TMI-2 RECOVERY PROGRAM ESTIMATE

REVISION 3

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INTRODUCTION

Purpose

In January 1985, GPU Nuclear Corporation initiated a review of estimated costs to complete cleanup operations at TMI-2 as part of an on-going program to plan, manage, and perform defueling and decontamination operations for the accident-damaged TMI-2 facility. This report summarizes the results of that review.

Summary

The program cost is, for practical purposes, unchanged from that forecasted in the Recovery Program Estimate, Rev. 2, December 1982 and the TMI-2 Defueling Study, August 1984. Activities to defuel the reactor vessel and associated systems, to remove or immobilize radioactive materials, and to complete end point verification are forecast to be completed in September 1988 at a total program cost (1979-1988) of $965,000,000.

Background

Since the March 28, 1979 operating accident, several TMI-2 Recovery Program Cost Estimates have been prepared. Appendix A presents a chronological summary of these estimates.

This report represents a revised estimate based on known plant conditions through June 30, 1985. It incorporates knowledge, planning, and experience gained since the last complete review of the program, as documented in the TMI-2 Recovery Program Estimate, Rev. 2, December 30, 1982 (RPE, Rev. 2), and as supplemented by the interim cost assessment, the TMI-2 Defueling Study, completed in August 1984.

Significant new information concerning plant and reactor fuel conditions has been acquired since the TMI-2 Defueling Study was prepared. The removal of the reactor vessel head in July 1984 provided the first direct inspection of vessel internals and video inspection of areas below the damaged reactor core. The plenum was removed in May 1985, permitting the first examinations of limited regions of the core support assembly

(CSA). In addition, remote radiation surveys were conducted to (1) detect the presence and determine estimated quantities of fuel external to the reactor vessel and (2) measure the radiation fields in the reactor building basement (El. 282').

Information obtained as a result these activities has increased our confidence that planned activities will accomplish desired results; i.e., safe defueling of the reactor while maintaining the plant in a stable and safe condition. However, uncertainty remains regarding actual defueling operations, particularly their estimated durations, because of their first-of-a-kind nature. Further, post-defueling workscope (e.g. decontamination and waste management) is sensitive to Phase III completion criteria.

Actual program costs may vary from those forecast in this report because of revised criteria or new data affecting assumptions. This estimate contains an identified amount considered to be sufficient to reasonably manage the known risks.

Approach Used in Developing the Estimate

In developing this estimate, program objectives, organization and completion criteria, as well as specific technical plans for accomplishing program objectives were reviewed and revised to incorporate current information and planning as of June 30, 1985. Tasks required to accomplish current program plans were identified, categorized within the program work breakdown structure (reference Work Breakdown Structure, TPO/TMI-116), and their cost effects assessed. Costs for planned activities for which no changes were identified were carried forward from the TMI-2 Defueling Study.

For non-level-of-effort tasks such as those contained in defueling and decontamination operations, the type, quantity, and duration of labor, both direct and indirect, and the material and equipment needed to accomplish each task were identified, with the appropriate pricing applied. These components were summarized to provide an estimate of cost for a given task.

Level-of-effort tasks, i.e., program support and plant stability/safety, were estimated based on program historical data adjusted to reflect planned changes in program requirements. These changes, in part, include a reduction in new systems engineering effort beginning in 1986, an increase in decontamination operations activity also beginning in 1986, and a planned license conversion in mid-1987.

Organization of Estimate

This report is organized around two primary sections: (1) a brief description of estimated workscope (Estimate Bases) and (2) Assumptions and Qualifications (Table 1) including summary reports of program costs (Tables 2 and 3) and the schedule to accomplish the work (Table 4).

Several appendixes support the two primary sections. Appendix A provides information for comparison of this estimate with previous program estimates. Appendixes B through D provide additional descriptions of program workscope; and Appendixes E through H provide supporting detail for program cost summaries presented in Tables 2 and 3.

Costs, assumptions and qualifications, and financial exposures are organized according to the program work breakdown structure (WBS) presented in Technical Plan TPO/TMI-116, Work Breakdown Structure. With the exception of the costs presented in Table 3, which is an organizational summary of project costs, all costs are associated with a program work element.

The WBS is composed of six major work categories, each of which is made up of several elements. The six major work categories are as follows:

1 - Program Support
2 - Stabilization, Dose Reduction, and Decontamination
3 - Reactor Disassembly and Defueling
4 - Radioactive Materials Management
5 - General Recovery Facilities/Systems
6 - Plant Stability/Safety

Further descriptions of work tasks that constitute a given WBS work element are provided in TPO/TMI-116. For convenience, a listing of program work elements is presented in Appendix B.

Estimate Bases

Technical Plan TPO/TMI-115, TMI-2 Program Strategy, describes the program workscope and completion criteria on which this estimate is based.

The recovery program is structured into three phases: Phase I - Stabilization, Phase II - Fuel Removal, and Phase III - Cleanup. Phase I is complete. Phases II and III are essential, relatively urgent, and unaffected by a decision as to the ultimate disposition of the plant. Costs associated with the disposition decision are excluded from the scope of this estimate.

The overall objectives of the TMI-2 Recovery Program are to effectively remove the remaining risk to public and worker health and safety from potential releases of radioactivity from TMI-2, to monitor the plant, and to support a future decision to refurbish or decommission TMI-2. While minimizing the radiation exposure during the program to the cleanup workforce, these objectives will be achieved when:

- o The possibility of criticality is no longer credible.
- o The potential for fission product mobility has been eliminated for all practical purposes; i.e., radioactive water, airborne contamination, and loose surface contamination will be removed or controlled.
- o Fuel has been removed and shipped off site.
- o Radioactive waste from the above activities has been packaged and shipped, or safely stored.
- o Radiation levels are reduced commensurate with the need for access: (1) to permit continued plant monitoring and (2) to support plant disposition decisions.
- o Water will be removed from plant systems and spaces and the potential for reintroduction of water will be precluded.
- o A safe, monitored plant condition is established.

The amount of fuel remaining at program end (completion of Phase III as described in TPO/TMI-115) is governed by the prevention of criticality and fuel accountability requirements. The intent is that as much fuel as practical will have been removed; i.e., bulk fuel will have been effectively collected and removed from the reactor and reactor coolant and connected systems. Some fuel contamination will remain within the plant systems and structures. (See Appendix C for additional descriptions of reactor disassembly and defueling activities.)

Phase II decontamination efforts will primarily support dose reduction for reactor disassembly and defueling, as well as ex-vessel fuel removal efforts. Additionally, some decontamination activities in the reactor and auxiliary and fuel handling buildings will be necessary to permit and maintain access for required safety surveillance operations and

maintenance, and to support establishing the radiological conditions of the plant at the end of Phase III. In Phase III, decontamination efforts will be directed to removing or securing mobile radioactive materials that remain following completion of fuel removal activities. (See Appendix D for additional descriptions of decontamination activities.)

At the completion of Phase III, plant systems will have been water flushed and drained. All water will have been removed from the reactor building basement. High radiation areas will exist in the plant at the completion of Phase III; however, non-adhering contamination will have been removed or fixed. Consistent with the objective of eliminating fission product mobility, there will be no liquid radwaste stored on site at Phase III completion.

Extended onsite storage of waste will be minimized. Waste will be packaged and shipped to offsite disposal facilities, either a commercial or U.S. Department of Energy (DOE) facility, depending on the nature of the particular waste. Abnormal waste disposal will be in accordance with the Memorandum of Understanding between the DOE and the Nuclear Regulatory Commission (NRC), March 15, 1982.

Plant components will be removed and shipped for disposal only when dictated by radiological control considerations, operational necessity, or clear cost advantage. Components not removed at the conclusion of Phase III activities will be left in place. However, many major items of defueling equipment will be removed.

Plant status and material conditions that will exist when the Phase III program objective is achieved do not represent the ultimate condition of TMI-2. Once a decision is made on the ultimate disposition of the plant, that decision will dictate the nature and scope of future, post cleanup activities. Activities related to refurbishment or decommissioning of the plant are not within the scope of the recovery program as defined by TPO/TMI-115 and, accordingly, not within the scope of this estimate.

Summary of Program Costs

Table 1 lists the general assumptions and qualifications on which program costs were estimated. Tables 2 and 3 summarize program costs by WBS element and organization, respectively.

The costs presented in Tables 2 and 3 include some provision for unplanned costs. Appendix F, "Potential Unplanned Workscope" identifies activities or events which have the potential for additional program costs.

The current total program estimate listed in Tables 2 and 3 is $965,000,000. Of this amount $561,000,000 has been spent as of June 30, 1985. The remaining $404,000,000 includes an allowance of approximately 10 percent of the 'to go' costs for unplanned workscope identified in Appendixes E and F.

For practical purposes the program estimate is unchanged from the previous program estimate, Recovery Program Estimate, Rev. 2, December 1982 and the TMI-2 Defueling Study, August 1984.

TABLE 1

TMI-2 RECOVERY PROGRAM ESTIMATE
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ASSUMPTIONS AND QUALIFICATIONS

Reference Number	Related WBS Element	
		General
1	All	The TMI-2 Program Strategy (TPO/TMI-115) is used as an overall basis.
2	All	All work will be accomplished in accordance with the Program Master Schedule, August 1985, presented in Table 4.
3	All	All costs are forecast in 1985 dollars with escalation added based on a 5 percent annual increase in costs per year compounded.
4	All	Resources required to support a decision on the future disposition of the plant have not been included in this estimate.
5	All	No salvage value has been considered.
6	All	Part 50 License is modified effective July 1, 1987, which is after the completion of in-vessel fuel removal.
7	All	Licensing requirements, including public hearings, are limited in scope and do not delay work.
		Stabilization, Dose Reduction, and Decontamination
8	227	Required work in the reactor building (RB) basement involves: o Removing bathtub ring o Desludging

Reference Number	Related WBS Element	
		Stabilization, Dose Reduction, and Decontamination (cont'd.) o Selective concrete removal o Gross decontamination via high pressure (HP) flushing, and/or application of fixing agents o Demolishing enclosed stairwell and removing rubble.
9	236	The TMI-2 fuel handling building will be decontaminated to prevent the spread of contamination from TMI-2 to TMI-1.
10	236	Auxiliary and fuel handling building (AFHB) walls, floors, overheads, system exterior surfaces, etc., will be decontaminated to a degree that residual contamination is acceptable and/or stabilized by fixing agents. The AFHB Decontamination Plan (TPO/TMI-130) establishes the criteria.
11	243	After defueling, the reactor coolant system (RCS) will be water flushed, drained, and closed. Costs for chemical decontamination are not included in the estimate.
12	243	Other RB and AFHB systems will be desludged, flushed, drained, and closed. In general, no liquids, sludges bearing fission products or fuel contamination will be left in plant systems. Costs for chemical decontamination of these systems are not included in the estimate.

Reference Number	Related WBS Element	
		Reactor Disassembly and Defueling
13	326-7	The fuel condition is assumed to be as follows: o Approximately 80-85 percent of the fuel is located in the core region. Of that amount, approximately half is readily removable by vacuuming and "pick and place" methods (i.e., no size reduction, mining, or other aggressive removal techniques are required for this portion). The balance consists of material in various physical forms, including agglomerated sections, all of which is extractable using strong mining tools. o Approximately 15-20 percent of the fuel is no longer in the core region. Nearly all of this is in the lower head region, in and below the CSA. Much of this material can be removed by "pick and place" and vacuuming methods; however, some may require more aggressive methods (breaking, separation, size reduction) to permit removal. o The balance of fuel (perhaps 1 or 2 percent of the total) is distributed throughout the RCS, primarily in the steam generators, J-legs, pressurizer, and surge line. Essentially all of this material consists of small particles removable by vacuuming or other mechanical methods.
14	386	Each canister can be loaded with core debris to an average 1500 pounds; an average of one canister per day can be loaded.
15	386	In-vessel fuel removal working area radiation field will average 15 mr/hr and worker dose limits will average 1 rem/qtr.

Reference Number	Related WBS Element	
		Reactor Disassembly and Defueling (cont'd.)
16	386	Access for ex-vessel fuel removal will be gained through various system entry points, based on characterization results. Access to the cold legs may be gained through holes cut in the CSA upper core barrel. The RCS water level can be lowered after bulk fuel removal to permit removal of the four reactor coolant pump motors.
17	388	Fuel accountability by conventional means and to normally established standards of precision is not possible because of the condition and distribution of the damaged fuel. Therefore, an accountability plan has been developed which is based primarily on a post-defueling survey of the plant which will establish, within practical limits, the quantity of fuel remaining in the plant. (Reference Technical Plan TPO/TMI-035, August 1985, TMI-2 Core Accountability.)
18	390/ 426	The CSA will be defueled in-place and remain in the vessel but may require cutting to gain access to fuel integral with the flow baffle structure and to gain access to the lower reactor vessel head.
		Radioactive Materials Management
19	400	Costs for waste shipping, handling, packaging, and processing are based on waste generation projections contained in Appendix H.
20	422	Facilities/procedures will be in place to accommodate onsite packaging, handling, and interim storage of all solid waste (dry active

Reference Number	Related WBS Element	
		Radioactive Materials Management (cont'd.)
20 (cont'd.)	422	waste and waste concentrate liners). Low-level wastes will be disposed of at an off-site, low-level waste disposal facility.
21	424	Contaminated permanent plant equipment will not be removed from the plant unless necessary for dose reduction or as required to avoid congestion within critical work areas. Defueling or decontamination systems determined to be of no benefit to future work will be removed from the plant.
22	431	All water in the plant will be processed by existing or planned systems (EPICOR II, SDS, boron recovery evaporator (BRE), DWCS). An allowance is included for the engineering, licensing, and implementation of water solidification and site storage. No allowance has been included for disposal costs.
23	426	The reactor vessel head will remain stored and shielded during defueling and will be replaced on the reactor vessel after defueling.
24	426	The reactor plenum will remain stored during defueling and will be reinstalled in the vessel after defueling.
25	442	All abnormal waste will continue to be disposable via the DOE.
26	442	All recovered fuel will be canned and shipped.
27	442	No more than 288 canisters (fuel, knockout, and filter) will be required to complete defueling.

Reference Number	Related WBS Element	
		General Reactor Facilities/Systems
28	500	There are no future permanent facilities included for TMI-2. An allowance has been provided for the design and installation of isolation, protection, and surveillance systems which should be adequate for several years. Operation of the systems is excluded.
		Plant Stability/Safety
29	600	Equipment facilities, etc., will be maintained in accordance with licensing requirements. Access to areas will be controlled as required for radiological protection.
30	600	Maintenance of equipment and facilities as investment protection or for preservation of future disposition options is excluded.

TABLE 2

TMI-2 RECOVERY PROGRAM ESTIMATE
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WORK BREAKDOWN STRUCTURE SUMMARY CASH FLOW
($ x 1000)

WBS	Description	1985	1986	1987	1988	Total
1	Program Support	51370	48140	37690	23780	160980
2	Decon & Dose Reduction	4865	21975	32000	24920	83760
3	Reactor Disassembly & Defueling	43035	23225	17625	1000	84885
4	Radwaste Management	8590	14500	23250	17015	63355
5	General Recovery Facilities/Systems	270		2000	2000	4270
6	Plant Stability/Safety	12600	12150	10735	7475	42960
	TOTAL (1985 dollars)	120730	119990	123300	76190	440210
Escalation Factor			1.05	1.103	1.144	
Escalated Total			125990	136000	87161	
Use		120700	126000	136000	87200	469900
PROGRAM COST - 1979-1984						495000
PROGRAM COST - 1979-1988						964900
Use						965000

TABLE 3

TMI-2 RECOVERY PROGRAM ESTIMATE
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PROGRAM COST SUMMARY BY ORGANIZATION
($ x 1000)

Organization	1985	1986	1987	1988	Total
Office of the Director	600	600	550	250	2000
Program Controls	1280	1000	800	200	3280
Recovery Programs	59200	55620	61040	34220	210080
Site Operations	17600	22260	30450	22360	92670
Technical Planning	4000	2700	1300	200	8200
Licensing & Nuclear Safety	3300	3300	2100	800	9500
Government & Industry Programs	970	970	600		2540
TMI-2 DIVISION	86950	86450	96840	58030	328270
Support Divisions	33780	33540	26460	18160	111940
TMI-2 PLANT (1985 dollars)	120730	119990	123300	76190	440210
Escalation Factor		1.05	1.103	1.144	
Escalated Total		125990	136000	87161	
Use	120700	126000	136000	87200	469900
PROGRAM COST - 1979-1984					495000
PROGRAM COST - 1979-1988					964900
Use					965000

TABLE 4

TMI-2 RECOVERY PROGRAM ESTIMATE
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TMI-2 PROGRAM MASTER SCHEDULE MILESTONES

1.	Remove Plenum	May 1985
2.	Start of Early Defueling	October 1985
3.	Complete Fuel Shipping Preparations	March 1986
4.	Complete Bulk Defueling	September 1986
5.	Complete Upper CSA Defueling	April 1987
6.	Complete Ex-Vessel Defueling	May 1987
7.	Complete In-Vessel Defueling	June 1987
8.	Complete Fuel Shipping	April 1988
9.	Complete Systems Decon	July 1988
10.	Complete Phase III End Point Verification	September 1988

TMI-2 PROGRAM MASTER SCHEDULE

TABLE 4

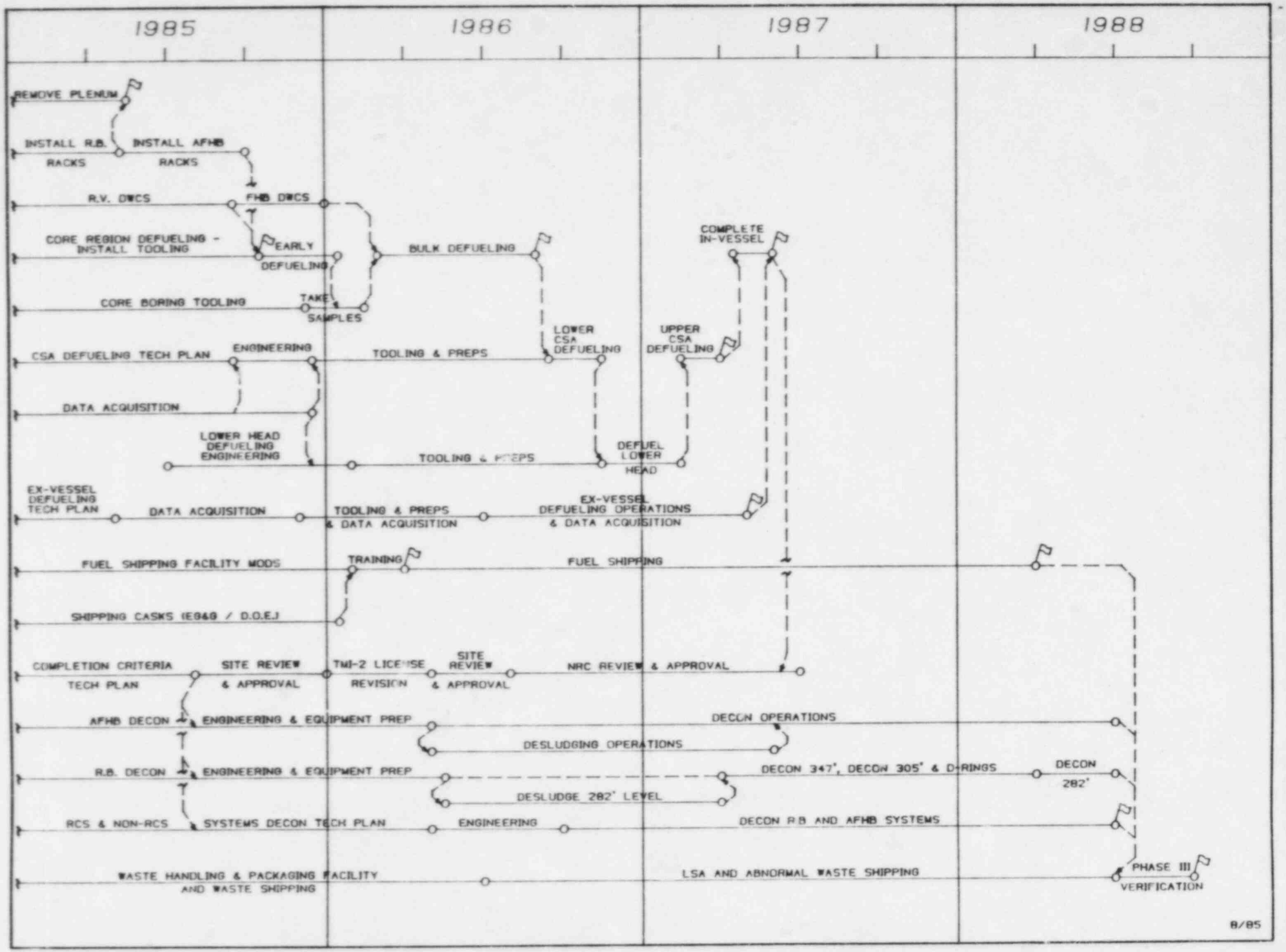

TABLE 4

APPENDIX A

TMI-2 RECOVERY PROGRAM ESTIMATE
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CHRONOLOGICAL SUMMARY OF RECOVERY PROGRAM ESTIMATES
($ x Millions)

Estimate	Date of Estimate	Estimated Program Completion Date	Program Cost[a]
TMI-2 Recovery Program Estimate	August 1980	October 1985	855
TMI-2 Recovery Program Estimate, Rev. 1	July 1981	December 1986	1034
TMI-2 Recovery Program Estimate, Rev. 2	December 1982	June 1988	975
TMI-2 Defueling Study	August 1984	September 1988	967
TMI-2 Recovery Program Estimate, Rev. 3	August 1985	September 1988	965

NOTE:

a The TMI-2 Defueling Study, August 1984, and the TMI-2 Recovery Program Estimate, Rev. 3, August 1985, are the only two estimates with scopes that are directly comparable. The narrative that follows briefly describes the most significant scope differences between the different estimates.

TMI-2 Recovery Program Estimate, August 1980

The August 1, 1980 Recovery Program Estimate constituted the first formal estimate of the TMI-2 cleanup and recovery program. It incorporated an assessment of plant conditions as of June 1980, a work plan and schedule that benefited from program experiences of the preceding 16 months, with an evolving understanding of the magnitude and complexity of the Recovery Program. One reactor building containment entry had been completed before the preparation of this estimate.

The estimated work scope encompassed cleanup through reconstruction to pre-accident conditions, refueling, and testing. The program end point (commercial operation) was scheduled to be attained in October 1985. Base operations and maintenance were excluded. Funding limits were not addressed in the estimate.

TMI-2 Recovery Program Estimate, Rev. 1, July 1981

The Recovery Program Estimate was revised in 1981 to reflect changes in program strategy and schedule. The original program logic concentrated the early effort on cleanup of those portions of the TMI-2 plant external to the containment building. Operations in the AFHB were thought to be less demanding than those that would be ultimately required inside containment. Thus, early operations were planned to serve as training for later, more difficult, in-containment tasks.

The Revision 1 estimate was based largely on data used for the August 1980 estimate, with some scope and estimating adjustments made to incorporate experience and data acquired since the August estimate. The estimated work scope encompassed defueling and decontamination to levels approximating those found in typical operating plants. Base plant operations and maintenance costs were included in the revision. Fuel loading, commissioning, and/or decommissioning costs were excluded. Seven containment entries had been completed before the preparation of the Revision 1 estimate.

The revised schedule had as its goal the earliest possible access to the reactor head to conduct in-reactor inspections and then lift the head from the reactor. The underlying logic for this plan was to obtain data as early as possible, to have adequate time to design the special tools and equipment necessary for removing fuel, and to assess any additional problems.

TMI-2 Recovery Program Estimate, Rev. 1, July 1981 (cont'd.)

In addition to the above schedule modification, the revised schedule reflected the reduction in program level-of-effort which occurred in September 1980, and identified the program end point as December 1986. The estimate did not, however, continue the reduced program level of effort through to the program endpoint. It assumed that the program completion would be unrestricted by funding beginning in January 1982.

TMI-2 Recovery Program Estimate, Revision 2, December 30, 1982

The Recovery Program Estimate was revised at the end of 1982 to reflect continued program funding constraints. In contrast to the Revision 1 assumption of unlimited program funding beginning in January 1982, the Revision 2 estimate included five funding scenarios. The scenario chosen to be the basis for planning purposes had $76 Million for 1983, $100 Million for 1984, $117 Million for 1985, $126 Million for 1986, $136 Million for 1987, and $81 Million for 1988. The program end point was extended to June 1988.

Cost estimates were largely based on Revision 1 data adjusted for schedule and work experience gained over the activities of the preceding 16 months. The estimated work scope encompassed defueling and decontamination to levels approximating those found in typical operating plants. Base plant operations and maintenance costs were included in the revision. Fuel loading, commissioning, and/or decommissioning costs were excluded. Three remote camera inspections of the reactor core and approximately 130 containment building entries had been completed before preparation of this estimate.

TMI-2 Defueling Study, August 1984

Delays associated with the polar crane refurbishment encountered in late 1982 and 1983 caused the recovery program schedule to slip approximately 1 year in 1983. In early 1984, management decided to recover lost time. An effort was initiated to develop a program in which reactor defueling activities would be accelerated to approximately coincide with the Recovery Program Estimate Schedule, Rev. F, dates contained in the TMI-2 Recovery Estimate, Rev. 2, mentioned above. This effort included refinement of defueling concepts and, in parallel, a reevaluation of program strategy and completion criteria.

The TMI-2 Defueling Study was initiated to assess the cost impacts of "early defueling" and revised program completion criteria. The work scope estimated encompassed defueling and decontamination to support defueling, Phase III completion criteria, and those inspections and surveys appropriate to make a decision on ultimate plant disposition. Base plant operation and maintenance costs were included in the estimated work scope. Fuel loading, commissioning, and/or decommissioning costs were excluded. Like previous Recovery Program Estimate revisions, the TMI-2 Defueling Study was not a "bottoms up" estimate, but rather a review of the previous Recovery Program Estimate, Rev. 2 with revisions incorporated to reflect current conditions.

APPENDIX B

TMI-2 RECOVERY ESTIMATE
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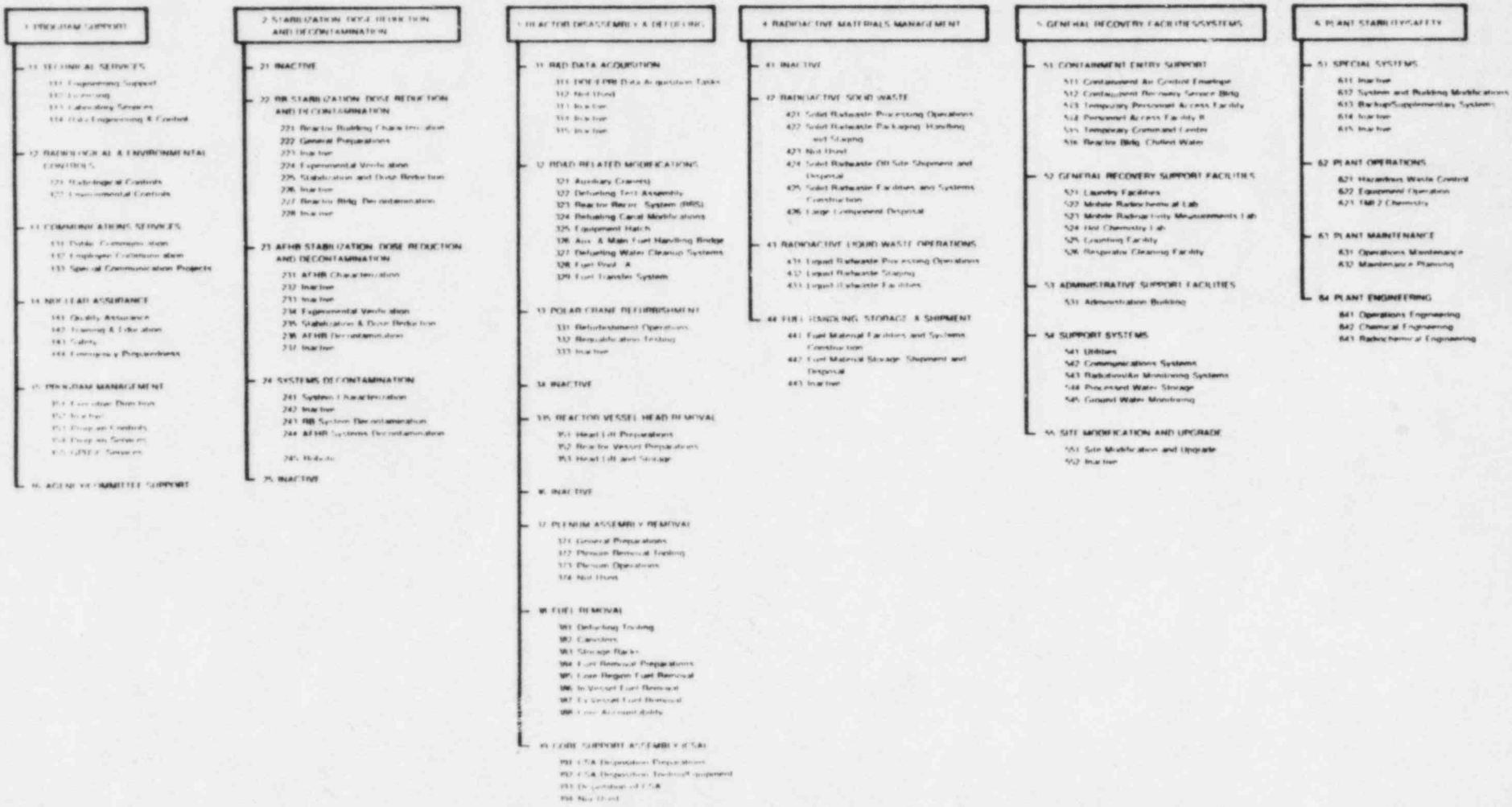
SUMMARY LISTING OF WBS ELEMENTS



APPENDIX C

TMI-2 RECOVERY PROGRAM ESTIMATE
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DEFUELING ACTIVITY SUMMARY

Figure C-1 summarizes planned defueling activity logic and workscope through program completion in 1988 to accomplish program objectives.

The following paragraphs, cross referenced to specific activity boxes on Figure C-1, briefly describe the nature of the identified activities. Block reference numbers appear first followed by WBS numbers.

1-391 - B&W Planning Study - This study, prepared by Babcock & Wilcox (B&W), examines defueling methods and recommends inspections and defueling methods for the lower CSA.

2-391 - CSA Defueling Technical Plan - This technical plan will establish defueling inspections to be performed, tooling functional requirements, and tooling selection methodology. It will also establish defueling sequence and logic.

3-386 - Upper CSA Defueling Method Selection - Based on upper CSA examination (reference Block 8-386) and technical plan recommendations, the areas to be defueled, the necessary tooling development, and the required procurement will be identified.

4-381 - Upper CSA Tooling: Engineer, Deliver, Install, and Test - Tools identified in Block 3-386 will be developed, installed, and tested, including mockup installation and training before actual RB installation.

5-386 - Lower CSA Inspection - The following video inspections are planned for the lower CSA:

- o Incore guide to flow distribution welds
- o Inserting camera through flow holes and examining the area between the flow distributor and incore support plate
- o With a fiber optic scope inserted through flow holes in the lower grid periphery via the former plates determine (1) amount of debris between lower grid and distributor plate; (2) damage to lower internal grid, distributor plate, etc.; and (3) if outer end fitting can be easily removed.
- o Blocked flow holes probed.

6-386 - Lower CSA Defueling Method Selection - Based on lower CSA inspection and debris analysis, necessary tooling development and procurement will be identified.

7-381 - Lower CSA Tooling: Engineer, Deliver, Install, and Test - The tools selected in Block 6-386 will be designed, procured, and tested. Following successful demonstration, the tools will be installed in the RB.

8-386 - Upper CSA Exam - Video inspections of the upper CSA will be performed by inserting a fiber optic scope through the core former plate flow holes. These inspections combined with previous video camera examinations will assist in the determination of (1) fuel accumulation on the core lower plates and internal areas of the CSA, (2) potential damage to the CSA structure and core lower plates/walls, and (3) debris concentrations and structural distortion of exposed surfaces.

9-384 - Lower Head Properties/Sample Analysis - Video and sample material taken in the lower head examinations (reference Block 12-384) will be analyzed for radionuclide content, maximum temperature, and composition.

10-386 - Lower Head Defueling Method Selection - Based on data from Lower Head Properties/Sample Analysis (reference Block 9-386), a method for defueling will be selected.

11-381 - Lower Head Tooling: Engineer, Deliver, Install, and Test - Tooling required for the defueling method selected will be designed, procured, and tested. Tool operators will be trained.

12-384 - Lower Head Exam - Video inspection of the elliptical flow distributor and incore guide tubes will be performed (where possible). This activity will also include retrieval of liquid and solid material samples.

13-386 - Lower Head Verify Integrity - Prior to core boring operations (reference Block 19-386), which precede lower vessel defueling activities, RV integrity must be verified. This task will establish the method for verifying RV integrity. Current considerations are (1) internal video inspection, (2) video external inspection, and/or (3) ultrasonic testing of in-core nozzle welds and lower head exterior.

B&W has prepared an analytical study of lower head integrity based on current data.

14-384 - Lower Head Debris Relocation - Debris in the lower head will be relocated (this may be accomplished by vacuuming to the core region) to determine if vacuuming is a reasonable method of defueling and if large solid masses are present.

15-386 - Early Defueling Operations - Based on the core region defueling strategy (reference Block 23-384), early defueling operations encompass the following activities:

- o Loading canister and debris baskets without significant debris size reduction
- o Transferring debris basket loads to canisters
- o Relocating debris in preparation for vacuuming operations
- o Vacuuming
- o Transferring loaded canisters out of the reactor vessel.

16-384 - Decision Regarding Core Boring - A decision will be made to determine if the core boring equipment developed by DOE will be used to extract several undisturbed, full-length core samples for accident analysis. The number and location of samples are to be determined.

17-311 - Core Boring Operation - Assuming that the decision in Block 16-384 is to proceed, cut core samples, load samples into fuel canisters, and transfer out of the reactor vessel.

18-386 - Bulk Defueling Operations - Bulk defueling will include, in addition to the operations described in early defueling operations (reference block 15-386), size reduction and the use of special tools to complete core defueling.

19-386 - Lower CSA Defueling Operations - Lower CSA defueling operations will remove core debris from the CSA below the lower grid including cutting and removal of structural materials for access to remove fused debris. Some debris may be moved to the RV bottom head.

20-384 - Decision to Bypass Lower Head - Based on information on RV integrity, a decision will be made to address or bypass lower head defueling at this time.

21-386 - Lower Head Defueling Operations - Lower head defueling operations will include pick and place, vacuuming, and size reduction operations. Care will be exercised to limit loads on in-core instrumentation nozzles.

22-386 - Upper CSA Defueling Operations - Flushing and vacuuming methods are planned for defueling debris bearing areas of the upper CSA. Cutting of the baffle plates and core barrel along with removal of vent valves may be required for access.

23-384 - Core Region Defueling Strategy - This procedure establishes controlling steps and provides instructions for accomplishing RV defueling.

24-387 - Pump 1B: Remove Components and Motor - Remove reactor coolant pump motor, decontaminate, and locate in storage area.

25-387 - Pump 1B: Prepare Area for Defueling - If the RV water level is to be maintained at the bulk defueling level, one option would be to procure, fabricate, install, and test a leaktight container which would be mounted on the reactor coolant pump and to install a work platform and video system. Following this, the pump internals will be removed, defueled, decontaminated, and stored.

Preparations may vary from those described above depending on defueling method decisions.

26-387 - Pump 1B: Defuel Discharge Piping - This task includes vacuuming and mechanical scraping of discharge piping to remove fuel debris.

27-387 - Pump 1B: Defuel J-Leg - This task includes vacuuming and pick and place operations to defuel the J-leg.

28-387 - Pump 1B: Defuel Bottom Heat Once-Through Steam Generator (OTSG) - Select defueling method. One of the methods under consideration is vacuuming supplemented by robotic applications.

29-384 - Core Region Exam - Multiple video inspections of the core region will be performed to inspect the crust layer beneath the loose debris bed. Examinations will specifically address hardness and size of the crust layer. The region below the crust will also be examined. Current plans are for a minimum of three examinations: (1) after plenum removal and before defueling; (2) after vacuuming and before bulk defueling; and (3) after bulk defueling; and, as needed, throughout defueling.

30-387 - "B" D-Ring Dose Reduction - Defueling will begin in the "A" D-ring followed by the "B" D-ring. Dose reduction activities will be prioritized to support the defueling schedule. They will include dose reduction work to allow D-ring access for mechanical and hydraulic defueling activities.

31-387 - Defuel "B" OTSG Upper Tube Sheet - This activity encompasses defueling method selection and implementation. Current plans include:

- o Prepare area for defueling by removing manhole covers and installing shielding
- o Install video system
- o Remove fuel and debris by "pick and place" and wet vacuuming methods.

32-387 - Remove "B" D-Ring Components for Pump Access - This activity includes removing:

- o Items stored in D-ring
- o Support hangers, support beams, and rods that support pump motors
- o Piping
- o Pipe hanger-steel, platforming, electrical cable and conduit
- o Reactor coolant pump rigid restraints and earthquake snubbers

In addition to the above, staging and storage areas must be identified for removed components. Components to be removed from the RB will need to be decontaminated.

33-387 - Pump 2B: Remove Components and Motor - See block 24-387.

34-387 - Pump 2B: Prepare Area for Defueling - See block 25-387.

35-387 - Pump 2B: Defuel Discharge Piping - See block 26-387.

36-387 - Pump 2B: Defuel J-Leg - See block 27-387.

37-387 - Pump 2B: Defuel Bottom Head OTSG - See block 28-387.

38-387 - D-Ring Access - Implement dose reduction activities in both D-rings to support ex-vessel fuel characterization activities.

39-387 - Ex-Vessel Fuel Location Operations "A" D-Ring - Radiation surveys will be performed to locate and quantify fuel within the RCS system in the "A" D-ring. Specific survey locations follow:

- o Pressurizer
- o OTSG
- o J-legs
- o Reactor Coolant Pumps
- o Core Flood Line

40-387 - Ex-Vessel Fuel Removal Plan - This issued technical plan presents information pertaining to mechanical, hydraulic, and chemical methods for removing fuel and debris; and the applicability of mechanical and hydraulic methods to each of the identified potential ex-vessel fuel bearing locations.

41-381 - Ex-Vessel Fuel Removal Tools: Engineer, Deliver, Install, and Test - An engineering evaluation will be performed to select tooling for ex-vessel fuel removal. Once selected, tooling will be designed, fabricated, tested, and installed.

42-387 - Defuel Decay Heat Drop Line - A method to defuel the decay heat drop line will be selected and then implemented. Current planning includes flushing debris to the RV and vacuuming into canisters.

43-387 - Defuel Core Flood Tank Lines - A method to defuel the core flood tank line will be selected and implemented. One method currently being evaluated is to fill the core flood tank with borated water, apply nitrogen over pressure, and flush debris to the RV for vacuuming into canisters.

44-386 - Lower Head Final Defuel and Cleanup - Implement "pick and place" and vacuuming operation in the lower head while protecting in-core instrument nozzles.

45-386 - End Point Verification - Methods will be selected at the completion of the defueling operation to verify that the program completion criteria have been met. Verification will likely include examination, surveys, and sample collection and analysis.

46-387 - Ex-Vessel Fuel Location Operations "B" D-Ring - Similar to operations described in block 39-387. Specific survey locations are the OSTG, J-legs, RCPs, and decay heat drop line.

47-387 - Pump 1A: Remove Components and Motor - See block 24-387.

48-387 - Pump 1A: Prepare Area for Defueling - See block 25-387.

49-387 - Pump 1A: Defuel Discharge Piping - See block 26-387.

50-387 - Pump 1A: Defuel J-Legs - See block 27-387.

51-387 Pump 1A: Defuel Bottom Head OTSG - See block 28-387.

52-386 - Defueling End Point - Defines defueling end point criteria which are practical, capable of being verified, and consistent with program and regulatory objectives that will be developed.

53-381 - End Point Planning/Engineering - This task develops techniques and equipment for completion verification including equipment manufacture and test. This task also includes planning and scheduling verification activities.

54-387 - "A" D-Ring Dose Reduction - See block 30-387.

55-387 - Defuel "A" OTSG Upper Tube Sheet - See block 31-387.

56-387 - Defuel Pressurizer Bottom Head - This task is comprised of the development and implementation of a defueling plan for the pressurizer bottom head. Preparations include spraying down the pressurizer internals, gaining access, and installing video systems. Operations would be accomplished with long-handled tools and vacuum system with a vacuum line routed through the surge line to the RV vacuum equipment.

57-387 - Defuel Surge Line - The plan is to flush debris to the RV.

58-387 - Remove "A" D-Ring Components for Pump Access - See block 32-387.

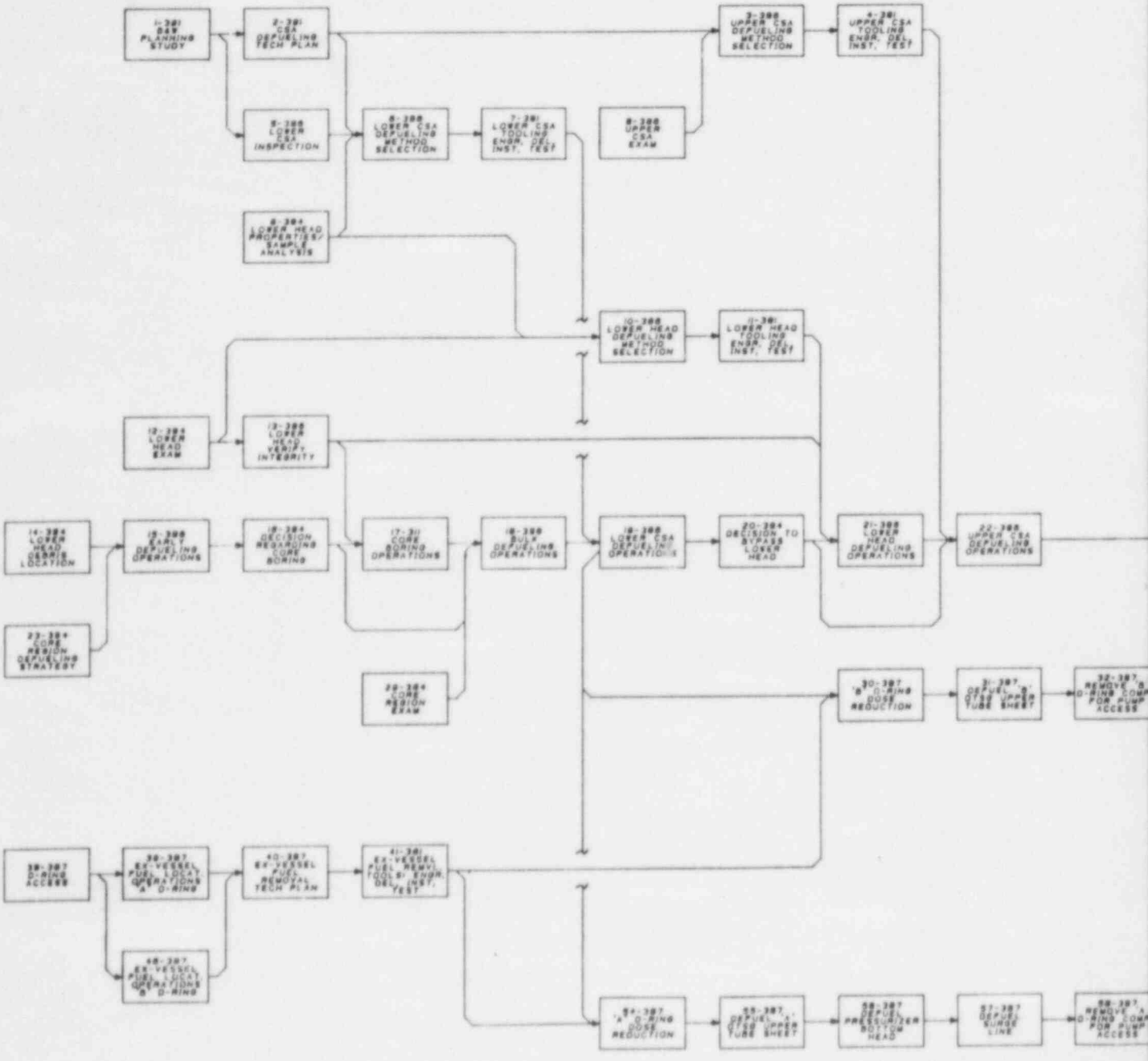
59-387 - Pump 2A: Remove Components and Motor - See block 24-387.

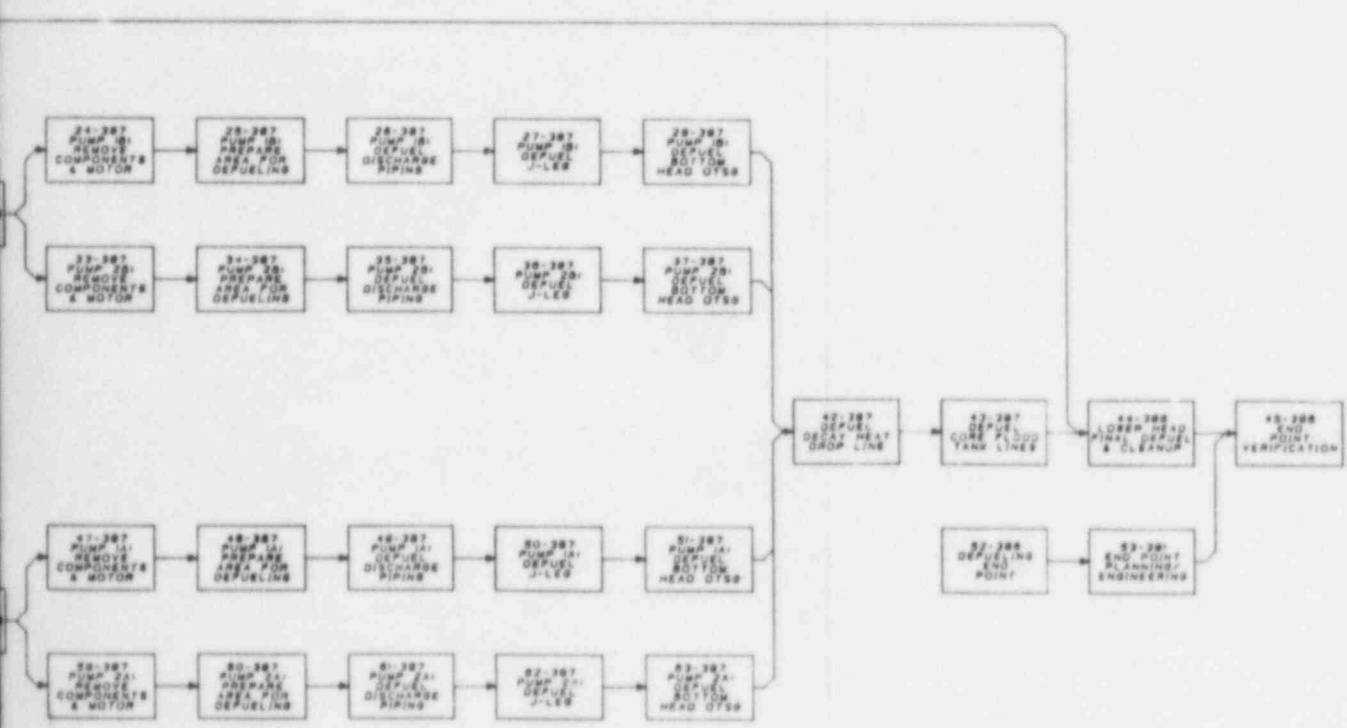
60-387 - Pump 2A: Prepare Area for Defueling - See block 25-387

61-387 - Pump 2A: Defuel Discharge Piping - See block 26-387

62-387 - Pump 2A: Defuel J-leg - See block 27-387.

63-387 - Pump 2A: Defuel Bottom Head OTSG - See block 28-387.


1-281 D&D PLANNING STUDY
2-281 CSA DEFUELING TECH PLAN
3-288 UPPER CSA DEFUELING METHOD SELECTION
4-281 UPPER CSA TOOLING ENGR. DEV. INST. TEST
5-288 LOWER CSA INSPECTION
6-288 LOWER CSA DEFUELING METHOD SELECTION
7-281 LOWER CSA TOOLING ENGR. DEV. INST. TEST
8-288 UPPER CSA EXAM
9-284 LOWER HEAD PROPERTIES/ SAMPLE ANALYSIS
10-288 LOWER HEAD DEFUELING METHOD SELECTION
11-281 LOWER HEAD TOOLING ENGR. DEV. INST. TEST
12-284 LOWER HEAD EXAM
13-288 LOWER HEAD VESSEL INTEGRITY
14-284 LOWER HEAD DEBRIS LOCATION
15-288 EARLY DEFUELING OPERATIONS
16-284 DECISION REGARDING CORE BORING
17-311 CORE BORING OPERATIONS
18-289 BULK DEFUELING OPERATIONS
19-288 LOWER CSA DEFUELING OPERATIONS
20-284 DECISION TO BYPASS LOWER HEAD
21-288 LOWER HEAD DEFUELING OPERATIONS
22-288 UPPER CSA DEFUELING OPERATIONS
23-284 CORE REGION DEFUELING STRATEGY
24-284 REGION EXAM
30-287 "B" O-RING DOSE REDUCTION
31-287 DEFUEL "B" CSA TUBE SHEET
32-287 REMOVE "B" O-RING COVER FOR PUMP ACCESS
39-287 B CORE ACCESS
40-287 EX-VESSEL FUEL REMOVAL TECH PLAN
41-281 EX-VESSEL FUEL REMVL TOOLING ENGR. DEV. INST. TEST
48-287 EX-VESSEL FUEL LOCA OPERATIONS "B" O-RING
49-287 "A" O-RING DOSE REDUCTION
50-287 DEFUEL "A" CSA TUBE SHEET
56-287 DEFUEL PRESSURIZER BOTTOM HEAD
57-287 DEFUEL SURGE LINE
58-287 REMOVE "A" O-RING COVER FOR PUMP ACCESS



GPU Nuclear TMI-2

DEFUELING

ACTIVITY LOGIC DIAGRAM

DWG. NO.	REV.
C-1	C

SCALE:

RPE, REV. 3
APPENDIX C

85,00101,02-01

APPENDIX D

TMI-2 RECOVERY PROGRAM ESTIMATE
REVISION 3

DECONTAMINATION AND DOSE REDUCTION ACTIVITY SUMMARY

Drawings D-1 through D-4 summarize planned decontamination and dose reduction activity logic and workscope through program completion in 1988. They identify activities required to accomplish program objectives as well as alternative activities that may be required should chemical decontamination be necessary. Costs for activities in support of chemical decontamination are excluded from this estimate.

The following paragraphs, cross referenced to specific activity boxes on Drawings D-1 through D-4, briefly describe the nature of the identified activities. Block reference numbers appear first followed by WBS numbers.

The four logic diagrams are as follows:

D-1 - Auxiliary/Fuel Handling Bldg Decon and Dose Reduction

D-2 - Reactor Building Decon and Dose Reduction

D-3 - Non-RCS Systems Decon and Dose Reduction

D-4 - Reactor Coolant System Decontamination

D-1 - Auxiliary and Fuel Handling Building Decontamination and Dose Reduction Activity Logic Diagram

101-235 - Maintenance Decontamination - Maintenance decontamination is an ongoing task to the end of Phase III to maintain a desired level of radiological cleanliness after completion criteria have been achieved.

102-235 - Technical Specification Decontamination - Certain inspections of equipment and facilities as required by Technical Specification require access to currently inaccessible areas of the AFHB. To improve radiological conditions there is an ongoing effort to reduce radiation dose rates and to decontaminate these areas to levels which permit personnel entry.

103-236 - Auxiliary and Fuel Handling Building Decontamination Technical Plan - This technical plan establishes the objectives for decontamination and radiation levels for the cubicles and general areas of the AFHB. It also establishes the priorities for the decontamination of these cubicles.

104-241 - Completion Criteria Technical Plan - This technical plan will establish the Phase III objectives for radiological conditions and fuel remaining in plant systems.

105-231 - Radiological Characterization - Characterization of general area dose rates, hot spots, and surface contamination levels is necessary to support cubicle surfaces and non-RCS system decontamination.

106-236 - Cubicle Surface Decontamination - The AFHB Decontamination Technial Plan establishes the surface contamination objectives for cubicles in the AFHB.

107-236 - Modify Spent Resin Storage Tank (SRST) - The spent resin storage tank will be modified to receive and process contaminated sludges from both the reactor building and the AFHB. This task will require significant engineering and labor man-hours.

108-236 - Install Sludge Transfer System - The sludge transfer system will be a temporary piping system installed to transfer sludges from several areas in the AFHB and reactor building. This task is being done in conjunction with the modification of the spent resin storage tank.

109-236 - Desludge Miscellaneous Waste Holdup Tank (MWHT) - The miscellaneous waste holdup tank is currently scheduled to be the first tank or sump to be desludged using the sludge transfer system and the spent resin storage tank.

110-236 - Desludge Other AFHB Sumps and Tanks - After the sludge handling equipment is demonstrated to be operational, the remaining sumps and tanks in the AFHB can be desludged. The sequence in which these operations will be performed is currently undetermined.

209-227 - Desludge RB Basement - See explanation under Drawing D-2.

111-236 - AFHB Resin Transfer - The sludge handling system will process the ion exchange resin contained in the demineralizers of the AFHB. Resins from such sources as the makeup and purification demineralizer will be collected in the spent resin storage tank for processing.

112- End of Phase III - Attainment of cleanup program radiological conditions.

D-2 Reactor Building Decontamination and Dose Reduction Activity Logic Diagram

201-245 - Identify Tasks Requiring Robots - Identify tasks in the reactor building requiring the use of robots due to high radiation levels in the basement.

202-245 - Robotics Development - Robots will be used for a variety of tasks ranging from characterization and data acquisition tasks to decontamination and dose reduction activities such as scabbling and hydrolazing. Robotics development will continue throughout most of the basement recovery activities.

203-221 - Reactor Building Basement Characterization - Reactor building basement characterization activities such as sludge sampling, concrete core boring, and radiological surveys will be ongoing throughout the basement recovery. These tasks will be performed primarily by robots and are dependent on timely robotics development.

204-227 - Reactor Building Basement Strategy Technical Plan - The Reactor Building Basement Strategy Plan is complete and was issued in December 1984. This technical plan establishes the basement recovery program objectives and provides the technical guidance required to achieve them.

205-227 - Reactor Building Basement Decontamination Technical Plan - This technical plan will provide technical guidance with regard to the activities required to achieve decontamination and dose reduction completion criteria in the basement.

206-227 - Reactor Building Basement Recovery - The Reactor Building Basement Strategy Plan outlines the scope of this program; i.e., the basement recovery effort will be achieved by stabilizing one zone at a time. These efforts will require extensive removal of highly contaminated concrete and concrete blocks, primarily by robots. Extensive data acquisition will be required to support tasks in the basement.

104-241 - Completion Criteria Technical Plan - This technical plan will include all of the radiological end points for the reactor building and will be used to guide the planning of all activities in the building. The building completion criteria published in the Completion Criteria Technical Plan will be derived primarily from the Reactor Building Decontamination and Reactor Building Basement Strategy Technical Plans. (Reference Drawing D-1, block 104-241).

207-227 - Resolve Reactor Building Basement Criticality Concerns - To ensure that an inadvertent criticality will not occur during reactor building basement sludge transfer operations, a safety evaluation will be performed.

208-227 - Reactor Building Sludge Transfer Skid - To transfer the sludge from the floor, a special sludge transfer skid will be fabricated and installed. A robot will be used to move sludge from the floor and transfer it to the skid. Pumps on the transfer skid will then pump the sludge from the RB basement to the spent resin storage tank in the AFHB.

209-227 Desludge Reactor Building Basement - The sludge on the basement floor and in the basement sump will be transferred to the spent resin storage tank in separate operations as the robot gains access to the various zones in the basement. It will not be a single operation but a series of individual operations using the sludge transfer skid.

Sludge in the RB sump will be transferred using sump pumps for transfer to the spent resin storage tank. The order in which floor and sump transfers will be performed is currently undefined.

210-227 - Reactor Building Decontamination Technical Plan - The Reactor Building Decontamination Technical Plan will provide the Phase III end points for the RB above the 305' elevation. It will also provide specific direction regarding the sequence in which areas in the building are decontaminated to Phase III completion criteria.

211-227 - Establish HVAC Controls in the Reactor Building - The Reactor Building Technical Plan calls for the establishment of HVAC controls to aid in the prevention of recontamination of previously decontaminated areas and the transport of contamination throughout the building in general. Techniques such as vent filtering and air flow balancing and control will be used to achieve these goals.

212-227 - Decontaminate Reactor Building 347' Elevation and Above - The Reactor Building Decontamination Technical Plan states that Phase III decontamination will begin with the reactor building dome and proceed down to the lower areas of the building. The technical plan delineates six zones on the 347 elevation and above and states that zones should be decontaminated in sequence from one to six.

213-227 - Establish Contamination Isolation from Other Plant Areas - During the decontamination of the zones identified in the Reactor Building Decontamination Technical Plan, it will be necessary to prevent cross contamination between the zone being worked in and the zones adjacent to it.

214-227 Decontaminate Reactor Building 305' Elevation and Above - After the 347' elevation and areas above have been decontaminated, the remaining areas outside of the D-rings on and above the 305' elevation will be decontaminated. The Reactor Building Decontamination Technical Plan identifies four zones in this region. Decontamination on the 305' elevation should begin in zone seven and proceed in order to zone ten.

215-227 - Decontaminate D-Rings on the 305' Elevation and Above - The last areas above the basement to be decontaminated will be the "A" and "B" D-rings. The "A" D-ring will be decontaminated first followed by the "B" D-ring. These decontamination activities will take place at or above the 305' elevation. The basement level of the D-rings will be handled as part of the overall basement recovery program.

216-227 - Defueling Manrem Reevaluation - The defueling manrem reevaluation will predict the man-hours to be spent in various areas of the reactor building and take into account the radiation levels in these areas. Dose reduction efforts will be directed to problem areas providing the highest ALARA benefit.

217-225 - Reactor Building Dose Reduction Technical Plan - This technical plan presents the overall reactor building dose reduction strategy and provides guidance for dose reduction work to provide an ALARA radiological environment for reactor disassembly and defueling.

218-225 - Reactor Vessel Defueling Dose Reduction - These activities will center primarily around dose reduction on the 305' and 347' elevations of the building and support Phase II defueling operations by reducing personnel radiation exposure.

219-387 - Ex-Vessel Defueling Dose Reduction - It may be necessary to defuel regions of the RCS outside of the reactor vessel; i.e., the pressurizer, reactor coolant pumps, and steam generators contained in the D-rings. It will be necessary to reduce the radiation levels in the "A" and "B" D-rings in order to reduce the exposure to personnel participating in the ex-vessel defueling effort.

22[illegible]-386 - Reactor Vessel Defueling - While reactor vessel defueling is not itself a part of the decontamination and dose reduction program, the logic diagram illustrates how such a program relates to defueling.

221-387 - Ex-Vessel Defueling - As with reactor vessel defueling above, ex-vessel defueling is not itself a part of the decontamination and dose reduction program. The logic diagram illustrates how such a program relates to defueling.

417-243 - RCS Decontamination Operations - In order to achieve Phase III radiological conditions in the reactor building, it may be necessary to decontaminate the RCS. RCS decontamination is the subject of the Reactor Coolant System Decontamination and Dose Reduction Logic Sequence Diagram and therefore will not be discussed here. It is shown on the reactor building logic diagram only to illustrate how this work fits into the scheme of reactor building activities. (Reference Drawing D-4, block 417-243.)

222-225 - Reactor Building Maintenance Decontamination - The reactor building is a highly contaminated environment. It will be necessary to continue a program of maintenance decontamination throughout the recovery effort.

D-3 Non-RCS Systems Decontamination and Dose Reduction Activity Logic Diagram

This estimate provides for flushing, draining, and sealing of non-RCS systems. Mechanical or chemical methods of decontamination of non-RCS systems are not included in this estimate.

301-241 - Ex-RCS Criticality Safety Technical Plan - This technical plan establishes criticality safety guidelines for the decontamination of ex-RCS systems. The plan was published in November 1984 and is currently being revised. The criticality safety issues discussed in the plan relate to the following non-RCS systems:

- o Makeup and Purification
- o Waste Disposal Miscellaneous Liquids
- o Waste Disposal Reactor Coolant
- o Waste Disposal Reactor Coolant Leakage Recovery
- o Decay Heat Removal.

302-241 - Non-RCS Systems Fuel Characterization - The Ex-RCS Criticality Safety Technical Plan requires characterization of the systems to determine their fuel content. The technical plan establishes the technique for system characterization as gamma spectroscopy keyed on Ce-144.

303-243/-244 - Non-RCS Systems Decontamination Technical Plan - This technical plan establishes programmatic guidance for the decontamination of non-RCS systems at TMI-2. It provides for the flushing and draining of those systems suspected of containing fissile material or systems having radiation dose rates above the limits for the areas in the AFHB or RB.

104-241 - Completion Criteria Technical Plan - This technical plan will establish the Phase III objectives for radiological conditions and fuel remaining in plant systems. It establishes the general area and how to spot dose rates

104-241 - Completion Criteria Technical Plan - (cont'd.)

for areas in the AFHB and RB. This criteria will be used to determine whether a system needs to be decontaminated. (Reference Drawing D-1, block 104-241.)

304-244 - Select Pumps for Use in Systems Decontamination - To flush and drain contaminated systems, Site Engineering has identified pumps for use in systems decontamination operations. These pumps are on site and can be placed in service as required.

305-244 - AFHB Decontamination Technical Plan Cubicle Priority List - The AFHB Decontamination Technical Plan establishes the sequence and priority in which cubicles are to be decontaminated. This cubicle listing also drives the selection and prioritization of systems flow paths to be decontaminated.

306-244 - Start AFHB System Decontamination Flowpath Selection - Site Engineering is currently doing the engineering for decontamination of approximately a dozen specific flowpaths in the AFHB. These flowpaths were selected to reduce dose rates in the top priority cubicles identified in the AFHB Decontamination Technical Plan.

307-244 - Pump ECAs and Installation - Site Engineering has selected a set of pumps to be hard piped to take suction from a fixed water source and deliver it to the systems being decontaminated. Engineering Change Authorizations need to be prepared and the pumps installed.

308-241 - Systems Radiological Characterization - A systems characterization program is required to develop a comprehensive set of data on systems radiological conditions to determine what piping systems contribute to the general area and hot spot dose rates.

309-244 - Select Other Decontamination Flowpaths - The remaining systems flowpaths requiring decontamination will be identified and prioritized as sufficient radiological characterization data are available.

310-244 - Flowpath Selection and Engineering - Once a particular flowpath has been selected for decontamination, the engineering and operations software (ECAs, DTSs, UWIs, etc.) must be prepared to accomplish the decontamination operations.

311-244 - Procure/Install Equipment - The majority of flowpaths will probably be decontaminated using existing or procured equipment. This equipment will have been identified as part of the engineering effort.

312-244 - Decontamination Operations - Decontamination operations will usually consist of flush and drain operations. However, it may be necessary to use more aggressive chemical or mechanical decontamination techniques to achieve Phase III completion criteria. These aggressive techniques will require more engineering effort and more specialized equipment than standard flush and drain operations. Decontamination operations will be primarily the responsibility of Recovery and Site Operations. This task will be repeated for every flowpath requiring decontamination.

313-241 - Receive and Evaluate Solvent Qualification Report from Pacific Nuclear Systems (PNS) - A series of solvent evaluation tests have been performed on contaminated TMI-2 artifacts. Results of these tests will provide the basis for selecting the solvents that can be used in systems decontamination.

314-241 - Select Solvent Evaluation Laboratory - It may be necessary to do additional solvent qualification work after receiving the PNS report. If required, a solvent evaluation vendor will be selected who has a background in chemical decontamination technology as well as adequate laboratory facilities.

315-241 - Obtain Contaminated Plant Samples - If further chemical solvent qualification testing is needed, contaminated plant samples must be obtained for use in testing.

316-241 - Complete Solvent Qualification Program - After the solvent qualification vendor has received the contaminated TMI-2 samples, they can complete the solvent qualification program. At this point, all of the research and development work on solvent processes will be complete.

317-241 - Prepare Chemical Decontamination Planning Study - A planning study will be prepared to evaluate the results of the solvent qualification activity. The planning study will review the decontamination effectiveness and waste treatability of each solvent tested.

318-241 - Prepare Chemical Decontamination Technical Plan - A Chemical Decontamination Technical Plan will recommend specific chemical solvent processes that can be used at TMI-2. This technical plan will identify solvents for use on specific systems. It will also describe waste treatment processes compatible with exisiting TMI-2 equipment.

D-4 Reactor Coolant System (RCS) Decontamination and Dose Reduction Activity Logic Diagram

This estimate provides for flushing, draining, and sealing of the RCS. Mechanical or chemical methods of decontamination of the RCS are not included in this estimate.

104-241 - Completion Criteria Technical Plan - This technical plan will be issued in August 1985. It will establish the Phase III objectives for many areas of concern such as radiological conditions and fuel remaining in plant systems. The Completion Criteria Technical Plan will establish the Phase III completion criteria for radiological conditions in the reactor building including radiation dose rates in the vicinity of the RCS. (Reference Drawing D-1, block 104-241.)

210-227 - Reactor Building Decontamination Technical Plan - The Reactor Building Decontamination Technical Plan will provide the Phase III completion criteria for all of the reactor building above the 305' elevation. These completion criteria will be the basis for the Completion Criteria Technical Plan. In addition, the plan will establish specific directions regarding the sequence in which various areas in the building are decontaminated to Phase III completion criteria. (Reference Drawing D-2, block 210-243.)

401-243 - Estimate Post-Defueling Dose Rates - To predict the need to decontaminate the RCS, calculations of radiation levels due to various levels of internal system surface contamination will be performed. A model of the RCS is being created to predict the contribution of RCS contamination to general area dose rates. As more information becomes available on RCS internal contamination, it will be added to the data base to refine the estimates of RCS dose rate contribution.

402-243 - RCS Decontamination Planning Study - This planning study will evaluate technologies available for RCS decontamination in order to choose which method or methods should be used to achieve Phase III completion criteria. An estimate of post-defueling dose rates will be presented in this planning study.

403-243 - RCS Decontamination Technical Plan - This technical plan will determine the techniques to be used and the scope of work to be performed to decontaminate the RCS.

404-241 - Select Solvent Evaluator - If preliminary post-defueling dose rate estimates indicate a strong probability that it will be necessary to decontaminate the RCS, it may be beneficial to begin evaluation of chemical decontamination solvents that could be used in the RCS. The first step in such a solvent qualification program is the selection of a solvent evaluation vendor.

405-241 - Take RCS Samples and Test - To develop and select the optimum solvent, contaminated RCS specimens will be used as sample coupons in solvent testing.

406-241 Solvent Qualification and Selection - The objective of this work is to select a solvent that can be used at TMI-2. Such a solvent must be capable of both meeting the desired radiological end points as well as being capable of undergoing waste processing at reasonable cost.

407-241 - Select Mechanical Decontamination Techniques Evaluator - If preliminary post-defueling dose rate estimates indicate a strong probability that it will be necessary to decontaminate the RCS, it may be beneficial to begin limited research and development of mechanical

407-241 - Select Mechanical Decontamination Techniques Evaluator - (cont'd.)

decontamination techniques that could be used to decontaminate the TMI-2 RCS. The first step in such research and development is the selection of a vendor to perform the required evaluation program.

408-241 - Take RCS Samples and Test - To develop and select the most useful mechanical decontamination techniques, it will be necessary to acquire contaminated RCS specimens that can be used as sample coupons in testing.

409-243 - Mechanical Technique Development and Selection - Once the mechanical techniques evaluator has received the necessary RCS samples, he may test the samples using a variety of mechanical methods. The objective of this work will be to select mechanical decontamination techniques which can be used at TMI-2.

410-241 - RCS Film Characterization - To predict post-defueling dose rates as well as to select the best available technology for decontaminating the RCS, it will be necessary to characterize the radiological and physical nature of films deposited on RCS internal surfaces. Radiological data will be used to predict system-wide post-defueling dose rates while chemical and hardness testing will be used in selecting the optimum decontamination technique.

411-241 - RCS Radiological Characterization - As defueling progresses, the radiological data collected in the vicinity of the RCS will be the most useful information used in evaluating the need to decontaminate the RCS. While calculated post-defueling dose rates will give an early indication of the need to decontaminate the RCS, the final decision will be based on survey data.

412-243 - Evaluate the Requirement for Vendor Services - If the decision is made to decontaminate the RCS, evaluate the use of on site resources or vendor services to accomplish the RCS decontamination.

413-243 - Evaluate RCS Closure and Access Points - Before a final decision is made on the method used to decontaminate the RCS, the ability to seal the system must be evaluated. Chemical decontamination of the RCS will probably require the system be sealed, whereas mechanical decontamination methods probably will not.

414-243 - Engineering/Design - Prepare engineering and operations software required to plan, schedule, and monitor the decontamination activities, and procure equipment or vendor services.

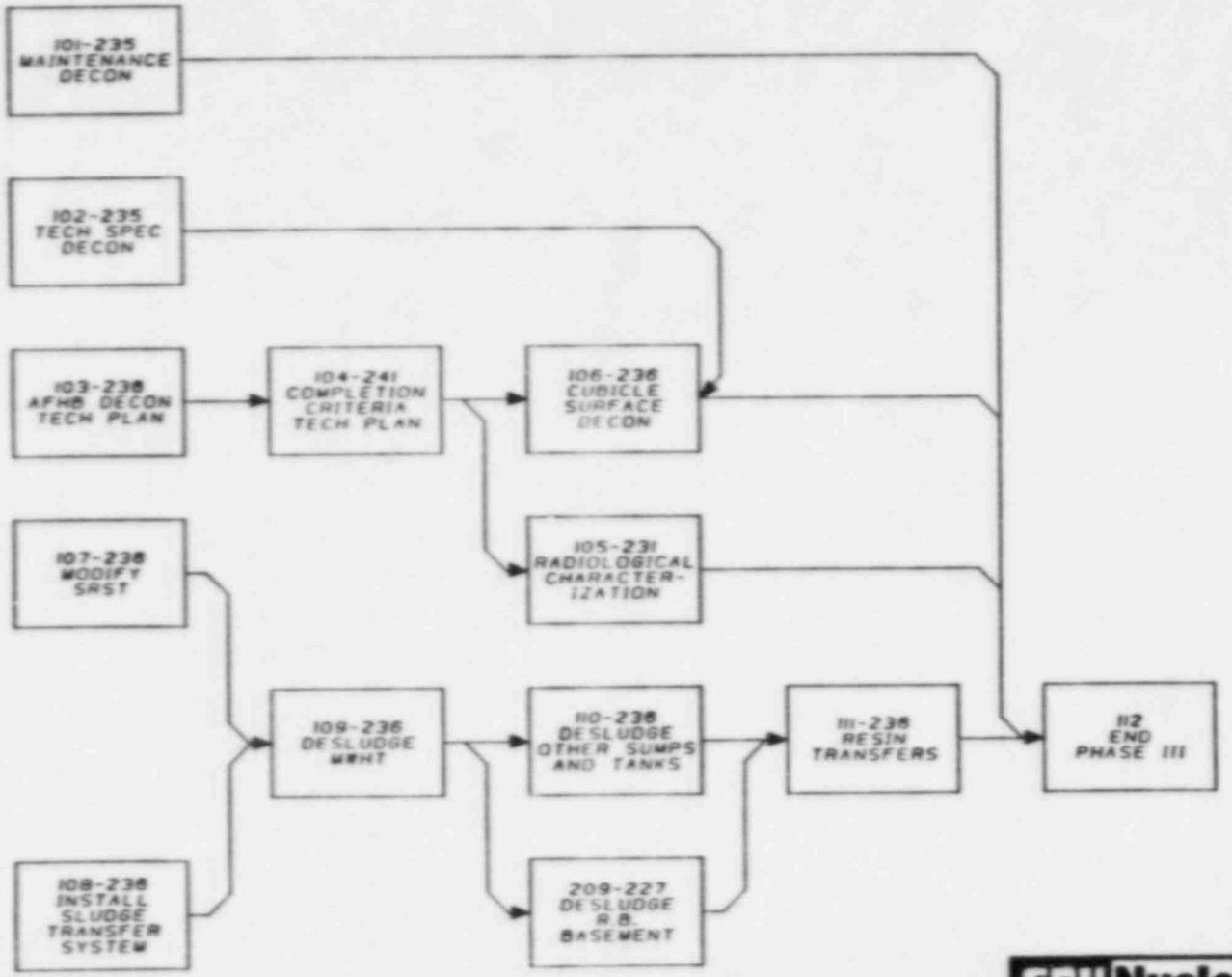
415-243 - Acquire Equipment/Vendor - Acquire any special equipment or vendor services to perform RCS decontamination.

416-243 - Equipment Installation and Testing - Install and test the required equipment and provide training.

417-243 - RCS Decontamination Operations - RCS decontamination operations will be completed at the same time as or after defueling operations and will be scheduled based on logistics requirement; i.e., availability of resources and access to work areas.

220-386 - RV Defueling - Reference Drawing D-2, block 220-386.

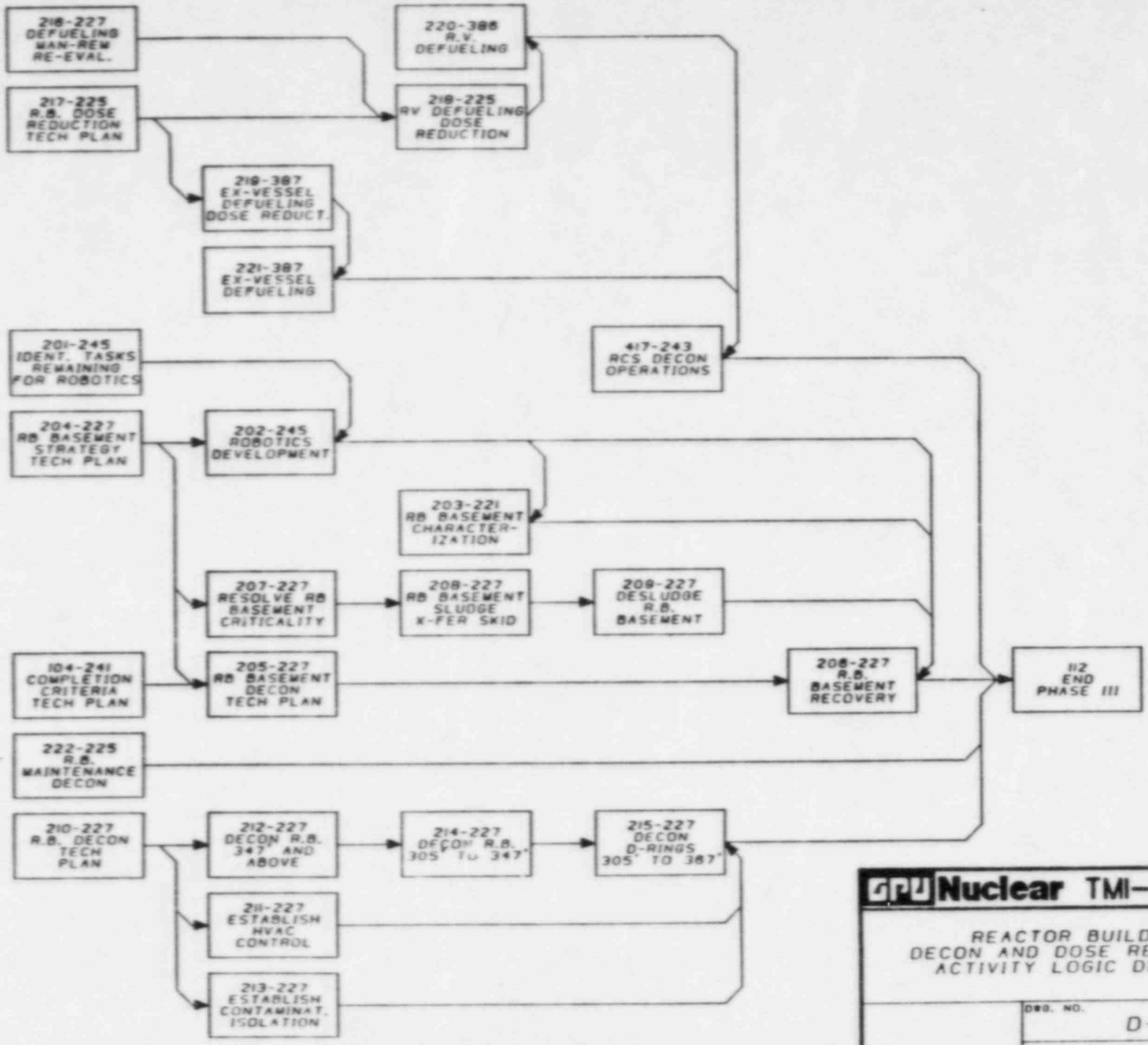
220-387 - Ex-Vessel Defueling - Reference Drawing D-2, block 220-387.



GPU Nuclear TMI-2

AUXILIARY/FUEL HANDLING BLDG
DECON AND DOSE REDUCTION
ACTIVITY LOGIC DIAGRAM

	DWG. NO.	REV.
	D-1	A
	SCALE:	



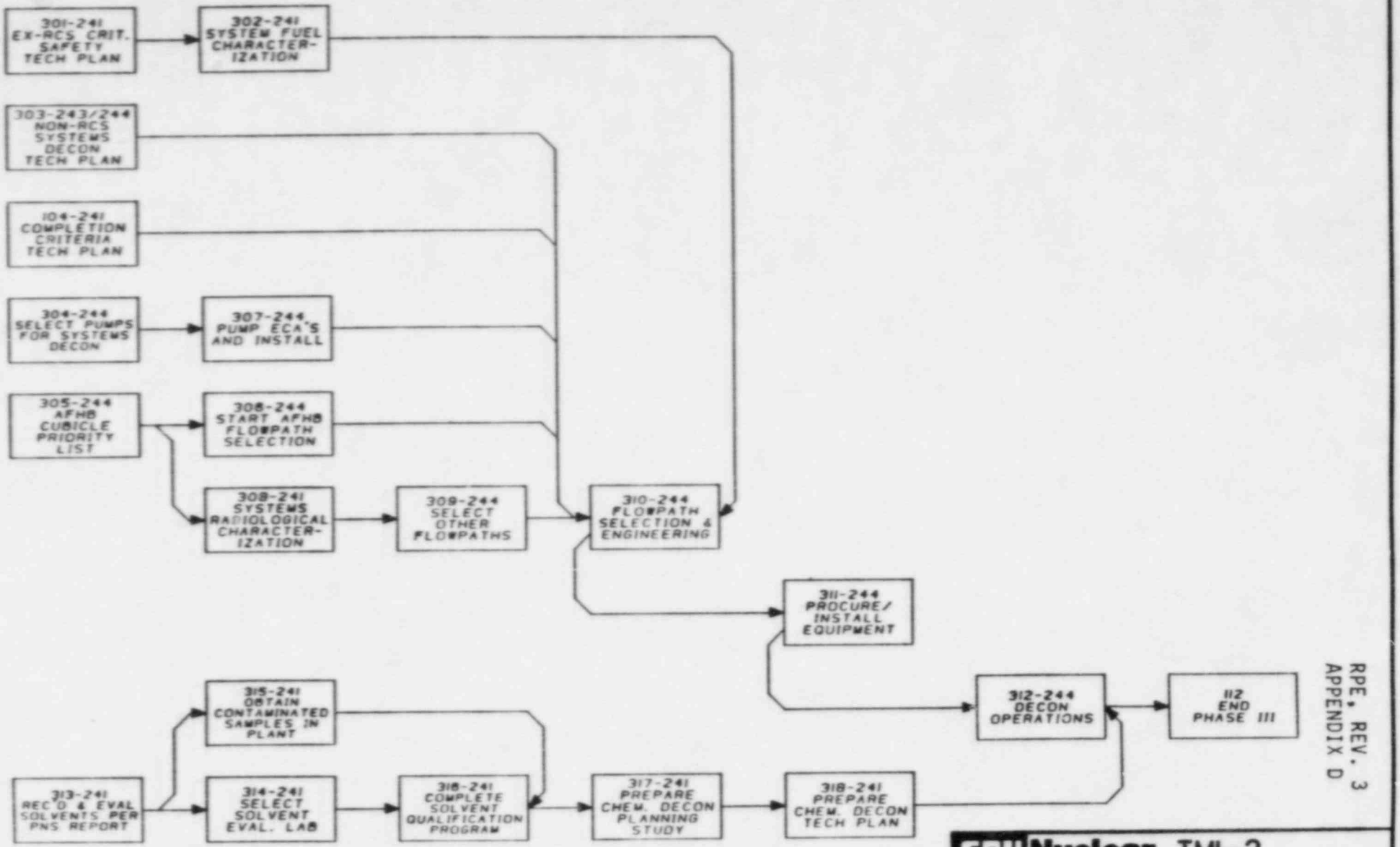
GPU Nuclear TMI-2

REACTOR BUILDING
DECON AND DOSE REDUCTION
ACTIVITY LOGIC DIAGRAM

DRG. NO.	REV.
D-2	A

SCALE:

RPE, REV. 3
APPENDIX D



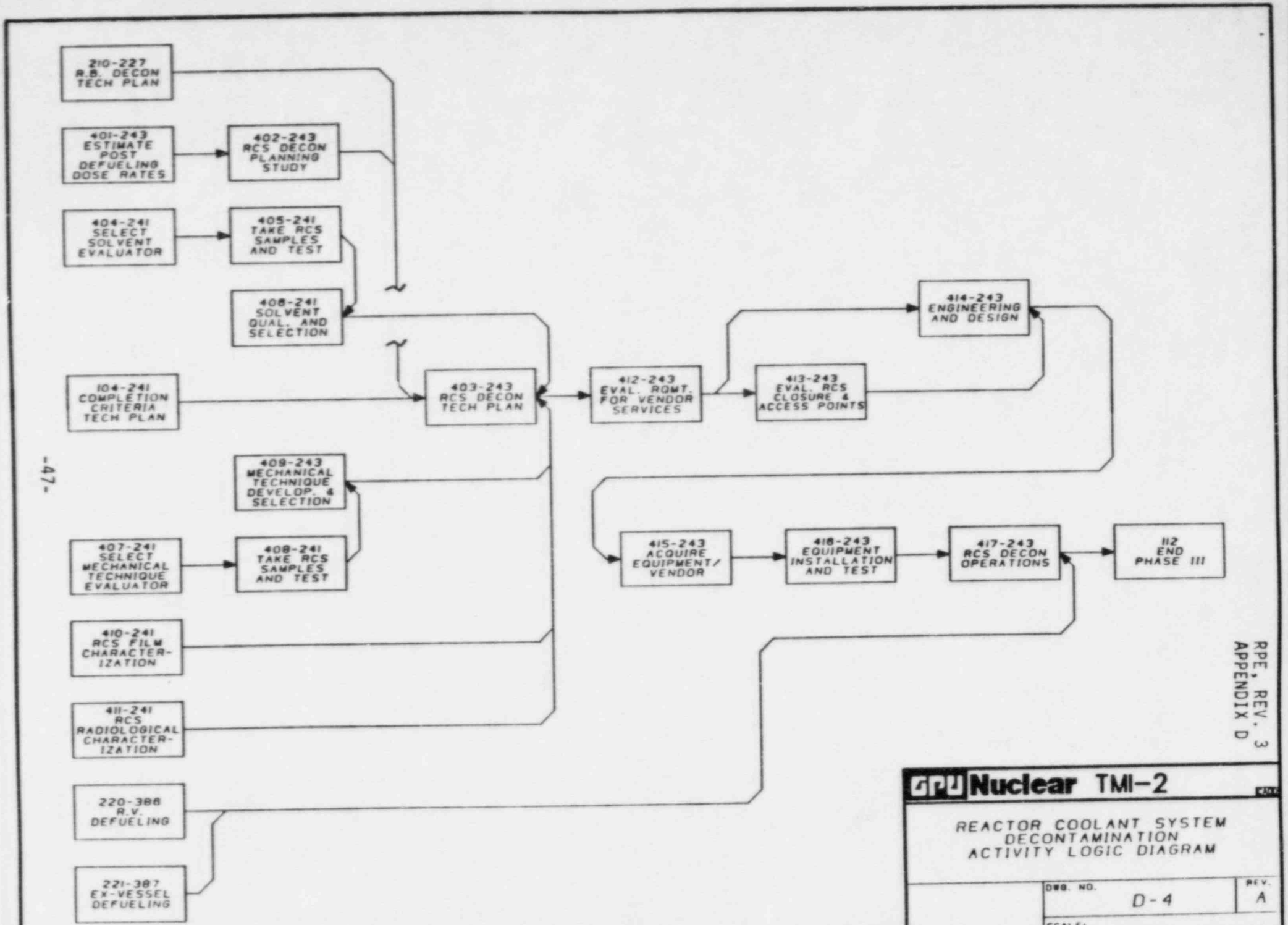
GPU Nuclear TMI-2

NON-RCS SYSTEMS
DECON AND DOSE REDUCTION
ACTIVITY LOGIC DIAGRAM

DWG. NO.	REV.
D-3	A

SCALE:

RPE, REV. 3
APPENDIX D



RPE, REV. 3
APPENDIX D

GPU Nuclear TMI-2

REACTOR COOLANT SYSTEM
DECONTAMINATION
ACTIVITY LOGIC DIAGRAM

DWG. NO.	REV.
D-4	A

SCALE:

APPENDIX E

TMI-2 RECOVERY PROGRAM ESTIMATE
REVISION 3

LEVEL-4 WBS COST DETAIL
($ x 1000)

WBS-1 - PROGRAM SUPPORT	1985	1986	1987	1988	1985-1988 Total
Site Management	1880	1600	1350	450	5280
Recovery Programs	7010	5000	3800	2800	18610
Site Operations	3325	2920	2830	1370	10445
Technical Planning	1105	810	550	200	2665
Licensing & Nuclear Safety	3300	3300	2100	800	9500
Gov't & Industry Programs	970	970	600		2540
Other Divisions/G&A	33780	33540	26460	18160	111940
TOTAL WBS-1	51370	48140	37690	23780	160980

WBS-2 - STABILIZATION, DECONTAMINATION AND DOSE REDUCTION	WBS	1985	1986	1987	1988	Total
RB Characterization	221 Total	220	1320	550	20	2110
Recovery Programs			1200	500	20	1720
Technical Planning		220	120	50		390

WBS-2 - STABILIZATION, DECONTAMINATION AND DOSE REDUCTION (cont'd.)	WBS	1985	1986	1987	1988	Total
RB Dose Reduction	225 Total	560	1680	800	300	3340
Recovery Programs		480	1600	800	300	3180
Technical Planning		80	80			160
RB Decon	227 Total	15	5000	11500	7300	23815
Recovery Programs		15	5000	11500	7300	23815
AFHB Characterization	231 Total	65	805	750		1620
Recovery Programs			700	700		1400
Technical Planning		65	105	50		220
AFHB Dose Reduction	235 Total	2370	3570	2400	600	8940
Recovery Programs		2275	3500	2400	600	8775
Site Operations		30				30
Technical Planning		65	70			135
AFHB Decon	236 Total	400	3100	4900	1800	10200
Recovery Programs		400	3100	4900	1800	10200
Systems Characterization	241 Total	140	1540	1075		2755
Recovery Programs			1300	1000		2300
Technical Planning		140	240	75		455
RB Systems Decontamination	243 Total	65	1880	2025	4300	8270
Recovery Programs			1800	2000	4300	8100
Technical Planning		65	80	25		170
AFHB Systems Decontamination	244 Total		3080	4000	1800	8880
Recovery Programs			3000	4000	1800	8800
Technical Planning			80			80
Robotics	245 Total	1030				1030
Recovery Programs		1030				1030

WBS-2 - STABILIZATION, DECONTAMINATION AND DOSE REDUCTION (cont'd.)	WBS	1985	1986	1987	1988	Total
Additional Scope	2XX Total			4000	8800	12800
Recovery Programs				3800	8800	12600
Site Operations				200		200
Total - Recovery Programs		4200	21200	31600	24920	81920
Total - Site Operations		30		200		230
Total - Technical Planning		635	775	200		1610
TOTAL WBS-2		4865	21975	32000	24920	83760

WBS-3 - REACTOR DISASSEMBLY AND DEFUELING	WBS	1985	1986	1987	1988	Total
DOE Data Acquisition	311 Total	1145	900	200		2245
Recovery Programs		935	700	200		1835
Site Operations		40				40
Technical Planning		170	200			370
RD&D Related Modifications	32X Total	9180				9180
Recovery Programs		9180				9180
Reactor Head Lift & Store	353 Total				300	300
Recovery Programs					300	300
Plenum Operations	373 Total	1630			300	1930
Recovery Programs		1585			300	1885
Site Operations		10				10
Technical Planning		35				35

WBS-3 - REACTOR DISASSEMBLY AND DEFUELING (cont'd.)	WBS	1985	1986	1987	1988	Total
Defueling Tooling	381 Total	11580	3800	2300		17680
Recovery Programs		11580	3800	2300		17680
Canisters	382 Total	6100	2000	550		8650
Recovery Programs		6100	2000	550		8650
Racks	383 Total	745				745
Recovery Programs		745				745
Defueling Preparations	384 Total	3725				3725
Recovery Programs		3010				3010
Site Operations		130				130
Technical Planning		585				585
In-Vessel Fuel Removal	386 Total	7835	7000	4755	400	19990
Recovery Programs		6985	4800	2690	400	14875
Site Operations		670	2200	2065		4935
Technical Planning		180				180
Ex-Vessel Fuel Removal	387 Total	875	8825	2020		11720
Recovery Programs		310	8310	1200		9820
Site Operations			240	820		1060
Technical Planning		565	275			840
Core Accountability	388 Total	50	25	400		475
Recovery Programs		30				30
Site Operations				200		200
Technical Planning		20	25	200		245
CSA Defueling	39X Total	170	675	2400		3245
Recovery Programs		5	510	2300		2815
Technical Planning		165	165	100		430

WBS-3 - REACTOR DISASSEMBLY AND DEFUELING (cont'd.)	WBS	1985	1986	1987	1988	Total
Additional Scope	3XX Total			5000		5000
Recovery Programs				5000		5000
Total - Recovery Programs		40465	20120	14240	1000	75825
Total - Site Operations		850	2440	3085		6375
Total - Technical Planning		1720	665	300		2685
TOTAL WBS-3		43035	23225	17625	1000	84885

WBS-4 - RADIOACTIVE WASTE MANAGEMENT	WBS	1985	1986	1987	1988	Total
Solid Radwaste Processing	421 Total	1765	1605	1605	800	5775
Recovery Programs		1585	1600	1600	800	5585
Site Operations		175				175
Technical Planning		5	5	5		15
Solid Radwaste Packaging	422 Total		800	800	400	2000
Recovery Programs			800	800	400	2000
Solid Radwaste Shipping	424 Total	1910	2230	3755	1500	9395
Site Operations		1910	2230	3755	1500	9395
Solid Radwaste Facilities	425 Total	1720	1985	350	300	4355
Recovery Programs		1640	1900	300	300	4140
Technical Planning		80	85	50		215
Large Component Disposal	426 Total			2300	1150	3450
Recovery Programs				1300		1300
Site Operations				1000	1150	2150

WBS-4 - RADIOACTIVE WASTE MANAGEMENT (cont'd.)	WBS	1985	1986	1987	1988	Total
Liquid Radwaste Processing	431 Total	2035	3090	2285	6410	13820
Site Operations		1885	2920	2190	6410	13405
Technical Planning		150	170	95		415
Fuel Material Disposal	442 Total	1160	4790	4305	2105	12360
Recovery Programs		1075	1500			2575
Site Operations			3200	4255	2105	9560
Technical Planning		85	90	50		225
Additional Scope	4XX Total			7850	4350	12200
Recovery Operations				2400		2400
Site Operations				5450	4350	9800
Total - Recovery Programs		4300	5800	6400	1500	18000
Total - Site Operations		3970	8350	16650	15515	44485
Total - Technical Planning		320	350	200		870
TOTAL WBS-4		8590	14500	23250	17015	63355

WBS-5 - GENERAL RECOVERY FACILITIES/SYSTEMS	WBS	1985	1986	1987	1988	Total
Containment Air Control Envelope	511 Total	270				270
Recovery Programs		270				270
Radiation/Air Monitoring Systems	543 Total			1500	1500	3000
Recovery Programs				1500	1500	3000
Ground-water Monitoring	545 Total			500	500	1000
Recovery Programs				500	500	1000
TOTAL WBS-5		270		2000	2000	4270

WBS-6 - PLANT STABILITY/ SAFETY	WBS	1985	1986	1987	1988	Total
Hazardous Waste Control	621 Total	630	520	465	360	1975
Site Operations		630	520	465	360	1975
Equipment Operation	622 Total	2510	2015	1455	940	6920
Recovery Programs		105				105
Site Operations		2405	2015	1455	940	6815
TMI-2 Chemistry	623 Total	1115	1105	605	275	3100
Site Operations		1115	1105	605	275	3100
Operations Maintenance	631 Total	6705	6690	5565	3810	22770
Recovery Programs		2850	3500	3000	2000	11350
Site Operations		3635	3090	2515	1810	11050
Technical Planning		220	100	50		370
Maintenance Planning	632 Total	430	395	275	175	1275
Site Operations		430	395	275	175	1275
Operations Engineering	641 Total	855	995	520	215	2585
Site Operations		855	995	520	215	2585
Radiochemical Engineering	643 Total	355	430	150		935
Site Operations		355	430	150		935
Additional Scope	6XX Total			1700	1700	3400
Site Operations				1700	1700	3400
Total - Recovery Programs		2955	3500	3000	2000	11455
Total - Site Operations		9425	8550	7685	5475	31135
Total - Technical Planning		220	100	50		370
TOTAL WBS-6		12600	12150	10735	7475	42960

APPENDIX F

TMI-2 RECOVERY PROGRAM ESTIMATE
REVISION 3

POTENTIAL UNPLANNED WORKSCOPE
($ x 1000)

Reference Number	Related WBS Element	Basis for Exposure
1	100 200 400 600	Program Support - Phase III end point completion criteria have not been fully defined. Achievement of an acceptable end point could require greater work effort than currently planned.
2	100	Program Support - General social/regulatory/political/fiscal considerations could affect schedule and cost; e.g., broad-based labor problems (strike), licensing delays (court injunctions, protracted public hearings), or political interference.
3	100	Program Support - Premium costs associated with schedule maintenance.
4	227	RB Decontamination - Basement decontamination has been estimated on the basis of currently envisioned robotic devices and limited characterization. Actual conditions may require additional equipment.
5	227 & 236	RB and AFHB Decontamination - RB and AFHB systems decontamination is based on water flush and dry layup. If chemical decontamination is required, costs for chemical flushes and equipment must be added.
6	387	Ex-Vessel Fuel Removal - Estimate is based on being able to remove ex-vessel fuel by vacuuming and through identified access points. Need for extraordinary equipment such as robotics or chemical dissolution of fuel could increase costs and extend schedule.

Reference Number	Related WBS Element	Basis for Exposure
7	424	Solid Radwaste Disposal - Disposal of plant processed water as solid waste.
8	425	Solid Radwaste Systems - Waste shipping and disposal costs are based on low specific activity (LSA) disposal at Hanford, Washington through 1988 and no storage on site thereafter. Construction and operation of an on-site low-level radwaste storage facility would increase program costs.
9	442	Fuel Shipping - The DOE fuel shipping agreement includes a specific period of performance. Program schedule delays could negatively affect the ability to meet contract fuel shipping schedules and result in additional cost.
10	600	Plant Stability/Safety - Plant stability/safety costs are based on a 10CFR50 license conversion occurring at the completion of fuel removal. Allowance for delays in securing the planned license change, or a more restrictive license, was not included in the estimate.

TOTAL ALLOWANCE FOR UNPLANNED WORKSCOPE -- $33.4MM

APPENDIX G

TMI-2 RECOVERY PROGRAM ESTIMATE
REVISION 3

PROGRAM STAFFING PLAN(1)

TOTAL BY TMI-2 DIVISION ORGANIZATION	1985	1986	1987	1988(2)	Total
TOTAL BY YEAR -	1015	1055	930	570	3570
Office of the Director	4	4	3	2	13
Program Controls	25	18	16	7	66
Recovery Programs	620	700	675	473	2468
Site Operations	274	258	191	75	798
Technical Planning	43	26	11	2	82
Licensing & Nuclear Safety	39	39	28	11	117
Government & Industry Programs	10	10	6	0	26

PERSONNEL DISTRIBUTION	1985	1986	1987	1988(2)	Total
TMI-2 DIVISION	1015	1055	930	570	3570
Nonmanual	588	397	304	207	1496
Manual	427	657	626	363	2073
SYSTEM	329	314	252	129	1024
Nonmanual	142	137	111	59	449
Manual	187	177	141	70	575
CONTRACTOR	686	741	678	441	2546
Nonmanual	446	261	193	148	1048
Manual	240	480	485	293	1498

(1) Totals exclude Support Divisions' personnel
(2) Average number of personnel required for a 9-month period.

APPENDIX H

TMI-2 RECOVERY PROGRAM ESTIMATE
REVISION 3

TMI-2 PROJECTED WASTE GENERATION SUMMARY[a,b]

Year	Total Volume	Commercial Disposal Class A	Class B	Class C	DAW*	Liners	U.S. DOE
1979	20567				20567	-0-	
1980	26841				20423	6418	
1981	14890				9360	5530	50
1982	6379				6229	150	828
1983	17009				12339	4670	1818
1984	9512	7982	1530		5262	4250	42
1985	17167	16717	225	225	14667	2500	58
1986	21388	19388	1000	1000	16978	4410	60
1987	17848	16198	825	825	14978	2870	100
1988	16733	16233	350	150	13833	2900	20
TOTAL	168334	76518	3930	2200	134636	33698	2976 [b]

NOTES: [a] - Volumes in cubic feet
[b] - Excludes fuel to DOE; 1985-88 are best estimates

REFERENCES: GPU Nuclear Corporation Memorandum, dated April 25, 1985; #4520-85-0032; from C. P. Deltete to S. Levin, "Revised Waste Projections 1985-1990"

GPU Nuclear Corporation Memorandum, dated June 27, 1985; #4520-85-0054; from C. G. Hitz to S. Levin, "Revised Abnormal Waste Projections"

* Dry Activated Waste

REFERENCES

TMI-2 RECOVERY PROGRAM ESTIMATE
REVISION 3

1. GPU Nuclear Corporation, August 1984. TMI-2 Defueling Study.

2. GPU Nuclear Corporation, November 1984. Work Breakdown Structure, Technical Plan, TPO/TMI-116.

3. GPU Nuclear Corporation, July 1985. TMI-2 Program Strategy, Technical Plan, TPO/TMI-115, Draft.

4. U.S. Department of Energy, March 15, 1982. Memorandum of Understanding Between the U.S. Nuclear Regulatory Commission and the U. S. Department of Energy Concerning the Removal and Disposition of Solid Nuclear Wastes from Cleanup of the Three Mile Island Unit 2 Nuclear Plant.

5. GPU Nuclear Corporation, March 1985. Auxiliary and Fuel Handling Building Decontamination, Technical Plan, TPO/TMI-130.

6. GPU Nuclear Corporation, August 1985. TMI-2 Core Accountability, Technical Plan, TPO/TMI-035.

7. General Public Utilities Corporation, August 1, 1980. TMI-2 Recovery Program Estimate.

8. Metropolitan Edison Company, July 1981. TMI-2 Recovery Program Estimate, Rev. 1.

9. GPU Nuclear Corporation, December 30, 1982. TMI-2 Recovery Program Estimate, Rev. 2.

10. GPU Nuclear Corporation Memorandum from C. P. Deltete, April 25, 1985, Revised Waste Projections 1985-1990, to S. Levin, #4520-85-0032.

11. GPU Nuclear Corporation Memorandum from C. G. Hitz, June 27, 1985, Revised Abnormal Waste Projections, to S. Levin, #4520-85-0054