspection of fuel element hardware
Rinsing and cleaning of fuel element hardware

TABLE 2

Numbers of Facilities Associated with a 150,000 MWe LWR Economy

Facility	Size	Number
Reactor	1000 MWe	150
Shipping Casks for Spent fuel	3 Tons Fuel	75
Reprocessing Plants	5 Tons/day	3
Conversion Plants	2.5 Tons/day	6
Fabrication Plants	2.5 Tons/day	6
Waste Repository		1

Other shipping containers for plutonium product, waste and scrap; the number depending on the extent to which plutonium is recycled. In a growing economy the need for fabrication plants leads, and the need for reprocessing plants lags, the construction and operation of reactors.

TABLE 3

Distribution of Plutonium in Fuel Cycle in 1980

Process Step	Kilograms of Plutonium: Recycle of All Pu Produced in LWRs	Kilograms of Plutonium: Storage (no recycle) of all Pu Produced
In-Reactor		
Reycled Pu	54,500	0
Pu formed in situ	48,700	55,100
TOTAL: In-Reactors	103,200	55,100
Ex-Reactor		
Cooling at reactor site	14,400	10,510
Shipment to reprocessing	1,800	1,320
Pre-reprocessing inventory	4,500	3,300
Reprocessing	900	660
Post-reprocessing inventory	900	660
Storage of reprocessed Pu		96,700
Ship to fuel preparation	900	
Pre-preparation inventory	900	
Preparation	900	
Pre-fabrication inventory	1,400	
Fabrication	1,400	
Post-fabrication inventory	500	
Shipment to waste repository	100	
In waste repository	1,400	
Ship to reactor	900	
Pre-irradiation inventory	3,600	
TOTAL: Ex-Reactor	34,500	113,150
TOTAL ALL	137,700	168,250

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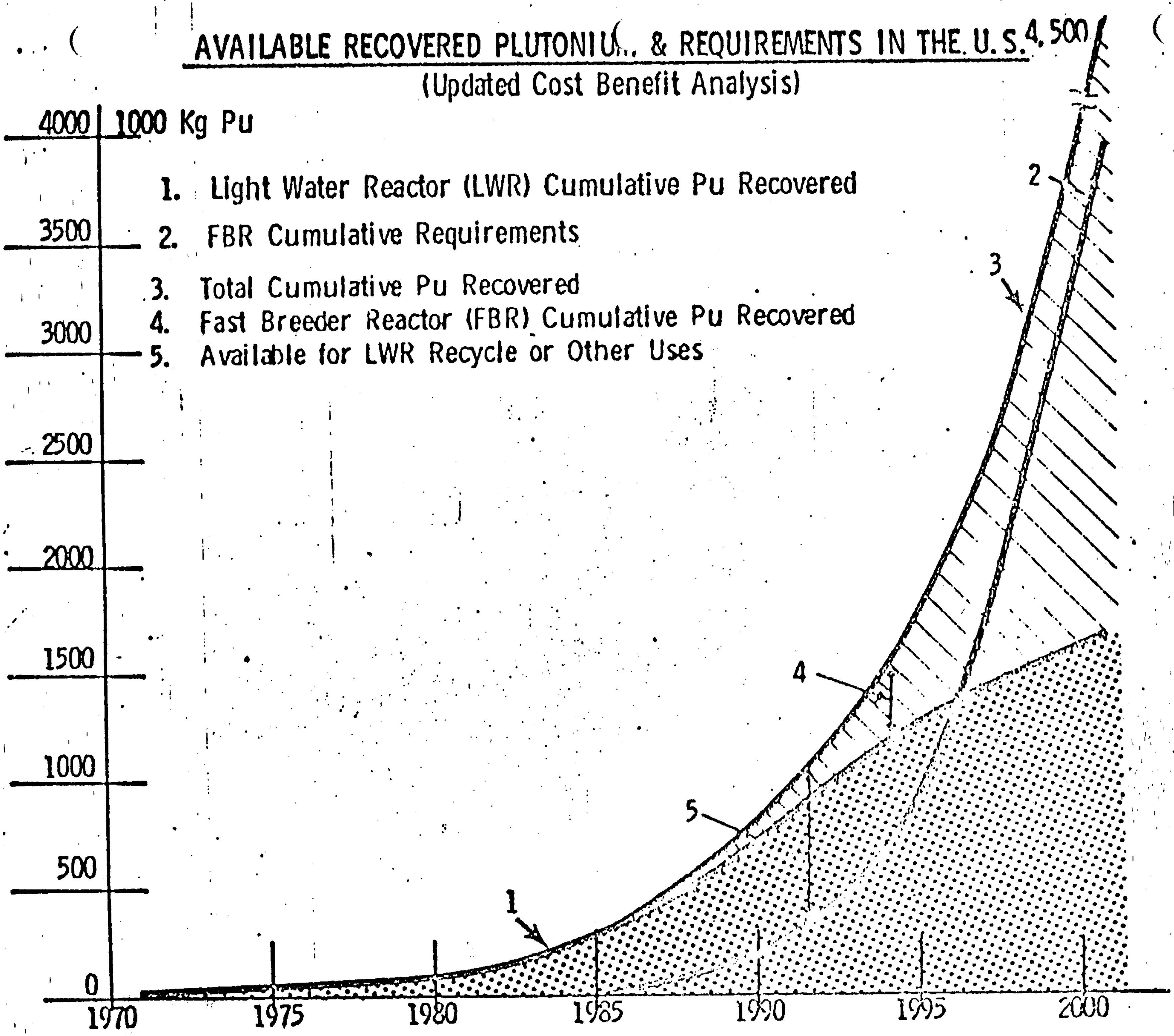
ENCLOSURE 2

AVAILABLE RECOVERED PLUTONIU.., & REQUIREMENTS IN THE U.S.

(Updated Cost Benefit Analysis)



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ENCLOSURE 3

Production of Transuranium
Elements in LWRs & LMFBRs
(relative to fissile Pu produced)

	LWR	LMFBR
$^{239}Pu + ^{241}Pu$	1.0	1.0
^{237}Np	0.077	0.002
^{238}Pu	0.027	0.011
^{240}Pu	0.34	0.31
^{242}Pu	0.056	0.052
^{241}Am	0.004	0.009
^{243}Am	0.015	0.004
^{242}Cm	0.002	0.0002
^{244}Cm	0.005	0.0002

ENCLOSURE 4

PLUTONIUM SOURCE TERMS
PREPARED BY FUEL RECYCLE BRANCH
DIVISION OF REACTOR DEVELOPMENT AND TECHNOLOGY

October 1972

"Source Terms" for plutonium throughout the reactor cycle are given in terms of its chemical and physical forms, its origin in the reactor cycle and whether or not it is associated with other radionuclides. With respect to the origin, we have included both normal and accident conditions as potential sources of plutonium. We assume plutonium becomes a "source term" once there is no longer control over it. In many cases, particle sizes of PuO_2 are not known; in others a range of particle sizes is included.

I. Pu Isotopic Composition (LWR Produced)

Pu Isotope	w/o
238	1.5
239	59.5
240	21.6
241	12.5
242	4.9

II. Potential Sources of Pu from the LMFBR

Pu Form	Particle Size	Fission Products Present	Origin
$(Pu,U)O_2$	?	Yes	Failed Fuel*

*Appears as trace contaminant in primary sodium, cold trap; to be considered in final disposal of sodium and cold traps; accident situations will not alter chemical form from $(Pu,U)O_2$.

III. Potential Sources of Pu Effluents or Releases from Recycle Facilities

A. Fuel Fabrication Plant

Pu Form	Particle Size	Fission Products Present	Origin
$Pu(NO_3)_4$	Aerosol, about 0.3 microns	No	Off-gas from conversion process
PuO_2	A small percent of particles 0.3 microns will not be trapped by filter systems*	No	Off-gas system

*An example of the particle size is shown in the attached appendix which is the specification for PuO_2 used in the fabrication of FTR fuel.

B. Reprocessing Plant

$Pu(NO_3)_4$ $UO_2(NO_3)_2$	Aerosol, about 0.3 microns	Yes	Off-gas from dissolver
PuO_2	A small percent of particles 0.3 microns will not be trapped by filter systems	Yes	Off-gas from waste solidification
PuO_2	A small percent of particles 0.3 microns will not be trapped by filter system.	No	Fire in Pu purification system

In the event of an accident in either the reprocessing or fabrication plants in which the filters fail, the size of the Pu bearing particles could vary for about 0.1 microns to greater than 100 microns.

Attachment:
Appendix

ATTACHMENT

R D T   S T A N D A R D

UNITED STATES ATOMIC ENERGY COMMISSION
DIVISION OF REACTOR DEVELOPMENT AND TECHNOLOGY

RDT E 13-1T
Date June 1971

FAST FLUX TEST FACILITY CERAMIC GRADE PLUTONIUM DIOXIDE

1. SCOPE

This standard establishes the requirements for plutonium dioxide, ceramic grade, for use in the fabrication of mixed oxide fuel pellets that meet the requirements of RDT Standard RDT E 13-6, FFTF Driver Fuel Pin Mixed Oxide Fuel Pellet.

2. APPLICABLE DOCUMENTS

The following documents form a part of this standard to the extent specified herein. In the event of conflict between the documents referenced and this standard, the detail requirements of this standard shall be superseding.

2.1 AEC-RDT Standards

RDT F 2-4T (October 1969) - Quality Verification Program Requirements

2.2 WADCO

WHAN-IR-5, FFTF Analytical Chemistry Methods in Support of Driver Fuel Fabrication, August, 1970

3. TECHNICAL REQUIREMENTS

3.1 Particle Size

3.1.1 Sieve Analysis. Plutonium dioxide powder shall meet the following sieve analysis:

Sieve. U.S. Standard. or Equivalent	Percentage PuO_2 Powder Passed
170-mesh 88 µ	100
200-mesh 74 µ	99 min.
325-mesh 44 µ	95 min.

3.1.2 Particle Distribution. The plutonium dioxide powder shall meet one of the particle size criteria listed below.

(a) Coulter Counter Method. At least 50% of particles shall be less than 20 microns.

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(b) Fisher Sub-Sieve Sizer. Average particle size shall be less than 10 microns.

UNITED STATES
ATOMIC ENERGY COMMISSION
WASHINGTON, D.C. 20545

March 23, 1973

M. Bender
W. Forster
R. Franklin
M. Goldman
D. Grahn
M. Minthorn
M. Schulman
R. Watters
W. Weyzen

PLUTONIUM PROGRAM PLAN COMMITTEE MEETING DATES

The Plutonium Program Plan Committee will meet regularly through April 4 on Tuesday at 1:00 p.m. to address questions regarding overlap and coordination of Task Group activities. Task Force leaders should plan to participate in these meetings.

The first meeting will be on Tuesday, March 27, at 1:00 p.m. in my office.

N F Barr

N. F. Barr, Assistant Director
for Measurement & Evaluation
Division of Biomedical and
Environmental Research

cc: C. Edington
C. Osterberg

1080548

UNITED STATES
ATOMIC ENERGY COMMISSION
WASHINGTON, D.C. 20545

March 27, 1973

M. Bender
W. Forster
R. Franklin
M. Goldman
D. Grahn
M. Minthorn
M. Schulman
R. Watters
W. Weyzen

SCHEDULE AND GUIDELINES FOR PLUTONIUM PROGRAM PLANNING

1. It is anticipated that each Task Force will address its specific problem area in reasonable depth, within the time limits allowed, to determine (a) the current status of our research program on plutonium and other radionuclides of interest to RDT and (b) to ascertain the future direction which our research efforts should take, if any, in the Task Force area of concern.

2. Each Task Force is expected to prepare a report which would cover its review activities, include an evaluation of research in its problem area and provide recommendations for future work that might assist in DBER's response to RDT needs.

3. Because of the time schedule which has been placed on us, it will be impossible for a detailed, completely documented report to be prepared. Nevertheless, it is anticipated that the report will be more than a skeleton or "bare-bones" document. Sufficient information must be provided for an understanding of the reasons for decisions and/or recommendations that have been made. This is important because the Division Director must have adequate back-up information to be able to discuss the problem as we see it with program directors. It is anticipated that a more detailed report can be and should be developed with time.

4. The report of each Task Force will be expected to be finished and in the hands of the Plutonium Program Planning Committee no later than Friday, May 4, 1973. When all Task Force reports are in, the Committee will prepare a report for Dr. Liverman. When this report is

prepared, it will be circulated to each Task Force Chairman for his review and comments. It is anticipated that the final report will be given to Dr. Liverman no later than May 15, 1973.

5. Your assistance in seeing that the deadlines are met will be greatly appreciated.

Charles W. Edington
Chief, Biology Branch
Division of Biomedical and
Environmental Research

cc: J. Liverman
W. Burr
N. Barr
C. Osterberg
J. Harley
J. Whitnah

UNITED STATES
ATOMIC ENERGY COMMISSION
WASHINGTON, D.C. 20545

April 24, 1973

Charles W. Edington, Chief
Biology Branch, DBER

PROGRESS REPORT - TASK FORCE 5

Deliberations by the Task Force 5 on removal of transuranic elements from the body were mainly guided by two aspects of this problem, the immediate need for improvement of currently used methods for removal of internally deposited transuranics in man, and the need for new, more effective agents.

With regard to the need for improved DTPA-therapy, three main problems were identified: dosage, toxicity and efficacy. With regard to dosage, it appears that there is no clear rationale for the therapeutic doses that are now being administered to patients. Recent literature indicates that significantly lower doses may be just as effective. This is a problem of immediate concern especially in view of the lack of information on human toxicity data for DTPA administered by aerosol. Closely connected is the lack of information on clinical efficacy. The continued use of DTPA in patients in an effort to decrease the potential for radiotoxicity cannot be justified unless reasonably accurate assessments of the risk of this therapy are available.

The Task Force also questioned whether increased mobilization and subsequent urinary excretion of transuranics are the only effects following DTPA administration. Some of the characteristics of Pu excretion following DTPA therapy suggest a potential for translocation. In view of this, it is important to verify in animal experiments the fate of injected chelated Pu in addition to determining possible translocation of Pu following DTPA therapy.

The possibility for the developments of new modes of therapy have been discussed extensively. Approaches considered to be most promising were selective screening of available chelating agents for toxicity in vivo and their effectiveness in chelating transuranics, and the developments of analogs of chelating agents that will be able to chelate intracellular deposited transuranics. Also the potential of new modes of therapy such as means to increase solubilization in vivo other than by chelation were considered.

Finally, current ongoing research was reviewed and evaluated in view of immediate and future needs.

An outline of the final report is enclosed.

Walter W. Weyzen, M. D.
Health Sciences Research and
Applications Branch
Division of Biomedical and
Environmental Research

Enclosure:
As stated

Outline of Final Report

1. Current status removal therapy of transuranics
   a. Clinical experience
   b. Ongoing research

2. Optimization of current therapy
   a. Clinical aspects
   b. Needs for supportive research

3. New modes of removal therapy
   a. Analogs
   b. New - chelating agents - screening
   c. New - modes of therapy
   d. Research needs

4. Immediate needs and priorities

5. Summary and recommendation

UNITED STATES
ATOMIC ENERGY COMMISSION
WASHINGTON, D.C. 20545

May 8, 1973

D. Grahn
M. Goldman
M. Schulman
M. Minthorn
M. Bender
W. Weyzen
R. Watters
R. Franklin
W. Forster

FINAL REPORT DEADLINE AND REQUEST FOR SPECIFIC INFORMATION

The Plutonium Planning Committee is in the process of preparing a report on the Division's review of the plutonium research program for Dr. Liverman. We have received final or draft copies of the activities of each Task Force. It is assumed that the reports which were submitted in rough draft form will be finished and resubmitted to the Committee no later than Friday, May 11. Each Task Force is encouraged to submit a report that is well organized, clearly presented with appropriate documentation and includes Task Force recommendations for work that they feel is needed to continue to be responsive to RDT needs. It is important that the recommendations for future work be considered very carefully and listed in order of priority for the Committee's consideration. It should be remembered that these reports will be appended to our report to Dr. Liverman and will represent the joint considerations of each Task Force. Each task force member should, therefore, approve the report and should indicate his approval by signing the report. If, for any reason, there is a difference of opinion, a minority report can be presented to the Committee.

There are a number of specific items on which the Committee needs additional information. These items are listed below with the Task Force which should respond. It would be appreciated if the responses to these items could be provided to the Committee no later than Friday, May 11.

All Task Forces

1. What is the degree of effort involved in our current and planned plutonium research effort in each Task Force area?

Task Force 1

1. Provide all information that is available on the concentration and distribution of plutonium, or other transuranium elements, in the gonads of experimental animals or man.

2. A number of calculations which could be made would be helpful to the Committee. These are:

    a. An absolute calculation of alpha emitters inhaled.

    b. Make relative calculations on basis of resuspension factors going from 10^{-6} to 10^{-8} or 10^{-9}.

    c. Make sensitivity analyses for foliar intake, gut and soil discrimination factors.

    d. Derive tumor and gonadal rads per 1000 Mw(e) years.

    e. Reprocessing and fabrication plant releases should be scaled between LWR and LMFBR cycles on basis of grams of alpha emitters processed per Mw(e) year.

    f. The method of calculating gonadal plutonium concentration should be clarified.

Task Force 2

1. How reliable are experimental data that have been obtained in the various experimental studies? Are sample sizes sufficient, especially in proposed experiments, to provide confidence in any statements about effects observed or not observed?

2. Some indication should be provided on how current data on animals can be used to estimate biological consequences in man exposed to MPC levels of plutonium.

3. Is it possible to use the non-appearance of pathology in humans to provide an upper estimate of potential health consequences?

UNITED STATES
ATOMIC ENERGY COMMISSION
WASHINGTON, D.C. 20545

May 8, 1973

D. Grahn
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