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Issue for Comment

MARTIN MARIETTA

EFS-95-001

GDP TURNOVER CONTINGENCY PLANNING

FACILITY TURNOVER CONDITIONS

JUNE 1995

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Prepared for the
U.S. Department of Energy
by
Martin Marietta Energy Systems, Inc.,
under contract DE-AC05-84OR21400

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FOR THE UNITED STATES
DEPARTMENT OF ENERGY

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CONTENTS

ACRONYMS vi

1. INTRODUCTION 1
   1.1 BACKGROUND 1
   1.2 PURPOSE AND SCOPE 2
   1.3 METHOD OF ACCOMPLISHMENT 2

2. DEFINITIONS AND ASSUMPTIONS 5
   2.1 TERMS AND DEFINITIONS 5
   2.2 PLANNING ASSUMPTIONS 6

3. FACILITY DISPOSITION SCENARIOS 8
   3.1 BASIC DISPOSITION OPTIONS 8
   3.2 POTENTIAL ALTERNATIVE MISSIONS 11
   3.3 MOST PROBABLE SCENARIOS AND IMPACT ON TURNOVER CONDITIONS 12

4. CASCADE DECONTAMINATION OPTIONS 13
   4.1 KEY QUESTIONS AND ISSUES 13
   4.2 INITIAL CASCADE CONDITION 13
   4.3 CASCADE TREATMENT TARGETS 14
   4.4 TREATMENT OPTIONS/FEASIBILITY 15

5. PREFERRED FACILITY TURNOVER CONDITIONS 17
   5.1 GENERAL PREFERRED FACILITY TURNOVER CONDITIONS 17
   5.2 PREFERRED TURNOVER CONDITIONS FOR SPECIFIC SYSTEMS . 17

APPENDIXES
A. WORKSHOP PARTICIPANTS A-1
B. MECHANISMS OF URANIUM DEPOSITION IN GASEOUS DIFFUSION CASCADES B-1
C. CASCADE TREATMENT AND TURNOVER PREPARATIONS C-1

ACRONYMS

BOP	balance of plant
D&D	decontamination and decommissioning
DOE	Department of Energy
GDP	gaseous diffusion plant or gaseous diffusion process
EM	Environmental Management
HEU	highly enriched uranium
LEU	low enriched uranium
MMES	Martin Marietta Energy Systems, Inc.
MMUS	Martin Marietta Utility Services, Inc.
NCS	nuclear criticality safety
NDA	nondestructive assay
NE	Nuclear Energy
PCB	polychlorinated biphenyls
PGDP	Paducah Gaseous Diffusion Plant
PORTS	Portsmouth Gaseous Diffusion Plant
RCW	recirculating cooling water
S&M	surveillance and maintenance
USEC	United States Enrichment Corporation
WBS	work breakdown structure

1. INTRODUCTION

1.1 BACKGROUND

On July 1, 1993, the United States Enrichment Corporation (USEC) leased two gaseous diffusion plants (GDPs) from the Department of Energy (DOE). These plants are located in Paducah, Kentucky, and Portsmouth, Ohio, and are referenced as PGDP and PORTS, respectively. Under the terms of the lease agreement[1], USEC may terminate the lease at one or both of the GDPs with a required prior two-year notification to DOE.

DOE has begun the process of contingency planning in case USEC decides to terminate the lease at one GDP. Highlights of the contingency planning project include:

- Development of a Facility Turnover Plan that will outline the preferred conditions of returned facilities at turnover and deactivation plans for these facilities;
- Identification of contracting strategies and potential alternative mission strategies;
- Development of a Regulatory Compliance Plan to ensure compliant management of the facilities after turnover;
- Identification of financial strategies and resource requirements necessary to complete the transition effort; and
- Establishment of agreements within DOE and between DOE and USEC regarding roles and responsibilities.

DOE's goal for the contingency planning project is to achieve a state of readiness for USEC's possible notification of intent to terminate the lease on a GDP. The project focuses on the development of plans to ensure a smooth transition in the event of lease termination and safe, efficient, and cost-effective activities at the site after turnover. Lessons learned from the shutdown of K-25 and the highly enriched uranium (HEU) cascade at PORTS will be incorporated in this project.

To achieve the desired state of readiness, DOE must identify and understand what activities would need to be initiated if USEC submits notification of their intent to terminate the lease at one of the GDPs. These post-notification activities will be aimed at achieving *preferred facility turnover conditions*: the conditions that ensure safe and compliant site activities after turnover, enhance the cost-effectiveness of future surveillance and maintenance (S&M) and decontamination and decommissioning (D&D) activities, and enable future alternative missions for the site.

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[1]*Lease Agreement Between the United States Department of Energy and the United States Enrichment Corporation*, July 1, 1993.

1.2 PURPOSE AND SCOPE

The purpose of this document is to define the preferred conditions of facilities, systems, and equipment at lease termination (turnover). These conditions are based on lessons learned from prior shutdowns of gaseous diffusion cascades, requirements for safe and compliant management and cost-effective D&D after turnover, and requirements for future alternative uses. The document defines and documents the turnover conditions for each major facility or system as appropriate. These turnover conditions provide the framework for developing turnover plans for these facilities/systems.

The scope of the task encompasses all leased premises and leased personalty as identified in Exhibits A and B of the DOE/USEC lease agreement dated July 1, 1993.

The remaining sections of the document are arranged as follows:

Section 2. Definitions and Assumptions: Defines terms used in this document and provides the planning assumptions used during development of the preferred turnover conditions.

Section 3. Facility Disposition Scenarios: Briefly describes the basic ultimate disposition options for facilities, potential alternative missions, and most probable scenarios for use of the GDP after turnover, and explains how these scenarios affected the development of preferred turnover conditions.

Section 4. Cascade Decontamination Options: Discusses current cascade condition, target cascade cleanup levels, and cleanup levels that can be achieved during the 2-year post-notification period.

Section 5. Preferred Facility Turnover Conditions: Presents the preferred turnover conditions for each of 14 categories of facilities/systems.

1.3 METHOD OF ACCOMPLISHMENT

The preferred turnover conditions were developed through a series of workshops and special-focus meetings involving a broad cross section of personnel from DOE; Martin Marietta Energy Systems, Inc., (MMES); Martin Marietta Utility Services, Inc., (MMUS); and subcontractor personnel. These personnel–who represent significant GDP technical, operations, and management experience and a variety of related expertise in D&D, future land use planning, and regulatory issues–are listed in Appendix A.

This work was performed within the overall project work breakdown structure (WBS) shown in Fig. 1, under Work Element 1.2, Operational/Technical Integrated Plan. Before determining the preferred turnover conditions for a returned GDP, it was necessary to identify likely future activities at the site after turnover, such as S&M, D&D, and alternative missions.

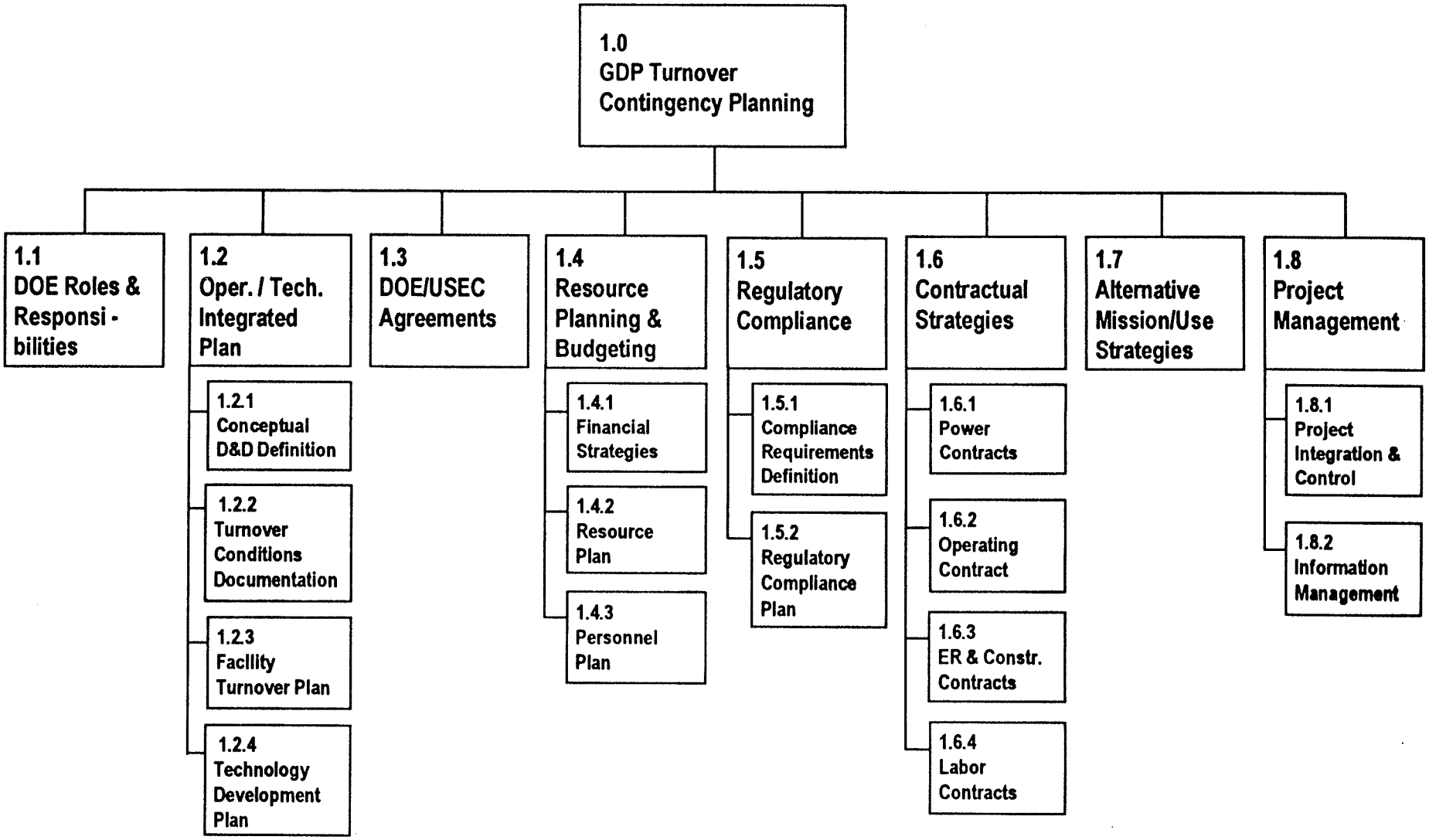

Figure 1. Work breakdown structure for GDP turnover contingency planning

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Therefore, this work element relied heavily upon results of other project work elements and their associated workshops and follow-up meetings.

The team established to develop a Conceptual D&D Definition (reference WBS 1.2.1 on Fig. 1) held two workshops, which were followed by several meetings of a smaller "core" team to refine and further develop the workshop results. Preliminary preferred turnover conditions were defined in these workshops and were based on probable facility disposition scenarios.[2] The team established to identify Alternative Missions/Use Strategies (reference WBS 1.7 on Fig. 1) held a workshop and follow-up meeting with a core team to refine the workshop results.[3] Both these work elements were focused on the *ultimate* disposition options for the returned facilities.

A GDP Turnover Conditions Workshop focused on cascade treatment options/feasibility and a resultant set of preferred turnover conditions. The results of the GDP Turnover Conditions workshop are presented in this document, along with summaries of the other workshops.

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[2]*GDP Turnover Contingency Planning Conceptual D&D Definition Document,* Martin Marietta Energy Systems, Inc., April 1995.

[3]*GDP Turnover Contingency Planning Documentation of Alternative Missions Workshop,* Martin Marietta Energy Systems, Inc., May 26, 1995.

2. DEFINITIONS AND ASSUMPTIONS

2.1 TERMS AND DEFINITIONS

This section defines key terms used in this document, to facilitate reader understanding.

Alternative Mission: A future use of some portion of the returned facilities that is different than uranium enrichment (may be private industry or government).

Cleanup: The process by which hazardous and/or radioactive materials, equipment, and facilities are removed or reduced.

Deactivation: The process of permanently ceasing uranium enrichment operations at a returned GDP facility in a planned and controlled manner. A deactivated facility has been adequately prepared to safely support necessary surveillance and maintenance activities and decontamination and decommissioning activities.

Decontamination and Decommissioning (D&D): The process by which a deactivated facility is cleaned of hazardous and/or radioactive materials and prepared for non-nuclear-related use. Activities could include revision of permits and reporting requirements, notification to appropriate regulatory agencies, etc.

Demolition: The act of tearing down, razing, or dismantling/disassembling facilities, systems, equipment, or structures.

Facility: A physical entity consisting of land, building structure, system(s), and/or equipment.

Leased Premises: Facilities (including systems and equipment) owned by DOE but used by USEC through the lease agreement.

Leased Personalty: Gaseous diffusion process equipment owned by DOE but used by USEC through the lease agreement.

Notification: The formal 2-year advance communication from USEC to DOE that USEC plans to terminate the lease of a gaseous diffusion plant.

Post-Notification: The time interval between USEC giving 2-year notice and the date of turnover (at least 2 years unless otherwise agreed to by USEC and DOE).

Post-Turnover: The time period after USEC's termination of the lease of a GDP.

Preferred Turnover Conditions: Those physical conditions of facilities that will: (1) ensure safe and compliant activities after turnover; (2) minimize life cycle costs of post-turnover DOE activities; (3) enable cost-effective and efficient D&D; and (4) facilitate future use of the site or facilities for alternative missions.

Surveillance and Maintenance (S&M): The methodical inspection, monitoring, and maintenance of a deactivated facility to ensure safety, security, structural integrity, and compliance with applicable regulations until completion of D&D activities.

Turnover: The process by which the lease with USEC is terminated for one GDP site and DOE assumes management responsibility for the formerly leased premises and personalty at that site.

Winterize: The process by which facilities, systems, and equipment are prepared to withstand cold weather without damage (i.e., to compensate for loss of heating). Winterize also includes conversion of facility heating systems that use hot recirculating cooling water, which will no longer be available after loss of process heat.

2.2 PLANNING ASSUMPTIONS

This section provides the planning assumptions used in development of the facility turnover conditions. More detailed listings of assumptions are contained in the Conceptual D&D Definition Document, Documentation of Alternative Missions Workshop, and the Project Management Plan.[4]

Key assumptions relevant to developing the preferred turnover conditions are as follows:

1. Definition of preferred turnover conditions will be based on reasonable and achievable conditions needed to enable compliant site management and cost-effective S&M, D&D, and/or alternative missions.

2. Turnover conditions encompass only the leased facilities, systems, and equipment to be returned to DOE by USEC at lease termination.

3. Only one GDP will be returned under initial notification of lease termination; operations at the other GDP will continue.

4. GDP Turnover Contingency Planning is not site specific; however, site differences will be considered.

5. After turnover, the cascade will no longer be used for isotopic enrichment.

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[4]*Working Draft GDP Turnover Contingency Planning Project Management Plan, Rev. 2,* Martin Marietta Energy Systems, Inc., June 1, 1995.

6. Agreement between USEC and DOE will be reached and funding will be available during the 2-year post-notification period to achieve the preferred facility turnover conditions.

7. If necessary to achieve needed cascade treatment, production rampdown and large-scale cascade treatment can begin immediately after notification.

8. Implementation of any plausible combination of D&D options and/or alternative missions at a returned GDP will necessitate some site support services and S&M activities for years after turnover.

9. USEC, through Utility Services, will provide resources as needed and agreed upon (via service agreement) to implement the post-notification turnover plans.

10. Any system reconfiguration needed for future use (e.g., utility system downsizing) will be done by DOE after turnover, unless otherwise agreed upon with USEC. However, prior to turnover, systems will be winterized and reconfigured as necessary to compensate for the loss of process heat.

3. FACILITY DISPOSITION SCENARIOS

A preliminary framework for defining facility turnover conditions was established by first envisioning a range of potential ultimate disposition scenarios for the returned facilities, systems, and equipment. The next step was to draw tentative conclusions about how the most probable of these scenarios would impact the preferred facility conditions at turnover (i.e., what turnover conditions would be most favorable for minimizing life cycle costs of ultimate facility disposition and enhancing implementation of alternative uses?). As indicated in Section 1.3, these steps were accomplished in a high-level, qualitative way through a series of brainstorming workshops and other focused work sessions involving a broad cross section of knowledgeable and experienced personnel representing GDP technology and operations, D&D, and future land use activities.

This section summarizes the results of these work sessions and the resulting preliminary framework for defining preferred facility turnover conditions. This section also addresses how the framework was then modified to include the requirements for safe, compliant, and cost-effective activities immediately after turnover, including minimizing S&M requirements.

3.1 BASIC DISPOSITION OPTIONS

Two workshops were held to facilitate development of a conceptual D&D definition. These workshops yielded four basic ultimate disposition options for the facilities:

- *Transfer of Ownership*–to private industry or other government agencies for alternative uses;
- *Demolition*–including dismantling and on- or off-site disposal or reuse of materials;
- *S&M*–including keeping structures intact, maintaining necessary safety systems, and periodic inspections and maintenance; and
- *Cleanup*–involving reduction of radioactive contamination and/or removal of hazardous materials as required by laws and regulations.

Because cleanup was considered a precursor to one of the other three options, rather than an endpoint, the following six disposition options for any individual facility result:

1. Transfer As Is (without cleanup);
2. Demolition As Is (without cleanup);
3. S&M As Is (without cleanup);
4. Cleanup and Transfer;
5. Cleanup and Demolition;
6. Cleanup and S&M.

Figure 2 depicts these options in a facility disposition logic diagram. As indicated in the figure, a combination of disposition options could be applied to *any* returned facility.

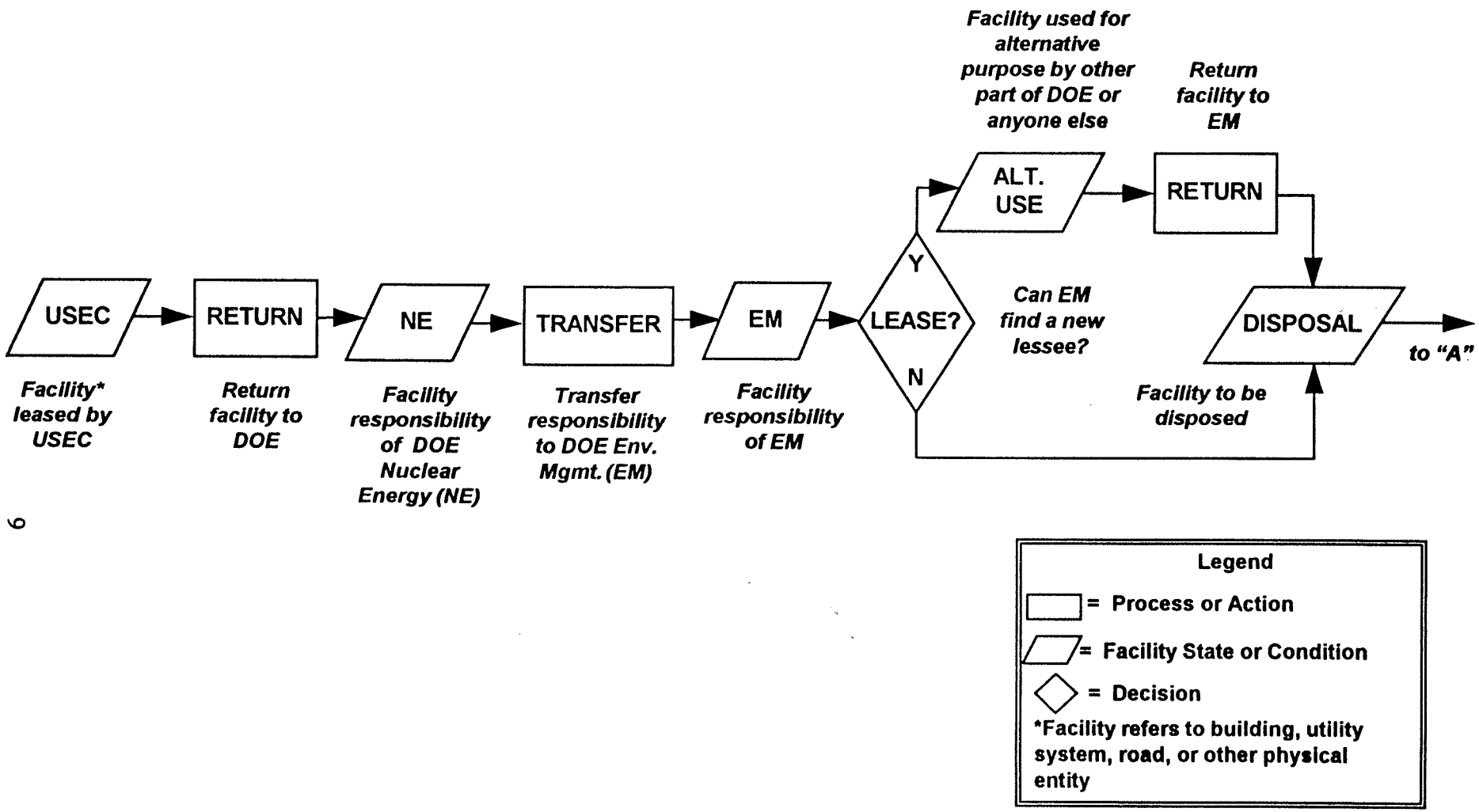

Figure 2. Facility disposition logic diagram

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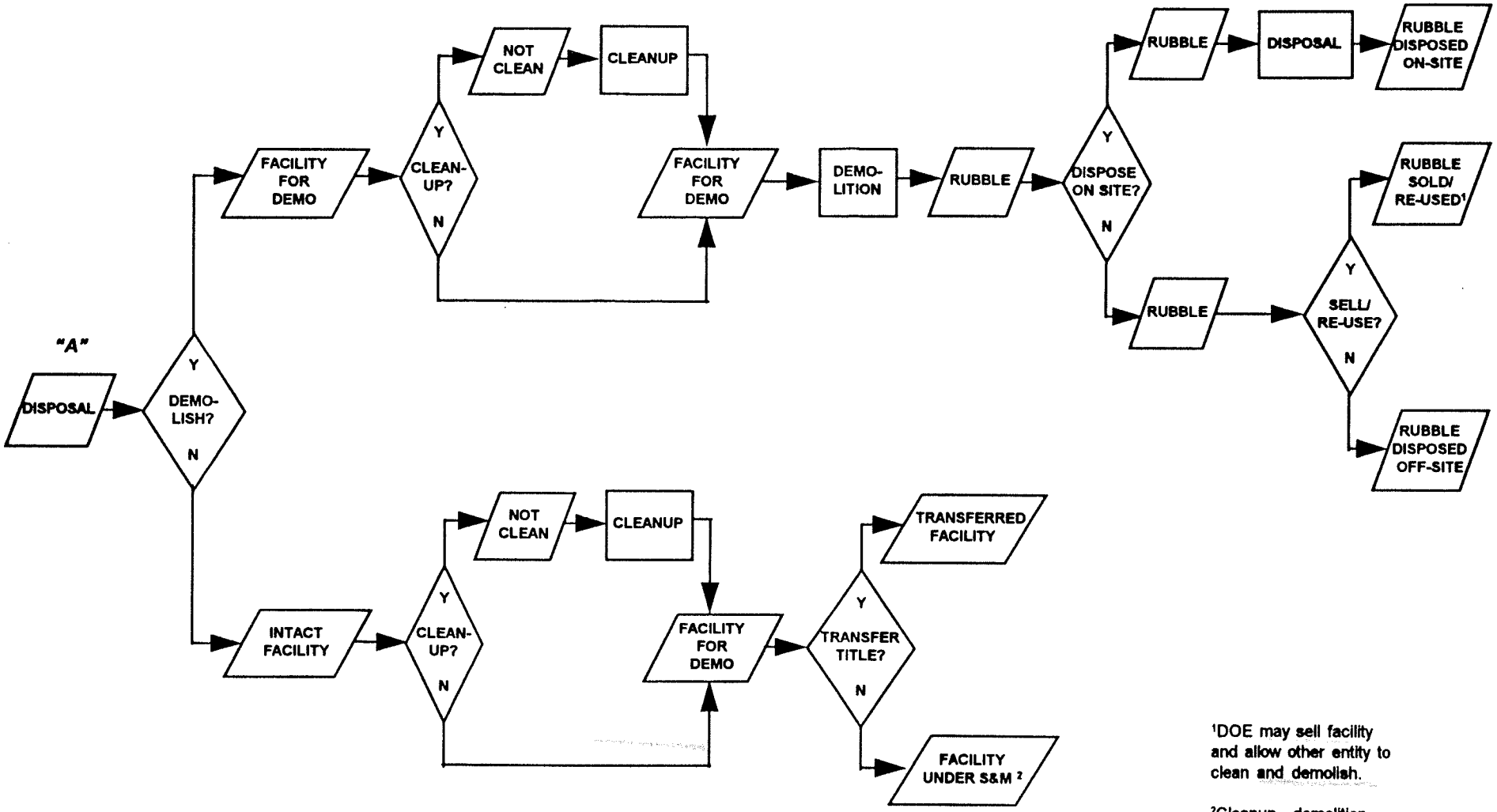

[1]DOE may sell facility and allow other entity to clean and demolish.

[2]Cleanup, demolition, and/or transfer may occur later.

Figure 2. Facility disposition logic diagram (cont.)

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Because of time constraints, the Conceptual D&D Definition workshops evaluated the sites only in terms of two broad categories of systems: gaseous diffusion process (GDP) and balance of plant (BOP). GDP refers to those systems directly used in the uranium enrichment process (e.g., cell and stage equipment; process auxiliaries, such as UF_6 feed and withdrawal; process building electrical systems; and process building services). BOP refers to those systems not directly used in the uranium enrichment process (e.g., utilities, laboratories, offices, warehouses, etc.). The workshops then considered the most probable combinations of the six disposition options applied to these two broad categories of systems and defined preliminary preferred turnover conditions for two of the most probable scenarios. Although the two scenarios were quite different, the preferred turnover conditions tentatively defined were very similar. These scenarios are discussed further in Section 3.3.

3.2 POTENTIAL ALTERNATIVE MISSIONS

The Alternative Missions workshop expanded on the "transfer" disposition options (with or without cleanup) to explore the potential for future alternative missions or uses for a site after lease termination. More than 40 ideas resulting from the brainstorming sessions were consolidated and categorized into the following six categories of likely alternative missions:

I. *Training and Education Center*–broad-based training and educational environment, including classroom, hands-on, and technology development and demonstration;
II. *Low-Level Radioactive Material Treatment/Storage/Disposal Facility*–broad-based disposition of DOE waste and depleted UF_6 (tails), including technology development and demonstration;
III. *Heavy Industry*–processes needed for large equipment manufacturing and/or requiring large quantities of power;
IV. *Industrial Park Complex*–a variety of light industry, offices, and/or material processing and handling;
V. *Resource Recovery Center*–an ongoing, major activity funded by DOE but conducted by private industry to clean up, dismantle, and "mine" or recover resources of value for reuse; and
VI. *Federal Needs (including DOE)*–use of the site to meet needs within DOE (e.g., tritium production) or needs of other federal programs.

Although the workshop did not assess the probability that one or more of these alternatives will become reality at a shutdown plant, it is thought that the probability is sufficient to warrant the definition of preferred facility turnover conditions that would enhance such potential.

3.3 MOST PROBABLE SCENARIOS AND IMPACT ON TURNOVER CONDITIONS

The most probable scenarios for ultimate disposition of returned leased facilities, as projected in the conceptual D&D workshops (see Section 3.1), are:

1. Cleanup and Transfer BOP and S&M GDP, without cleanup;
2. Demolish BOP and S&M GDP, without cleanup of either;
3. S&M BOP and GDP (entire site) without cleanup; and
4. Cleanup and Transfer BOP, Cleanup and Demolish GDP.

The Conceptual D&D Workshop selected Scenarios 2 and 4 from this list for development of preferred turnover conditions for several of the primary GDP and BOP systems. Although other ultimate disposition combinations may be feasible, especially on an individual facility basis, these were considered adequately representative for our purpose of defining preferred facility turnover conditions favorable to potential future facility disposition. For example, the Cleanup and Transfer BOP component of the above scenarios, as well as the Cleanup and Demolish GDP (or maybe even S&M GDP) components, could lead to one or more of the Alternative Missions described in Section 3.2.

The preliminary framework for preferred facility turnover conditions was then modified by considering the requirements for safe, secure, and compliant conditions immediately after turnover. The turnover conditions were also modified by consideration of: (1) the expectation that significant site support services will be needed for several years after turnover to support ongoing site activities such as S&M and waste management, irrespective of ultimate facility disposition; (2) the degree of cascade cleanup thought feasible prior to turnover, as described in Section 4; and (3) some adjustments thought needed to make the turnover conditions more reasonably achievable by turnover. The results of these various workshops and subsequent refinements are reflected in the preferred turnover conditions presented in Section 5.

4. CASCADE DECONTAMINATION OPTIONS

This section addresses key questions and issues regarding cascade cleanup treatment options and feasibility prior to the turnover of leased facilities and equipment. A GDP Turnover Conditions Workshop was held in Oak Ridge on May 31, 1995, to address these questions and issues. Results from that workshop pertaining to cascade treatment are summarized in this section, and additional details are provided in Appendixes B and C.

4.1 KEY QUESTIONS AND ISSUES

In order to define the preferred turnover conditions for the cascade systems (including primary process equipment, auxiliary systems, and other cascade support systems), it is necessary to answer the following key question:

Will cascade and supporting systems need to be operating or operable at turnover (i.e., will DOE need to do additional treatment after turnover to remove uranium deposits)?

To answer this key question, the following additional questions must be answered:

1. What is the *starting point* for cascade treatment (i.e., what are the sizes and locations of uranium deposits)?
2. What is the *target* cleanup level for process equipment?
3. How much cleanup treatment *must* be done (difference between the answers to 1. and 2.)
4. How much cleanup treatment *can* be done prior to turnover?

Answers to these questions are developed in the following sections.

4.2 INITIAL CASCADE CONDITION

At this time, it is not possible to accurately project the condition of either the PGDP or PORTS cascade at the time of notification of a lease termination. In fact, nondestructive assay (NDA) measurements will likely be needed to determine the sizes and locations of any uranium deposits in the cascade equipment. However, it is possible to make a qualitative assessment to approximate the answer to Question 1:

What is the starting point for cascade treatment?

This qualitative assessment can be made using NDA measurements at PGDP and PORTS and on the shutdown low enriched uranium (LEU) buildings at K-25, estimates of uranium compound adsorption and corrosion on internal surfaces, and results of routine operations monitoring at PGDP and PORTS.

There are three mechanisms of uranium deposition in gaseous diffusion cascades: chemical adsorption, metal corrosion, and hydrolysis. These mechanisms are described in Appendix B. Although inexact, estimates have been made for those uranium deposits in the LEU cascade process equipment at PGDP or PORTS that are the result of chemical adsorption and corrosion mechanisms. These estimates range from 4,000 to 8,000 kg U, with the lower end of the range applicable to PGDP and the higher end to PORTS.

The exact number and sizes of uranium deposits due to hydrolysis resulting from inleakage of moist air are not known at this time. However, gamma scans are routinely made at each plant to detect large deposits, and monitoring of barrier performance provides some indication of moist air inleakage. In addition, NDA measurements at K-25 have shown only a few (fewer than 20) uranium deposits in the LEU equipment that are a concern from a nuclear criticality safety (NCS) perspective. Most (14) of these deposits are in K-29, and about half are in equipment such as booster stations, purge and evacuation stations, and pipe sections.

Although it is not possible to draw firm conclusions regarding the exact sizes of deposits at PGDP or PORTS that result from hydrolysis, the K-25 measurements and results of routine monitoring at PGDP and PORTS do provide some indication of such deposits. Periodic NDA measurements are used as a trending tool to ensure that known deposits remain in control from NCS, uranium inventory, and operational perspectives. For example, recent NDA measurements made at PGDP have identified 17 deposits of more than 50 pounds, none of which exceed the NCS "safe mass" threshold at their assay levels. However, because the locations and sizes of uranium deposits in an operating cascade can change, a thorough characterization for deposits should be done at termination notification.

The general conclusion from the qualitative assessment of cascade condition is that the LEU cascades at PGDP and PORTS are not expected to contain a large number of uranium deposits of NCS concern. However, it is expected that the cascades will contain several thousand kg U of uranium compounds uniformly deposited on internal surfaces.

With respect to operability of cascade process equipment, each site has several cells that are currently inoperable, some of which have been "cannibalized" for years. Some of these cells could be made operable with significant effort, but it is expected that their inoperability will not have a significant impact on cascade treatment feasibility. However, it is important that these cells remain closed and that any cannibalization for spares be carefully controlled and documented.

4.3 CASCADE TREATMENT TARGETS

Question 2 pertains to target cleanup levels:

What is the target cleanup level for process equipment?

The answer to this question is summarized in the following paragraphs. The evaluation process identified the following three priorities for cleanup levels:

Priority 1: Reduce uranium deposits to below "safe mass" as defined by NCS criteria. Safe mass varies with enrichment assay levels. For example, it is 800 g ^{235}U at 5 percent assay and increases with decreasing assay. As indicated in Section 4.2, it is expected that a relatively small number of deposits in the returned LEU cascade will be of NCS concern.

Priority 2: Reduce the total quantity of uranium and other radionuclides in a "segmented facility" to below Category 3 nuclear facility threshold levels (ref. DOE-STD-1027-92). The categorization of a facility as a radiological facility (below Category 3 nuclear facility) is significant in terms of ongoing costs of S&M, including documentation, health and safety protection and monitoring, training, security, etc. This cost difference at PGDP or PORTS could be millions of dollars per year.

In addition to the maximum allowable total quantities of residual uranium (less than 13,000 kg ^{238}U) or other radionuclides to be classified as a radiological facility, the NCS safe mass deposit criteria must also be met. The definition of "segmented facility" is a little unclear. As a minimum, a separate process building should qualify as a segmented facility. It is possible that cascade units within a building could be physically isolated and/or specific pieces of equipment removed to make it easier to achieve the segmented facility quantities of residual uranium.

Priority 3: Treat as feasible to reduce later D&D costs (i.e., treat all cells if possible). This treatment target cannot be quantified without a comprehensive analysis of D&D life cycle costs and trade-offs versus treatment levels, and such an analysis is beyond the scope of this project. Intuitively, it is thought that the cleaner the cascade, the less costly the later D&D to meet as-yet-undetermined waste management criteria or material release criteria.

Priority 1 and 2 cleanup targets described above are considered the minimum acceptable for the purpose of defining preferred turnover conditions for cascade systems.

4.4 TREATMENT OPTIONS/FEASIBILITY

Building on the answers to Questions 1 and 2, and therefore, Question 3, the GDP Turnover Conditions Workshop focused on answering Question 4:

How much cleanup treatment can be done prior to turnover?

The results of this exercise are presented in detail in Appendix C. The appendix includes additional questions that were addressed and specific tasks and their durations and sequence that were defined pertaining to achievable cascade treatment during the 2-year post-notification period.

The primary conclusion drawn from the workshop exercise is that it should be possible to achieve the Priority 1 and 2 cleanup targets by turnover *if* production/power rampdown begins soon after notification so that cascade treatment can be prioritized and optimized during the two-year post-notification period. Therefore, the cascade process equipment and most auxiliary systems should be shut down at turnover (see Section 5 for a more explicit definition of preferred turnover conditions).

Further, it was concluded that most, if not all, of the cascade could be treated by turnover *if* key preparation actions ("precursor tasks") can be completed prior to notification. These precursor tasks include:

1. Establish capability for large-scale treatment, including:

    - concurrent treatment of multiple cells;
    - disposal of treatment gases, including possible increase of surge drum volume, upgrade of purge cascade and trapping systems, and/or development of an alternative disposal process for treatment gas; and
    - agreement with regulators on acceptable release limits.

2. Determine cascade deposit sizes and locations, to guide treatment activities and priorities.

3. Establish R-114 storage capability.

Although not directly related to cascade treatment, another key precursor task that results from the loss of process heat is the advance preparation for conversion of facility heating systems that use hot recirculating cooling water (RCW) to an alternative heating method. These systems must be converted prior to the first winter after loss of process heat, and the conversion may be extensive and time-consuming. Therefore, planning and design must begin prior to notification.

Additional discussion and details of these precursor tasks and related assumptions are presented in Appendix C.

5. PREFERRED FACILITY TURNOVER CONDITIONS

This section lists the preferred turnover conditions for leased facilities, systems, and equipment. (Reference Section 2 for the definition of preferred turnover conditions.) As described in Sections 3 and 4, these conditions were developed from several workshops that addressed long-term facility disposition scenarios, alternative missions, cascade treatment options, and expected near-term site activities after turnover. The preferred turnover conditions compiled here represent the collective judgment of a broad cross section of experienced technical, operations, and management personnel from DOE, MMES, MMUS and several subcontractors, as indicated by the listing of workshop participants (see Appendix A).

5.1 GENERAL PREFERRED FACILITY TURNOVER CONDITIONS

General preferred turnover conditions applicable to all facilities are as follows:

- All facilities and systems "winterized" as necessary prior to the first winter after loss of cascade process heat, including:
  - conversion of process building fire sprinkler systems to dry systems,
  - modification of facility heating systems that currently use hot RCW,
  - draining of water systems in process buildings, and
  - providing alternative heating, where necessary.
- USEC fissile and hazardous materials removed from the site or consolidated under an acceptable material management plan.
- Equipment needed for ongoing activities at the returned GDP retained at the site in good operating condition. Such equipment will include:
  - UF_6 cylinder handling equipment;
  - emergency vehicles such as fire trucks, ambulances, etc; and
  - equipment needed for S&M and cleanup.
- "Characterization" data (e.g., NDA, environmental, health and safety) documented.
- Building roofs intact, with some remaining life.

5.2 PREFERRED TURNOVER CONDITIONS FOR SPECIFIC SYSTEMS

Detailed preferred turnover conditions for the 14 categories of facilities, systems, and equipment are listed in Table 1.

Table 1. Preferred turnover conditions for GDP facilities, systems, and equipment

System Description	Operating Condition[1]	Other Conditions[2]
System 1: Cascade Cell/Stage Process Equipment		• All systems purged to UF_6 negative (<2 ppm). • Systems treated as necessary to reduce uranium deposits to below NCS safe mass levels and to reduce radioactive isotopes to less than Category 3 nuclear facility quantities (ref. DOE-STD-1027-92). • All cells treated prior to turnover, if feasible. • Residual deposit levels NDA-verified and documented. • UF_6 systems intact and filled with dry air to atmospheric pressure. • All block valves *opened* during purging to remove trapped UF_6 and *closed* after treatment and shutdown.
A. Converters (including barrier and gas coolers)	shut down	
B. Compressors (including shaft seals)	shut down	
C. Interstage Piping and Control Valves	shut down	
D. Intercell Piping (including block valves)	shut down	

[1]Operating Condition definitions:
Operating =fully functional and running or in use;
Operable =not operating, but functional and readily operable (i.e., "hot standby");
Shutdown =permanently shutdown and deactivated.

[2]Specific conditions to ensure safe condition and compliance with applicable regulations at turnover and to minimize life cycle costs of ultimate disposition, including S&M, D&D, and/or alternative missions.

Table 1. Preferred turnover conditions (continued)

System Description	Operating Condition[1]	Other Conditions[2]
System 2: Primary Cascade Auxiliary Systems		• All UF_6 systems purged to UF_6 negative (<2 ppm).
A. UF_6 Feed System (including Steam Supply)	shut down	• All uranium deposits reduced to below NCS safe mass levels.
B. Product Withdrawal System	shut down	• All UF_6 systems intact and filled with dry air to atmospheric pressure.
C. Tails Withdrawal System	shut down	• Trap media from shutdown traps removed (see [a]).
D. Purge Cascade	shut down	• Lube oil drained to storage tanks and disposed.
E. Chemical and Cold Trap Systems	[a]	• Seal exhaust pump oil removed and disposed.
F. Booster Stations and Tie Lines	shut down	• All auxiliary UF_6 system valves and manifolds opened to primary process system (System 1).
G. Freezer/Sublimer System	shut down	• All UF_6 pipe housing heaters deenergized after UF_6 evacuation.
H. Storage (Surge) Drums	shut down	
I. Treatment System	shut down	
J. Instrumentation System	shut down[b]	
K. Lube Oil System	shut down	
L. Cascade Air System	operating	
M. Cascade Nitrogen System	shut down	
N. Purge and Evacuation Stations	shut down	
O. Wet Air Pump Stations	operable[c]	
P. Seal Feed and Exhaust Systems	shut down	
Q. Fluorine Generation System	shut down	

[a]Some trapping systems may need to remain operable at turnover; others should be shut down and media removed (see also[c]).

[b]Cell pressure instrumentation will be needed to monitor cell pressures after treatment and shutdown; however, it is expected that conversion to a simpler pressure measurement system will be feasible.

[c]Some method of sweeping process systems in each process building needs to be retained at turnover (see also [a]).

Table 1. Preferred turnover conditions (continued)

System Description	Operating Condition[1]	Other Conditions[2]
System 3: Cascade Power System		• Motor reservoirs drained of oil.
A. Stage Motors	shut down	• Process electrical equipment de-energized and disconnected.
B. Building Transformers, Circuit Breakers, etc.	[a]	• Building auxiliary power retained in service, reconfigured as necessary for safe and cost-effective operation (see [a]).
C. Control Panels	[a]	
D. Building Wiring	[a]	
E. On-Site Transmission Lines	[a]	• Switchyard electrical equipment de-energized and disconnected, except as needed for cascade auxiliary power and site power (see [b]).
F. Switch Yards (transformers, circuit breakers, condensers)	[b]	
G. Emergency Diesel Generators	shut down	• Current 1-line diagrams available.
H. Battery Rooms	operating[c]	• Shutdown/deactivated electrical equipment drained of PCB-contaminated oil (see also [a] and [b]).

[a]All cascade building electrical systems to be shut down and deactivated except as needed for auxiliary power. Reconfiguration after turnover is likely.

[b]Switchyard electrical systems to be shut down and deactivated except as needed for cascade auxiliary power and remaining site power. Reconfiguration after turnover is likely.

[c]Battery rooms will need to be reconfigured.

Table 1. Preferred turnover conditions (continued)

System Description	Operating Condition[1]	Other Conditions[2]
System 4: Process Cooling System		• R-114 inventory removed, if feasible, and vapors purged. If R-114 remains, oxygen deficiency detection system must be in place and operable (see also [a]).
A. R-114 Piping	shut down[a]	
B. Condensers		
C. RCW Piping	shut down[a]	• RCW drained from condensers.
D. RCW Pumps and Pump Houses	shut down[b]	• RCW removed, treated, and discharged.
E. RCW Cooling Towers	shut down[b]	• Chemical inventories disposed.
F. RCW Treatment Facilities	shut down[b]	• Cooling tower gear boxes drained.
G. R-114 Transfer and Associated Equipment	shut down[b] operable[a]	

[a]If R-114 is not removed from cascade, R-114 system will need to be intact and transfer equipment operable.

[b]Some limited RCW service (such as air plant compressors and wet air pumps) will be needed until alternative cooling is arranged; any required RCW operating system will be determined prior to turnover.

Table 1. Preferred turnover conditions (continued)

System Description	Operating Condition[1]	Other Conditions[2]
System 5: Process Buildings and Service Systems		• Fire protection systems converted to dry systems *or* • Exemption from DOE order obtained to permit less expensive alternative. • Ventilation system louvers closed except as needed for any continuing activities. • Roof expansion joints repaired/modified to prevent leaks after process heat is lost.
A. Structure, per se	operating[a]	
B. Ladders and Elevators	operating	
C. Shops	operable[b]	
D. Control Rooms	[c]	
E. Electrical (lighting, etc.)	operating	
F. Sanitary Water	operating	
G. Sewage	operating	
H. Cranes	operating	
I. Ventilation System	operable (partial)	
J. Fire Protection	operating	
K. Interior Storm Drains	shut down[d]	

[a] "Operating" structure means fully functional (i.e., roofs with remaining life, functional doors, intact structure, etc.).

[b]Shops should be consolidated as much as possible.

[c]Portions of control rooms may be needed for operating auxiliary and/or service systems; the rest can be deactivated.

[d]Interior storm drains will need to be sealed, cut, or blanked.

Table 1. Preferred turnover conditions (continued)

System Description	Operating Condition[1]	Other Conditions[2]
System 6: Other Process-Related Facilities		• UF_6 Sampling/Transfer Systems maintained to enable UF_6 cylinder handling and transfer (e.g., tails), including purging and cold trapping capability.
A. Decontamination and Uranium Recovery	operating	
B. UF_6 Sampling and Transfer Facilities	operable	
C. UF_6 Cylinder Washing Facility	operable	

Table 1. Preferred turnover conditions (continued)

System Description	Operating Condition[1]	Other Conditions[2]
System 7: Site Utilities[a]		
A. Electrical, Exterior Lighting	operating	
B. Sanitary (Potable) Water	operating	
C. Sewage Plant	operating	
D. Stormwater	operating	
E. Telephone	operating[b]	
F. Radio and Other Communication systems	operating	
G. Computing and Networks	operating	
H. Steam	operating	
I. Nitrogen (non-cascade)	shut down	
J. Compressed Air (non-cascade)	operating	
K. Chilled Water (PGDP)	operating	
System 8: Roads, Railroads, and Grounds	operating	

[a]Reconfiguration of several systems will be necessary and will include downsizing to match reduced demand, conversion from RCW to sanitary water for cooling, and conversion of heating systems to compensate for loss of process-heated RCW.

[b]PAX system should be shut down.

Table 1. Preferred turnover conditions (continued)

System Description	Operating Condition[1]	Other Conditions[2]
System 9: Maintenance Facilities		
A. Central Shops (machine, weld, carpenter, etc.)	operating	
B. Field Shops	operating[a]	
C. Cascade Equipment Repair Shops	shut down	
D. Vehicle Maintenance	operating	
E. Laundry	operating	
System 10: Fire Protection Systems		
A. Fire Water System (tanks, piping, sprinklers, hydrants, etc.)	operating	
B. Extinguishers	operating	
C. Fire Hall	operating	
D. Fire Trucks	operating	

[a]Field shops for operating facilities may be needed; however, significant consolidation should be feasible.

Table 1. Preferred turnover conditions (continued)

System Description	Operating Condition[1]	Other Conditions[2]
System 11: Plant Protection Systems		
A. Emergency Operations Center	operating	
B. Central Control Facility	operating	
C. Fences, Portals, Badge Reader Systems	operating	
D. Guard Headquarters	operating	
E. Plant Public Address System	operating	
F. Emergency Vehicles	operating	
G. Medical Facility	operating	
H. Criticality Alarms	operating[a]	
I. Monitoring Systems (environmental, meteorological)	operating	
System 12: Laboratory Facilities		
A. Analytical Chemistry	operating	
B. Research and Development	[b]	

[a]Criticality alarm clusters shut down as appropriate.

[b]R&D facilities should be shut down unless some future need is identified prior to turnover.

Table 1. Preferred turnover conditions (continued)

System Description	Operating Condition[1]	Other Conditions[2]
System 13: Office and Related Service Facilities		
A. Office Buildings	operating	
B. Training Facilities	operating	
C. Food Service Facilities	operating	
D. Records Handling and Storage	operating	
E. Warehouses	operating	
F Stores Facilities	[a]	
G. Change Houses	[a]	
System 14: Waste Management & Tails Storage Facilities		• All USEC-owned waste and UF_6 tails properly dispositioned.
A. Waste Treatment, Storage, and Disposal Facilities	operating	
B. UF_6 Tails Cylinder Storage Yards	operating	

[a]Stores facilities and change houses should be consolidated to the extent feasible (to be determined).

APPENDIX A
WORKSHOP PARTICIPANTS

Name and Organization	Workshop(s) Attended			
	Conceptual D&D Definition		Alternative Missions	Preferred Turnover Conditions
	Initial	Follow-Up		
Carlos Alvarado, DOE PGDP			✓	
John Bolling, MMES K-25	✓	✓		✓
Mike Buckner, MMUS PGDP				✓
Bill Cahill, DOE-ORO EM	✓		✓	
Steve Cates, SAIC	✓	✓	✓	✓
Dan Charles, MMES CES	✓	✓	✓	✓
Sandy Childers, SAIC PORTS			✓	
Steve J. Davis, MMES PGDP	✓	✓	✓	✓
Bob Dyer, ATI		✓		
Ann Farrar, MMES EFS	✓	✓	✓	✓
Richard Faulkner, MMES K-25				✓
Clayton Gist, DOE-ORO EM			✓	
Bill Halicks, MMUS PGDP				✓
Terry Humphrys, MMES EMEF			✓	
Debora Jolly, MMES PGDP			✓	
Wray Jordan, MMUS HQ		✓		
Marci Kastl, Analysas	✓	✓	✓	
David T. Kendall, MMES CES	✓		✓	
George Kidd, MMES K-25	✓	✓	✓	✓
Brendan Kirby, MMES ORNL				✓
Bill Lemmon, Theta				✓

Name and Organization	Workshop(s) Attended			
	Conceptual D&D Definition		Alternative Missions	Preferred Turnover Conditions
	Initial	Follow-Up		
Andy Loebl, MMES EMEF			✓	
Larry Long, MMES EMEF	✓	✓		
Ann Lovell, DOE-ORO EF	✓			
Jimmy Massey, MMES EMEF			✓	
Mike Milam, MMUS PORTS				✓
Ralph M. Nolfi, MMES PORTS	✓	✓	✓	
John Overly, MMES CES			✓	
Larry Owens, MMES EMEF	✓	✓	✓	✓
Gary Person, MMES K-25 D&D	✓	✓		✓
Steve Rice, DOE-ORO EF	✓	✓	✓	
Bob Ritter, MMUS OR				✓
Ana Rosado-Gonzalez, DOE-ORO ER D&D	✓			
Bill Schloesslin, MMES PORTS D&D	✓	✓		
John Sheppard, DOE PORTS			✓	
Rodney Smith, Barge-Waggoner			✓	
Debbie Wattier, MMES PGDP			✓	
Robin White, MMES EMEF	✓			

SAIC: Science Applications International Corporation
CES: Central Engineering Service
ATI: American Technologies Incorporated
EFS: Enrichment Facilities Support
EMEF: Environmental Management and Enrichment Facilities
ORNL: Oak Ridge National Laboratory
EF: Enrichment Facilities

APPENDIX B

MECHANISMS OF URANIUM DEPOSITION IN GASEOUS DIFFUSION CASCADES

R. L. Ritter

Uranium-containing materials are deposited on the surfaces of GDP equipment by three mechanisms: adsorption, metal corrosion, and hydrolysis.

Adsorption. An initial deposition of uranium [as uranium hexafluoride (UF_6)] occurs almost instantaneously because of chemisorption of UF_6 on the equipment surfaces. Another feature of chemisorption is that it occurs everywhere the gas can reach, including the interior of porous materials and deep, closed-end recesses. Because pressures and temperatures necessary to remove this chemisorbed UF_6 cannot be achieved in cascade equipment, all the chemisorbed gas will remain on the cascade surfaces even after the shutdown and in-place cleanup of equipment. The quantity of chemisorbed material does not change with exposure time; it is always present after initial exposure.

A relatively small additional quantity of physically adsorbed UF_6 will be present on the surfaces while the equipment is in operation, but this physically adsorbed material is loosely bound to surfaces and is completely removed, along with gaseous material, during normal cascade shutdown, evacuation, and purging procedures.

The total quantity of adsorbed UF_6 is of the order of 10 kilograms (kg) of U (in the form of UF_6) per 000 cell and 7 kg U per 00 cell. Physical adsorption accounts for about 10 percent of the total adsorbed material, and the other 90 percent is the very tightly bound chemisorbed material.

Corrosion. The internal structural materials of the cascade (which are principally nickel, aluminum, nickel-plated steel, copper, and small quantities of iron) are corroded by UF_6. The corrosion process produces a deposit of solid, reduced uranium fluoride, probably either UF_5 or U_2F_9. The rate of this deposition is minimized in diffusion cascades by prestabilization of the metal surfaces with fluorine to form a protective metal fluoride film on the surfaces. Because a protective film is not formed on iron surfaces, prestabilization is not effective in reducing the subsequent corrosion rate of the iron surfaces.

Deposition of these reduced uranium fluorides will continue during the entire operating life of the cascades, and the rate will depend on the temperature and pressure conditions used. As a rough estimate, these deposits will form at the rate of something less than 0.1 kg U per month per operating cell.

Hydrolysis. Solid uranium-containing material can also be deposited on cascade surfaces, in the form of uranium oxyfluorides (principally UO_2F_2 but possibly others as well) by the reaction of UF_6 with water vapor (hydrolysis) that enters the cascade through small leaks in process equipment. It is extremely difficult to quantify the rate of deposition of this material, because the rate is dependent on the frequency and extent of wet air inleakage, which can vary widely with time and with cascade location. Most of the solid material formed by this mechanism is deposited on surfaces in the vicinity of the inleakage point.

APPENDIX C

CASCADE TREATMENT AND TURNOVER PREPARATIONS

During the GDP Turnover Conditions Workshop on May 31, 1995, the participants examined the question "How much cascade treatment can be done during the 2 years after notification of lease termination and before actual turnover?". Because of site differences that could impact the answer to this question, the participants were divided into two work groups to focus on PGDP and PORTS separately. The groups were asked to define specific activities and their durations and the sequence needed to achieve prescribed cascade treatment targets (see Section 4.3).

Specific questions, which had been included in the advance preparation package for the workshop, and some ground rules were used to help guide the group activity. The specific questions were:

- What are production/power rampdown constraints?
  - Time needed for inventory removal?
  - Power reduction constraints?
  - Cascade configuration constraints?

- What is the maximum rate of R-114 removal from the cooling systems?

- What is the maximum treatment rate?
  - Purge cascade and trapping system constraints?
  - Other constraints on treatment gas disposal?
  - Other constraints on treatment rate?

- What would be likely treatment priority?
  - Sequence?
  - Timing?

- What is treatment process for uranium deposits in auxiliary systems?
  - Priority?
  - Sequence?
  - Timing?

The ground rules were:

- Treat one unit at a time on inverse recycle. (The validity of this assumption was later questioned, and "multiple cells" at a time is considered more realistic. However, the conclusions drawn from the exercise should not be significantly affected.)

- Remove R-114 before treatment begins.

- Limit maximum quantity of treatment gas per unit to 10 times the current limit per cell.

- Begin production/power rampdown immediately after notification, if necessary to achieve treatment targets.

- Disregard financial/cost considerations (for the exercise).

The actions developed by the two work groups during the workshop, plus some additional input after the workshop, have been consolidated and depicted on a time line (Figure C-1). The following observations should be noted:

1. Both groups tentatively concluded that *if certain precursor preparations were done prior to the notification date*, sufficient cascade treatment could be completed prior to the turnover date to permit shutdown of the process equipment and most of the cascade auxiliary equipment. The required precursor tasks are shown in Figure C-1. The most critical of these tasks are: characterizing the cascade condition (i.e., deposit size and location) to guide the treatment work; establishing a large-scale treatment capability and plan; and establishing R-114 storage capability. It may take several months to complete these tasks; consequently, if they are not initiated sufficiently in advance of the 2-year post-notification interval, it is questionable whether desired cascade treatment could be completed by the turnover date.

2. There were no obvious site differences that impacted the activities or conclusions of the two groups, at least at the high level at which the questions were addressed. The number of units to be treated at each plant and the process and pace of treatment considered by each group were similar.

3. A major assumption (ground rule) influencing the groups' conclusions was the ability to treat a unit (or at least multiple cells) at a time. Although it appears this methodology is feasible, it has not been done and would have to be demonstrated. Additionally, it was assumed that treatment gases could be disposed at a rate to support the treatment rate developed. Both these assumptions would need to be verified as part of the precursor task to establish the capability for large-scale treatment.

Although a little beyond the focus on cascade treatment prior to turnover, each group also defined other cascade-related tasks that need to be accomplished prior to turnover (e.g., winterization) and tasks that need to be initiated prior to or soon after turnover. These are also shown in Figure C-1.

Figure C-1. Cascade Treatment and Related Activities for Turnover

Task Name	Year 1				Year 2				Year 3			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
A. PRECURSOR (PRE-NOTIFICATION) TASKS	Notification							Turnover				
(must be completed prior to notification for the post-notification tasks (B)												
to be performed on schedules indicated)												
A.1. Characterize Cascade Condition												
A. Upgrade NDA capability												
B. Determine deposit size and location (NDA)												
C. Estimate uranium adsorption/consumption (Ritter)												
D. Determine equipment condition (e.g., operability)												
A.2. Establish R-114 Storage Capability												
A. Purchase tank cars?												
B. Use shutdown units for temporary storage?												
A.3. Develop Preliminary Production Rampdown Plan												
A. Prioritize cell/unit off-stream and reconfiguration sequence												
B. Develop schedule for power reduction												
A.4. Establish Large-Scale Cascade Treatment Capability and Plan												
A. Evaluate cell vs. unit treatment issues, including failure considerations												
B. Evaluate alternatives and issues for treatment gas disposal												
C. Establish acceptable release limits with regulators												
D. Upgrade purge cascade and trapping capabilities												
E. Upgrade instrumentation (e.g., FTIR)												
A.5. Prepare for Conversion of Facility Heating Systems that use hot RCW												

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Figure C-1. Cascade Treatment and Related Activities for Turnover

Task Name	Year 1				Year 2				Year 3			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
B. POST-NOTIFICATION TASKS	Notification							Turnover				
B.1. Refine Production Rampdown Plan and Negotiate Power Schedule												
B.2. Treat Units/Cells (until power level reaches ~500 MW)	~10-12 units; ~ 12 months											
A. Take unit/cells off stream and reconfigure cascade as needed												
B. Withdraw UF6 inventory; reduce power												
C. Purge and evacuate to UF6 negative												
D. Remove R-114 inventory and isolate RCW												
E. Place on inverse recycle and charge with treatment gases												
F. Treat to endpoint criteria												
G. Evacuate and purge treatment gases												
H. Verify deposit removal (NDA)												
I. Repeat treatment, purging, and NDA cycle as necessary												
B.3. Shut Down Treated Units/Cells		~10 to 12 units										
A. Shut down, pressure with dry air to atmospheric pressure, and												
close block valves (unless use temporarily for treatment gas storage)												
B. Drain lube oil and motor reservoirs												
C. Drain condensers and RCW lines												
D. De-energize electrical equipment												
B.4. Complete UF6 Withdrawal From Cascade												

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Figure C-1. Cascade Treatment and Related Activities for Turnover

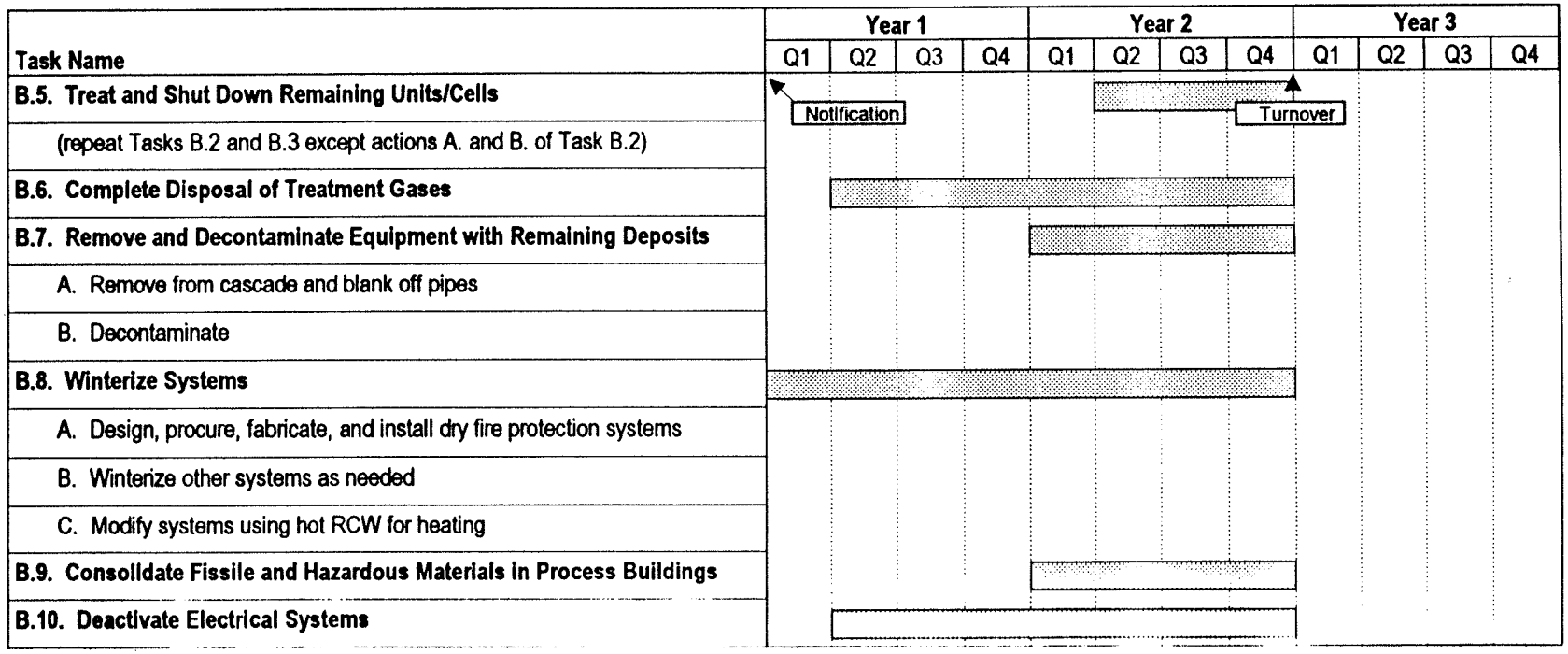

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Figure C-1. Cascade Treatment and Related Activities for Turnover

Task Name	Year 1				Year 2				Year 3			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
C. POST-TURNOVER TASKS	Notification							Turnover				
C.1. Reconfigure Systems for Reduced Requirements												
A. Process Building electrical												
B. Switchyards												
C. Air												
D. Steam												
E. Water												
F. Others as necessary												
C.2. Implement S&M as necessary												
C.3. Consolidate Personnel Into Selected Facilities												
C.4. Remove Hazardous Materials as Necessary												

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