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AECL Technologies Inc.

Plutonium Consumption Program

CANDU Reactor Project

Feasibility of BNFP Site as

MOX Fuel Supply Facility

Final Report

June 30,1995

DISCLAIMER

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by

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1.0 Summary and Conclusions

At the request of DOE's Office of Materials Disposition, AECL Technologies has conducted a brief evaluation of the technical feasibility, cost and schedule for converting the existing, unused, Barnwell Nuclear Fuel Facility into a Mixed Oxide (MOX) CANDU fuel fabrication plant for disposition of excess weapons plutonium. This MOX fuel would be transported to Ontario, Canada where it would generate electricity in the existing Bruce CANDU reactors owned and operated by Ontario Hydro. This report presents the results of this evaluation.

The CANDU MOX option is one of about a dozen options being considered by the U.S. Government for disposition of weapons plutonium, and is also the subject of a similar joint study being planned by the Russian and Canadian Governments. The U.S. National Academy of Sciences, in its January, 1994 report "Management and Disposition of Excess Weapons Plutonium," urged the U.S. and Russian Governments to act expeditiously to demilitarize excess fissile material from dismantled nuclear weapons, calling the continued availability of such materials, even when placed in safe storage, a "clear and present danger".

Consequently, in a study performed for the DOE in 1994 (excerpts of which are included in an appendix to this report), AECL recognized the urgency of the situation, and in cooperation with Ontario Hydro, chose the use of Ontario Hydro's Bruce A station containing four CANDU reactors as the reference case. AECL and Ontario Hydro also concluded that the existing, proven, 37 pin natural uranium fuel bundle design could be applied directly to MOX fuel without significant change. The 1994 study examined the use of an existing facility in Hanford, Washington, known as the FMEF, to produce the required quantities of CANDU MOX fuel.

The 1994 study concluded that it was feasible and cost effective to utilize an existing facility such as FMEF for CANDU MOX fuel production. Costs for facility conversion and startup, including licensing by the NRC, were estimated at about $118 million, with a lead time of about 4 years required for conversion, licensing and testing of the facility. The DOE subsequently requested that AECL examine other facilities at Savannah River to determine their suitability as well. Based on a joint determination of DOE and AECL, the existing Barnwell Nuclear Fuel Plant (BNFP), which is located adjacent to DOE's Savannah River-facility, was selected for this study.

Since the BNFP is privately owned by Allied Signal, Chevron, and Shell, collectively known as AGNS, this study was performed with the permission of the owners. However, AGNS was not a member of the study team, and does not take a position on the conclusions reached herein.

A major objective of the study was to compare the cost and schedule of converting BNFP to a CANDU MOX facility with the cost and schedule for converting the FMEF at Hanford, as reported in the 1994 study. DOE asked that AECL attempt to compare apples with apples, and, if necessary, make adjustments to the FMEF conclusions, including specifically the costs involved with privatizing the entire MOX production operation.

1.1 Key Assumptions

It was assumed that the same basic CANDU MOX fuel design which formed the base case in our 1994 study would be used in this study. This is the standard 37 pin design now used as the natural uranium reference fuel in all existing CANDU reactors, and is shown in Figure 1-1.

As in the 1994 study, mixed oxide pellets with 1.2 to 2 % plutonium, and the balance depleted uranium, are substituted for the natural uranium used in traditional CANDU reactors. To balance the core reactivity, the 7 central pins are made of dysprosium oxide mixed with depleted uranium oxide, and are to be manufactured at another facility and delivered to the MOX plant for final assembly into the bundle. Arrangement of the fuel and poison pins within the bundle is shown in

Figure 1-1. Details of the fuel performance characteristics were provided in the 1994 study, excerpts of which are appended herein.

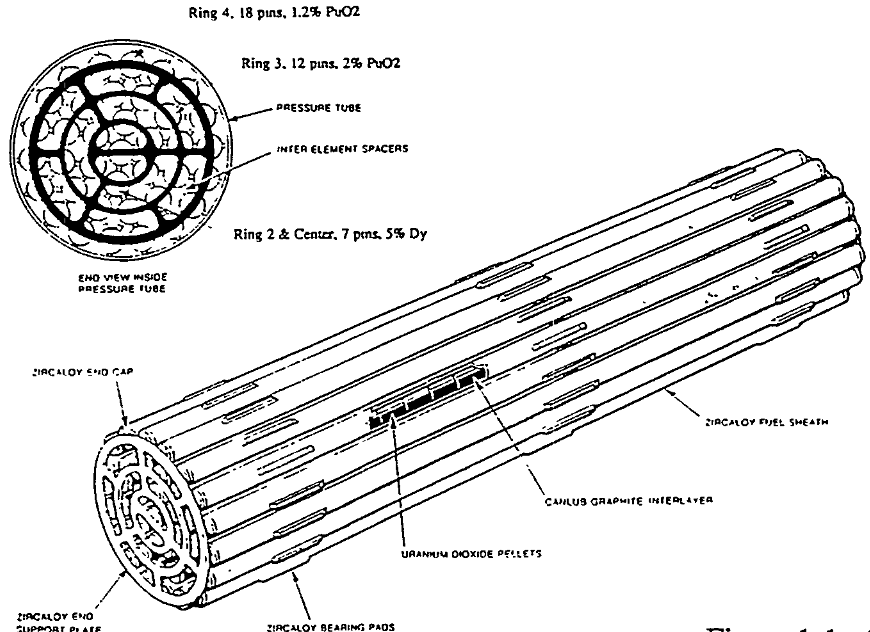


Figure 1-1 CANDU Fuel Bundle

Parameters of importance to this MOX fuel fabrication study, which are the same as used in the FMEF study, include the following:

(1) Each bundle contains 232 grams of plutonium. 9,050 bundles per year are required to fuel two Bruce reactors, thus utilizing about 2.1 tonnes per year of weapons plutonium. This is the rate requested by DOE in the 1994 study. This leads to a facility nominal throughput of 157 tonnes per year of mixed oxide, excluding the dysprosia pins. To allow for internal recycle and possible transition to the more advanced CANFLEX fuel bundle design, the facility and equipment is to be sized for 170 tonnes of mixed oxide per year. The following summarizes the nominal throughputs of the facility for standard CANDU fuel.

UO_2 converted per year for MOX fuel -	154.2 tonnes
PuO_2 converted per year -	2.4
Net MOX fuel fabricated per year	156.6 tonnes
UO_2 converted per year for Dy poison fuel	34.7
Dy oxide converted per year -	1.8
Nominal MOX fuel fabricated per year	193.1 tonnes

(2) The assumption is made that DOE provides the plutonium to the MOX facility in the form of PuO_2, with a maximum of 0.2 % americium. DOE is considering various options for converting the weapons pits to oxide. Those options, including the cost of conversion and transportation to the MOX facility are beyond the scope of this study. With regard to the americium, our previous study found that the radiation dose rates from the americium would be within acceptable limits; it is likely that even higher concentrations of americium would be acceptable but this would require further study.

(3) The assumption is made that the fuel bundles would be packaged and shipped in the standard package (seven bundles per stainless steel drum) and shipping arrangement described in the FMEF report. (see Appendix A) Cost of designing and licensing the shipping package are not included herein, nor is the annual cost of shipping. However, space is provided in the modified BNFP for buffer storage of a six month supply of completed fuel bundles and shipping drums, the same finished inventory as assumed in the FMEF study.

(4) The assumption is made that the same MOX fuel manufacturing process used in the FMEF will be used at the BNFP. The FMEF process parameters and equipment selection was made after careful engineering evaluation which is described in the 1994 report. No changes were made to these process parameters and functions. A brief description of each process function and equipment selection is included herein.

(5) The assumption is also made that the BNFP facility must also be capable of switching, at some future time, to the manufacture of the advanced CANDU bundles known as CANFLEX. These bundles can achieve almost twice the burn-up as the referenced bundles (17,100 versus 9,700 MWD/T) and are expected to be proven in service a few years from now. Qualification of CANFLEX fuel for MOX application would take additional 4 to 5 years. Switching to this fuel design would allow the plutonium consumption to be increased to 4 tonnes per year, using 4 Bruce reactors, with only a slight increase in the MOX fuel facility production rate, from 157 tonnes per year to 168 tonnes per year.

(6) Figure 1-2 illustrates the BNFP facility which is located on a 1600 acre site in Barnwell County, South Carolina, directly adjacent to DOE's Savannah River Facility. For purposes of this study, we assumed that the BNFP facility, currently in private hands, would be purchased by a private entity, modified for production of CANDU fuel, licensed by the NRC, operated for the time period required to dispose of DOE's fuel, and then decontaminated and decommissioned as per NRC regulations. Although it was assumed that all of the existing facilities and structures could be made available if needed, the team concluded it would be cost effective to only use those portions of the facility which lend themselves to the MOX fabrication program, Thus we did not use many process cells, which would be sealed off during this program, we did not use the extensive fuel pools and lifting equipment, which remain available for other programs if needed, and we did not use the UF_6 conversion building. We also limited our usage to only those portions of the building which had been hardened against external events as part of the original design, construction, and NRC licensing effort in the mid 1970's.

1.2 Principal Conclusions

(1) VIABILITY OF CANDU OPTION - The CANDU option continues to be viable option for disposition of U.S. weapons plutonium. Although this study focused only on the MOX fabrication aspects, it necessarily took cognizance of any new developments since the 1994 study. There have been no significant changes. Continued work in support of DOE's PEIS indicates that no changes will be required to the Bruce plant except the addition of a new fuel storage building. The use of MOX fuel in Bruce is within the existing AECB licensing envelope, and a modest fuel confirmation program of under $25M and less than 4 years would be required to support this licensing.

Because the CANDU MOX fuel operates at lower thermal loadings than the licensed natural uranium fuel, there is a high degree of certainty that the MOX program can be successfully licensed by the AECB within the 4.5 years allowed in our schedule. Thus, with a Record of Decision (ROD) by DOE in late 1996, the actual plutonium disposition in the Bruce Reactors could begun in the year 2001. The CANDU option has a unique advantage resulting from the CANDU core design which allows the MOX fuel to be operated with more thermal margin than the existing licensed fuels. It is this advantage, combined with an efficient licensing process in Canada, and the ease of fabricating CANDU MOX fuel in an existing facility within 4.5 years as concluded herein, that provides us with assurance that we can achieve the schedule of 4 to 5 years from Record of Decision (ROD) to start of MOX operation.

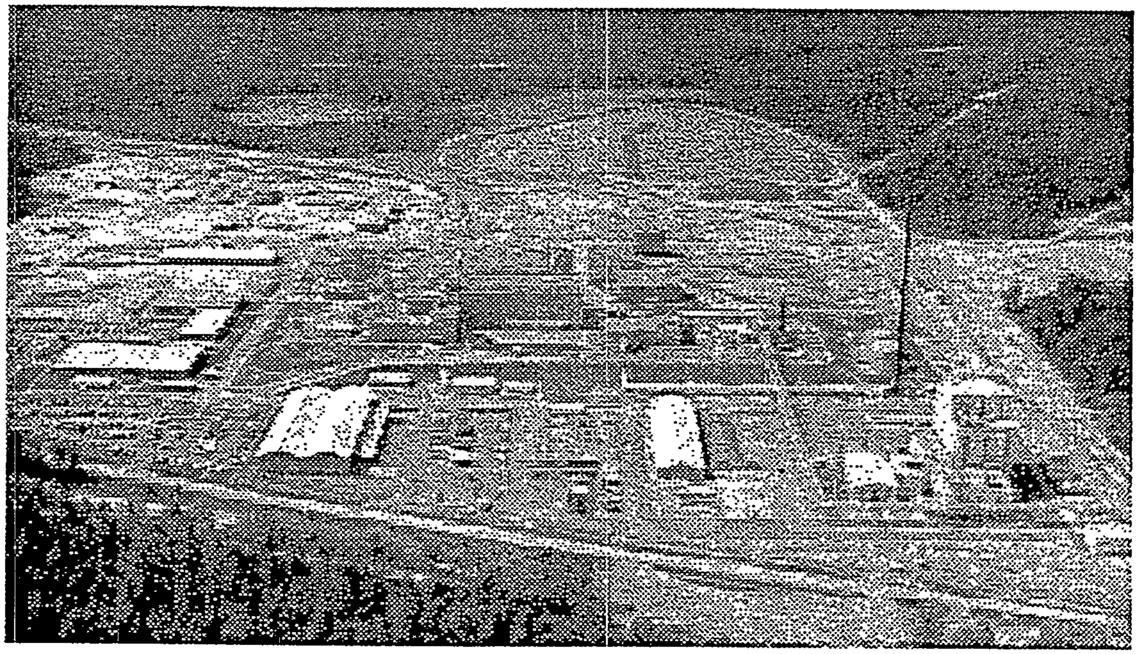


Figure 1-2 BNFP Site

(2) CONVERTIBILITY OF BNFP TO MOX FUEL - The fuel supply team concluded that the BNFP can be prepared for this mission, including modifications, process equipment procurement, installation and testing, with all necessary licensing and permitting, within a period of 4 1/2 years and for a cost of about $172 million. This cost estimate is based on a very detailed review of every process function required, a detailed layout of these process functions within the existing facility, the current status of the facility, and the licensing, permitting, safeguards, accountability and security requirements.

The degree of difficulty for facility conversion is greater at BNFP as compared to FMEF, since BNFP was originally designed as a reprocessing facility and not a fuel manufacturing facility. This is reflected in the cost estimates.

The comparable cost estimate for FMEF is $112 M, about $6 M lower than the 1994 estimate. This decrease results from a more thorough review of the NRC licensing costs, and deletion of some financing fees, that were erroneously included in the startup costs.

In its examination of the options for use of different spaces within the BNFP, the team chose to avoid using the existing "Fuel Receiving and Storage Building" noting that this facility was being considered for other purposes. As a result, we have included in our conceptual design the erection of a new hardened structure adjacent to the existing Process building and Waste Exchange Gallery for use in pellet processing operations and for secure shipping and receiving. This decision has increased the cost of the BNFP option by about $25 million. The team recommends that this choice be reexamined in any future study of this facility for MOX use, since it may be that use of the Fuel Receiving and Storage Building would be a practical option, and could reduce the total cost of BNFP conversion by a substantial amount.

(3) SITE INFRASTRUCTURE - Like the FMEF, locating a MOX fabrication facility at the Savannah River complex will make available existing infrastructure that will prove valuable during the design/conversion period, as well as the operating phase. For example, if Savannah River glove box facilities were selected by DOE for converting the metal pits to oxide (not covered in this study), the plutonium feed stock could be easily transported directly to BNFP with a high degree of security and safeguards that could not be achieved if the two operations where widely separated geographically. The existing human resource base, including highly experienced engineers, technicians and workers, would be a great asset.

(4) OPERATING AND FINANCING COSTS - We have concluded that the overall MOX fuel supply costs for two Bruce Reactors (standard 37 pin design) would be about $93.5 million per year, including site security and landlord functions, ultimate decontamination of the facility, and the costs of private financing and operation, including return on investment. This compares with about $86.2 million per year for MOX fuel from FMEF, and about $16 million per year for the current natural uranium fuel supply. (not included are the transportation costs, the Bruce Facility modification and licensing costs, and an initial fuel demonstration program.) The FMEF costs have been adjusted to reflect the costs of private financing, so that FMEF and BNFP are on an apples to apples basis. Site acquisition cost have not been included since this is an unknown in both cases. Financing assumptions are described in section 10.

(5) EXPANDABILITY OF BNFP SITE FOR LWR MOX - As shown in figure 1-2, the 1600 acre BNFP site has ample protected space for the addition of LWR MOX capacity. A hardened building addition could be erected adjacent to the existing process building for conversion of the 10% master blend (from the CANDU MOX facility) into LWR pellets, and for manufacturing of pins and assemblies. Such an approach would allow DOE to get started with disposition almost immediately using the CANDU option, and then increase the rate of disposition using LWR plants a few years later, once an LWR utility and NRC license for MOX fuel, appear assured. Erecting the LWR pelletizing, pin and assembly building at BNFP, would allow shared infrastructure such as safeguards, security, shipping and receiving, master blending, etc., with the CANDU MOX line, and would significantly reduce the overall cost to the DOE.

(6) SCHEDULE - One year has passed since AECL's 1994 report to DOE, and 1-1/2 years since the National Academy's "clear and present danger" warning. The prompt disposition of weapons plutonium remains urgent. We have revised the schedule for FMEF, and developed a new schedule for BNFP, using common assumptions and based on this sense of urgency. The new schedule is shown on Figure 1-3. The critical path is NRC licensing, which is about 6 months longer than previously estimated. The current estimate is based on input from the NRC staff, and is achievable. Although there is more physical work to be done at BNFP, we concluded that the extra work was not enough to displace the critical path, so that both BNFP and FMEF facility conversions require a schedule of 4.5 years.

(7) BUILDING SUITABILITY; NATURAL PHENOMENA; PHYSICAL SECURITY; PROCESS SYSTEMS. We found that the existing BNFP building structure is quite suitable for this fabrication program. The structure has been designed to withstand external events such as tornado and earthquake. Our cost estimate includes allowance for the restoration of utility functions such as electrical power, which have been removed. It also includes allowance for an additional hardened building addition to allow for some of the process equipment and joining of two existing hardened structures. Contrary to the case of FMEF, where some existing process equipment could be used, all the processing equipment at BNFP will be new. This, plus the cost of more extensive facility refurbishment, and the cost of the new building, accounts for the additional cost at BNFP.

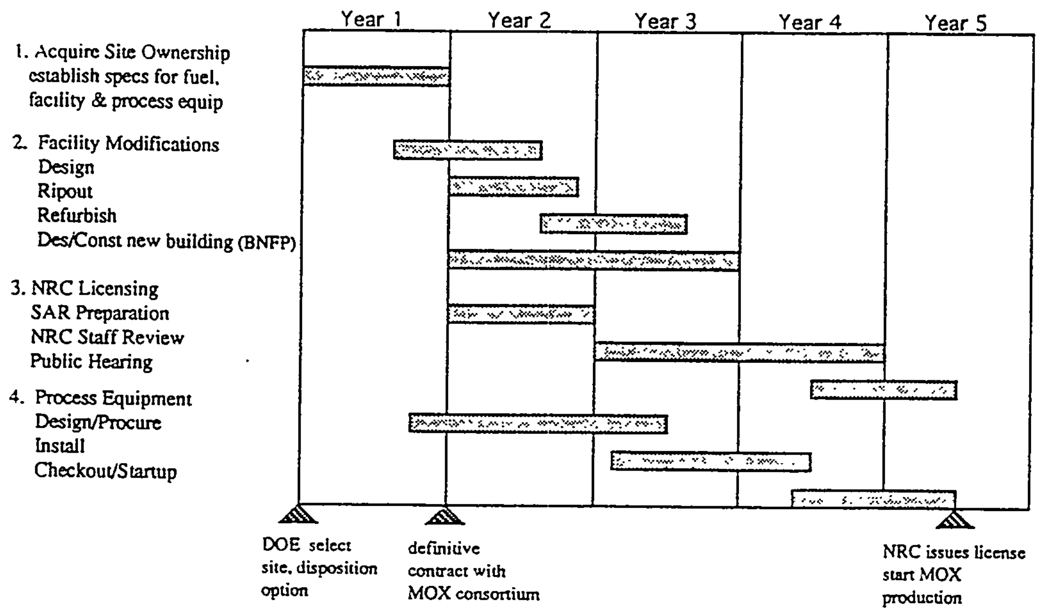


Figure 1-3 Schedule for MOX Facility (BNFP & FMEF)

(8) ENVIRONMENTAL BENEFITS - The environmental benefits of disposing of U.S. weapons plutonium in Bruce remain quite significant. As shown in Figure 1-4, using the CANDU option with 2 reactors will eliminate 6,300 tonnes of mining waste per year, consume 24.7 tonnes of excess depleted UF_6 per year, convert 2.1 tonnes of Pu per year to useful energy, and reduce the quantity of spent fuel generated per kwhr at the existing CANDU units by 10% compared to natural uranium. The environmental benefits of converting to the CANFLEX advanced fuel option, using 4 Bruce reactors, are even greater, since the higher burn-up fuel will lead to even lower quantities of spent fuel per kwhr.

(9) DEPLETED UO_3 AT SAVANNAH RIVER - An additional environmental benefit is possible at Savannah River. DOE can dispose of excess depleted UO_3 which was produced during thirty years of weapons production at Savannah River and is now in interim storage on the Savannah River site. Although not officially classified as a waste, this material is in fact a significant liability for Savannah River and DOE. Because of its low fissile content, it would make a satisfactory alternative diluent for the PuO_2 in the CANDU MOX fuel subject to more detailed study to confirm its suitability for conversion. Using this material instead of the depleted UF_6 at Oak Ridge would actually reduce the annual cost of the CANDU MOX fuel by about $1.7 million per year because the defluorination step would be eliminated.

(10) LICENSING AND REGULATION: We believe the converted BNFP facility, and our proposed processing operations can be planned, designed and installed to be fully consistent with applicable NRC safety and environmental regulations. We have incorporated into our program schedule and cost estimates, sufficient time and money to achieve this objective, and to allow a thorough NRC review and licensing activity.

The time and cost estimates for the preparation of licensing documentation and the actual licensing activities are based on a more thorough review than was done for the FMEF. For example, the fuel supply team conducted a detailed review of each of the SAR chapters that would have to be submitted to the NRC, and reviewed these with the NRC staff. Although no commitments were requested or offered at this meeting, the NRC staff did agree that our current estimates of resources and schedule were reasonable. We also received comments from the NRC General Counsels office with regard to the public hearing process for materials processing licenses, and have allowed for that activity in our schedule.

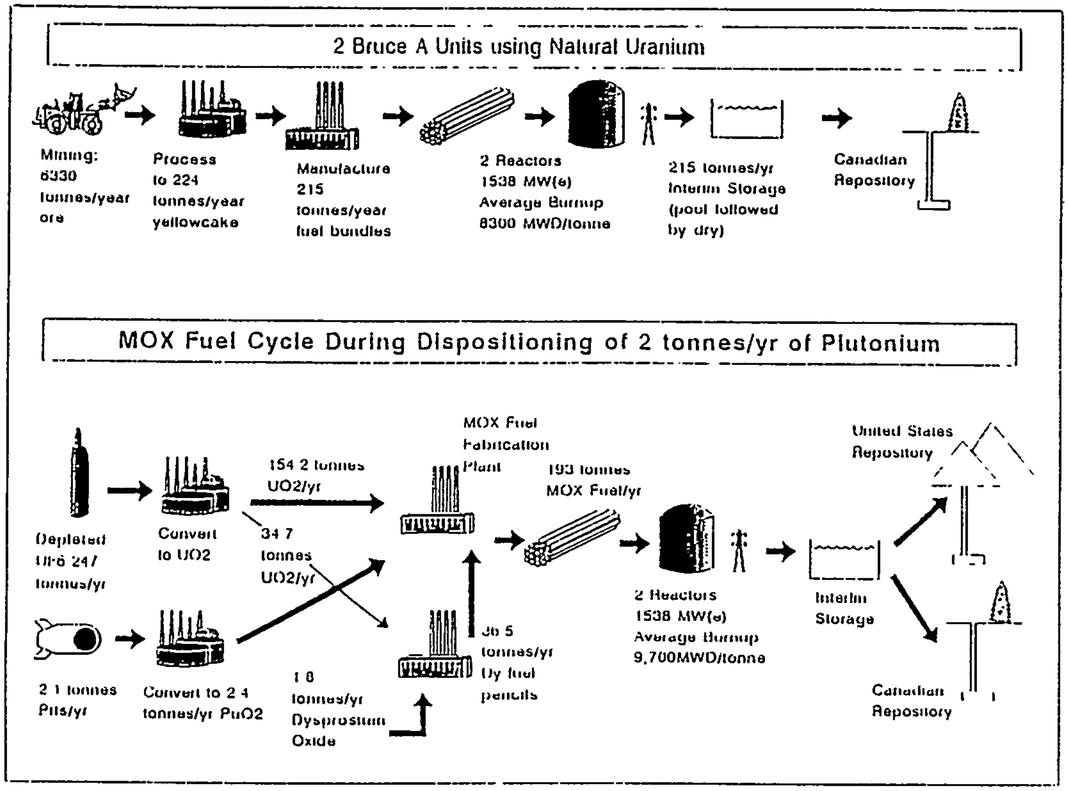


Figure 1-4 Material Flow (2 Bruce Units on Reference MOX Fuel)

(11) SAFEGUARDS AND ACCOUNTABILITY: Our study is based on the assumption that the entire MOX fabrication facility will be under the umbrella of international (IAEA) safeguards agreements. These will require extensive measurements and accounting by the facility operator, as well as provisions for permanent and frequent IAEA inspections and measurements. For example, we have assumed a near real time accountancy system. We have conservatively assumed that such a system would be used at BNFP and have allowed for the costs ($10 million) in our estimates. Figure 1-5 shows a schematic layout of the BNFP facility and associated process flow concept. Consideration of safeguards and accountability requirements was one of the primary factors dictating the facility configuration and process flow design

(12) WASTE ARISING - We estimate that the MOX plant will generate about 260 to 390 55 gallon drums of TRU waste per year, consisting of compacted solids and miscellaneous equipment (for purposes of this report, the availability of WIPP for TRU waste disposal is assumed). The LSA waste is estimated at less than 50 drums per year, with hazardous (non-radioactive) waste at 30 to 50 drums per year. No mixed wastes are anticipated. These results have been adopted from the FMEF study without change. Cost of waste disposal is included in our annual operating costs.

(13) OCCUPATIONAL RADIATION EXPOSURES: We estimate (using calculations and some measurements) that the average contact dose on a standard (37 pin) CANDU MOX fuel bundle will be 15 to 25 mRem/hr, including about 5 mRem/hr neutron dose and the balance gamma dose. In

the bundle assembly area, a shielded work station consisting of a 4 inch panel of water extended polyester (WEP) sandwiched between 1/8 inch sheets of stainless steel would reduce these dose levels to below 1 mRem/hr. A thinner (about 1 inch of WEP) cylindrical shield would be used to handle the bundles after assembly and in storage. Contact dose rates would be under 5 mRem/hr. Based on the proposed processing layout, and recent experience from LANL TA-55 and Belgonucleaire, we are confident the yearly operator dose rate can be kept under 500 mRem, consistent with new NRC standards. Exposure estimates have been adopted from the FMEF study without change.

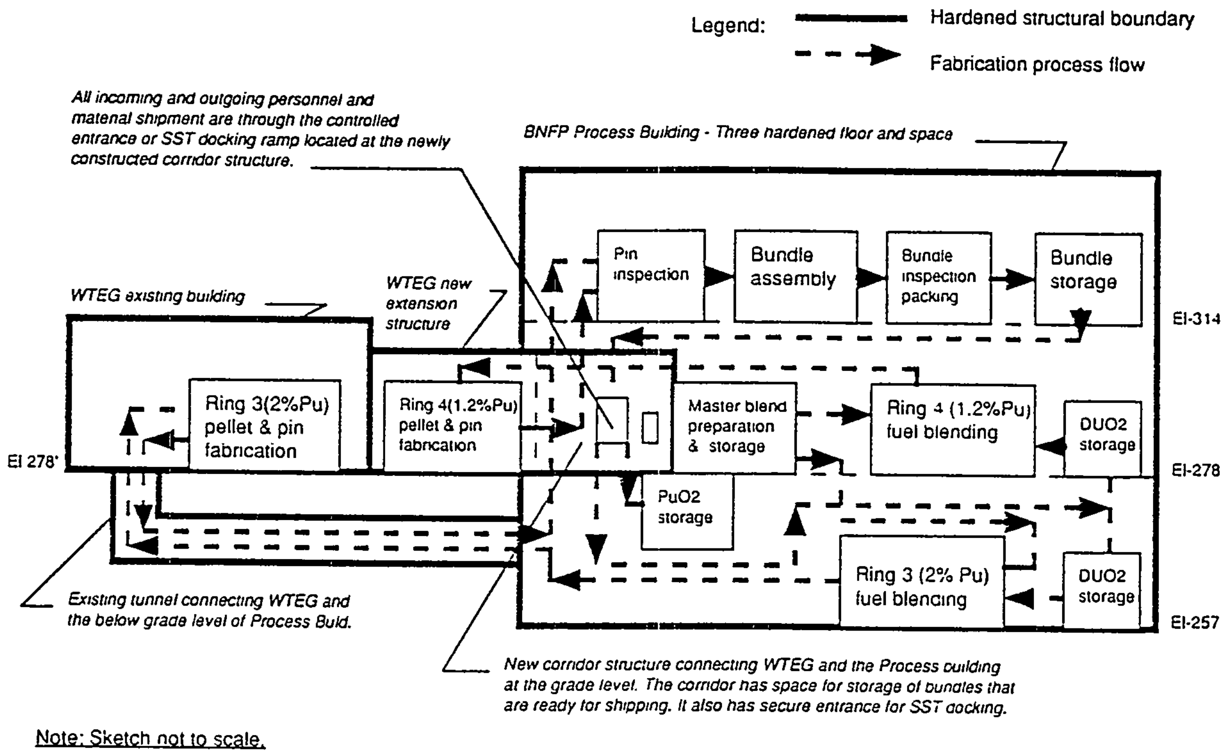


Figure 1-5 MOX Process Configuration for BNFP

(14) REDUCTION IN FUELING COSTS USING CANFLEX: The advanced CANFLEX design is a more efficient fuel bundle because it can utilize higher Pu concentrations, and achieve longer burn-up, without exceeding core thermal limits. Therefore, it can be used to dispose of the weapons plutonium at twice the rate of the reference fuel bundle, using the same sized MOX fuel factory, but using four Bruce reactors instead of two. However, several years of additional testing are required before the utility will have sufficient confidence to use this new design in commercial reactors. That testing is already well underway for natural uranium applications, and could be supplemented for MOX applications by an additional DOE funded fuel confirmation program, as recommended in our 1994 report.

Therefore, our recommended scenario is to start the fabrication and commercial operation programs using the standard bundle design, and then switch to CANFLEX after the new fuel system is proven. The fuel fabrication process lines proposed herein can accommodate this switch. The cost of producing 168 tonnes of CANFLEX MOX fuel per year would only be marginally higher than 157 tonnes/yr of standard MOX fuel. We estimate about 20%. Such an arrangement could allow the modified BNFP facility to increase its Plutonium utilization rate from 2 tonnes/yr to 4 tonnes/yr (using 4 Bruce Reactors) and thereby shorten the entire program from 25 years to about 15 years.

This is our recommended approach, and would lead to a total fueling cost for the fifteen year program of $1.6 billion which includes $93.5 million/year for fueling two reactors during the first five years, allowance for a 6 month, $23 million shutdown for transition, and about $109 million/year cost for fueling four reactors during the last 10 years. The annual financing costs for the latter 10 year CANFLEX operating period have been adjusted to allow for recovery of investment. Based on a start date of 2001, the entire program for disposing of the 50 tonnes of plutonium would be completed by 2016. Facility decontamination would be completed by 2018, and funds for this are accumulated during the operating period. The overall schedule for facility conversion, startup, operation, and decommissioning, using this "hybrid" approach as compared with the "reference" case is shown in Figure 1-6 below.

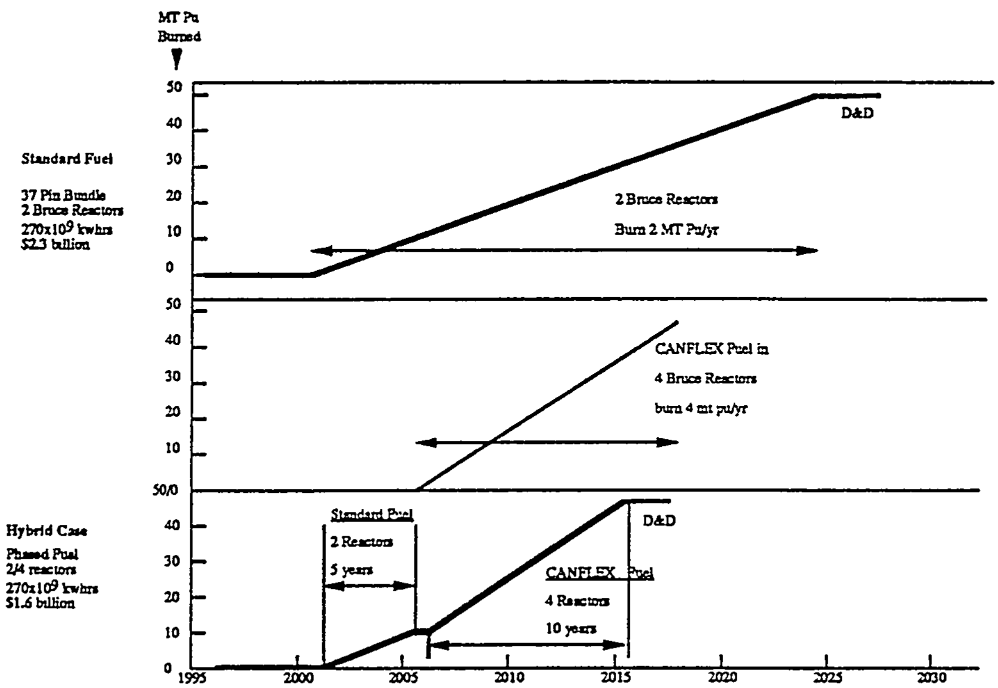


Figure 1-6 CANDU MOX Fuel Consumption Options and Schedule

(15) AVOIDED COST OF SPENT FUEL DISPOSAL IN U.S. REPOSITORY - An additional savings would accrue to DOE should the decision by both Governments allow the continued disposal of the Bruce spent fuel in the planned Canadian repository. In this case, DOE would avoid the cost of direct disposal of spent fuel in the planned U.S. repository, which at recently estimated costs of $160/kg, (1994 OECD Nuclear Fuel Cycle Study) would lead to an avoided cost of about $500 million for the estimated 3000 tonnes of spent fuel.

(16) CONSUMPTION OF PLUTONIUM WASTE PRODUCTS FROM DOE SYSTEM: The MOX processing equipment outlined in this report includes an oversized MOX recycle station. Normally this recycle process equipment is required for internal recycle of rejected product including powder, green pellets and fired pellets, so that the net yield of the facility is close to 100%, and a minimum amount of plutonium is incorporated in the waste stream. The fuel supply team found that, by increasing the size of this station, it will be possible to utilize much of the plutonium scrap in the DOE system, such as the green FFTF fuel pellets, scrap plutonium oxide and metal at the Rocky Flats, Savannah River, Hanford, Oak Ridge and LLNL facilities. This scrap material can be processed through the recycle unit, along with internal recycle, and blended

into the normal process stream at a ratio of up to 10 to 20%. This could significantly reduce the environmental and cost burden to DOE's Environmental Management programs.

(17) OWNERSHIP AND OPERATIONAL RESPONSIBILITY - An essential prerequisite for the proposed Pu disposition in CANDU option is that the utility, Ontario Hydro, must be assured that:

(a) switching from their present 20 reactor natural uranium CANDU fuel supply condition to this MOX supply for Bruce A will not disrupt their overall fuel supply plan (for BRUCE A and their other 16 reactor plants) which has been developed and implemented at great effort over many years; and

(b) the MOX fuel supply for the Bruce A reactors committed to use MOX will be of sufficient quality and reliability (guaranteed supply) that they can fully depend on this supply to meet their customers' electricity needs.

To achieve this level of assurance by the utility, it is essential that the utility and its current fuel suppliers, be directly involved in the entire MOX fuel fabrication program, from inception through development and licensing, through production and transportation.

We have based this fuel supply study on the assumption that the MOX facility will be privatized. With the agreement of Ontario Hydro, a consortium of private companies, would be established at the outset to finance, license, and manage the conversion, operation, and decontamination of the MOX facility.

2.0 Study Approach

In April, 1995, DOE requested AECL Technologies to perform a limited study of Barnwell Nuclear Fuel Plant (BNFP) located in South Carolina for fabricating the CANDU MOX fuel assemblies. The objective is to evaluate the feasibility, cost, and schedule for utilizing the existing facilities at the BNFP site to perform the same CANDU MOX fuel fabrication functions as analyzed by AECL Technologies for the DOE Hanford FMEF site. The evaluation would be done in such a way as to permit a direct comparison of the two options.

AECL Technologies assembled a study team which maintained the continuity from the previous study. The team also included new members who are familiar with the design of the AGNS/BNFP facility. The team consisted of AECL experienced technical and financial staff, Ontario Hydro, Zircatec Precision Industries, Gamma Engineering Corporation, ER Johnson Associates, and Scientech Inc. ER Johnson Associates and Scientech are new members of the study team who are familiar with the design and licensing aspects of the BNFP facility.

The study team visited the BNFP facility in March 1995 and conducted on-site working sessions with participation of DOE Savannah River (SR) office, Los Alamos National Laboratory, Westinghouse SR office, and Bechtel. The AGNS site office has provided valuable support to this study including making available needed system design and reference documents.

During the onsite working sessions at BNFP facility, the study team developed a preliminary concept of the facility layout. Based on this initial concept, the team members continued the study and analyzed four major areas of requirements for a MOX fuel facility at BNFP. The four areas are; facility modification requirements, fuel fabrication process equipment design, regulatory and licensing requirements, and financing concept and costs estimate. Interim results of the study were reviewed and discussed in a second working session of the study team in April. The second working session also included refinement of the facility layout concept and resolution of issues concerning all pertinent factors affecting the design and operation of a MOX fuel facility at BNFP.

This report is presented in 11 chapters which are structured in a similar sequence as compared to the Chapter 4 - Fuel Supply of the previous study report. Some sections in the previous report are not shown in this report because the subjects were not in the scope of this study and the findings of the previous study are expected to be equally applicable to the BNFP site.

To provide a background of the findings of the MOX fuel facility at FMEF and the CANDU reactor plutonium consumption study performed by AECLT in 1994, the Executive Summary and conclusions of the FMEF fuel supply study of the previous report are attached as Appendix A along with fuel packaging and transportation findings. The Appendix B provides a chronological summary of major events and licensing actions related to the BNFP site from 1968 through 1977. The Appendix C describes the more detailed work scope and equipment items along with costs associated with BNFP facility modifications.

In parallel with this study, the DOE Savannah River Office and site operating contractor performed an evaluation of the various options for utilizing surplus materials (depleted UO_3) and material processing expertise at the Savannah River Lab for providing feed material to the BNFP MOX facility. The results of this evaluation is contained in a Westinghouse Savannah River Company's report (WSRC-TR-95-0271) titled "Plutonium/Uranium Oxide Powder Production at Savannah River Site", dated July 1995. This effort was quite valuable to the study team. Reference is made later in this report to cost savings which would accrue if DOE chooses to provide the depleted UO_3 as feed material for MOX fuel. Further information on these material options can be obtained from the DOE Savannah River Office.

3.0 Existing BNFP Facility Description

This section provides an overview of the existing BNFP facility including a description of the structures which will be used for fabricating the CANDU MOX fuel, its original intended functions.

In 1968, Allied Chemical Corporation applied to the AEC for a construction permit for a reprocessing plant at Barnwell, SC. The permit was issued in December 1970 and construction work commenced the next month. Gulf Oil Corporation, through its subsidiary Gulf Energy and Environmental Systems, Inc., expressed an interest in reprocessing, and subsequent negotiations led to the formation of Allied Gulf Nuclear Services in February 1970, a 50-50 partnership. In 1974, with the formation of General Atomic Co., as a partnership of Gulf Oil Corporation and Scallop Nuclear, Inc. (a company of the Royal Dutch/Shell Group), the partnership name was changed to Allied-General Nuclear Services, Inc. (AGNS).

The Barnwell Nuclear Fuel Plant (BNFP) (see Figure 3-1), was designed as a special purpose reprocessing plant, with a throughput of 1,500 MTU/year, for zirconium or stainless steel clad light water reactor fuel aged 160 days or more, and having a burn-up of less than 40,000 MWD/ton. The site (owned and controlled by AGNS) is located on land adjacent to the eastern perimeter of the DOE Savannah River Plant, and contains over 1,600 acres (see Figure 3-2). The main process building complex (the Separations Facility) located in the southwest section of the site, is a reinforced concrete building containing heavily shielded process cells that house remotely operated equipment and provide confinement integrity for design basis accidents and naturally occurring events such as earthquakes and tornadoes. Major construction was completed in 1976. The BNFP Fuel Receiving and Storage Station (FRSS) is adjacent to the Separations Facility.

3.1 Fuel Receiving and Storage Station

The FRSS is connected to the main process building by the fuel transfer conveyor tunnel. The pool walls and liners are designed to maintain their containment integrity during a design basis earthquake or tornado, but the building walls above the pools are non-Q structures. No part of the FRSS is planned to be used for CANDU MOX fuel fabrication. Figure 3-3 shows the relative location of the FRSS structure to the main Process building.

3.2 Main Process Building

The major features of the Main Process Building are shown in Figures 3-3 and 3-4. The primary functions of the main process cells are listed in Table 3-1. Most of the building is constructed of reinforced concrete designed to remain intact during a design basis earthquake or tornado. In addition to the process cells, the building contains a wide variety of facilities and equipment that were to be used for process monitoring, equipment maintenance, and carrying out auxiliary operations.

The areas outside the main process cells are generally divided into regions called "galleries", "areas", or "stations". These areas enclose and protect service piping, process support equipment and instrumentation. The floors of all cells are covered with continuously welded stainless steel liners while the walls are covered with either stainless steel or a radiation resistant paint.

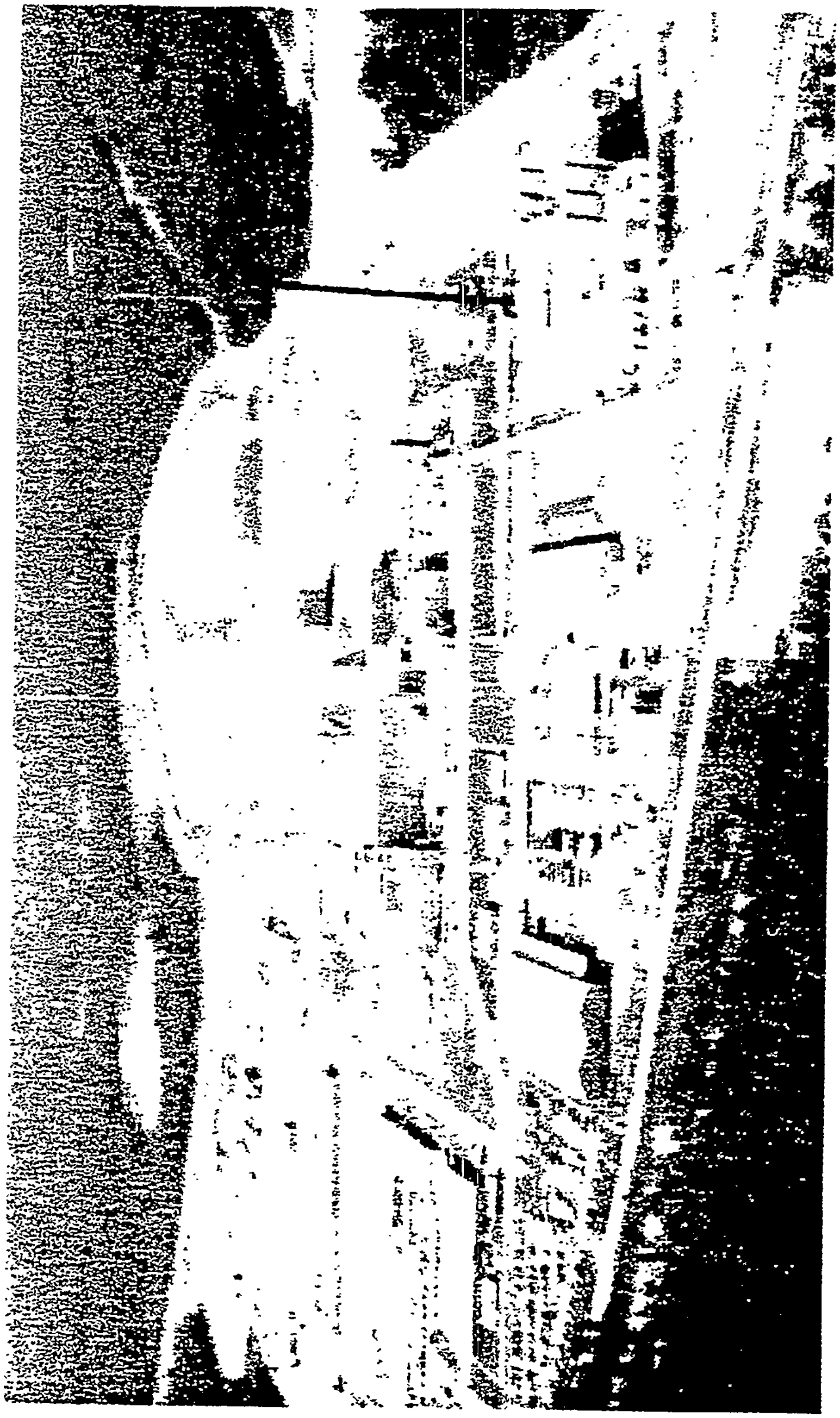


Figure 3 - 1 BNFP Site

South Carolina

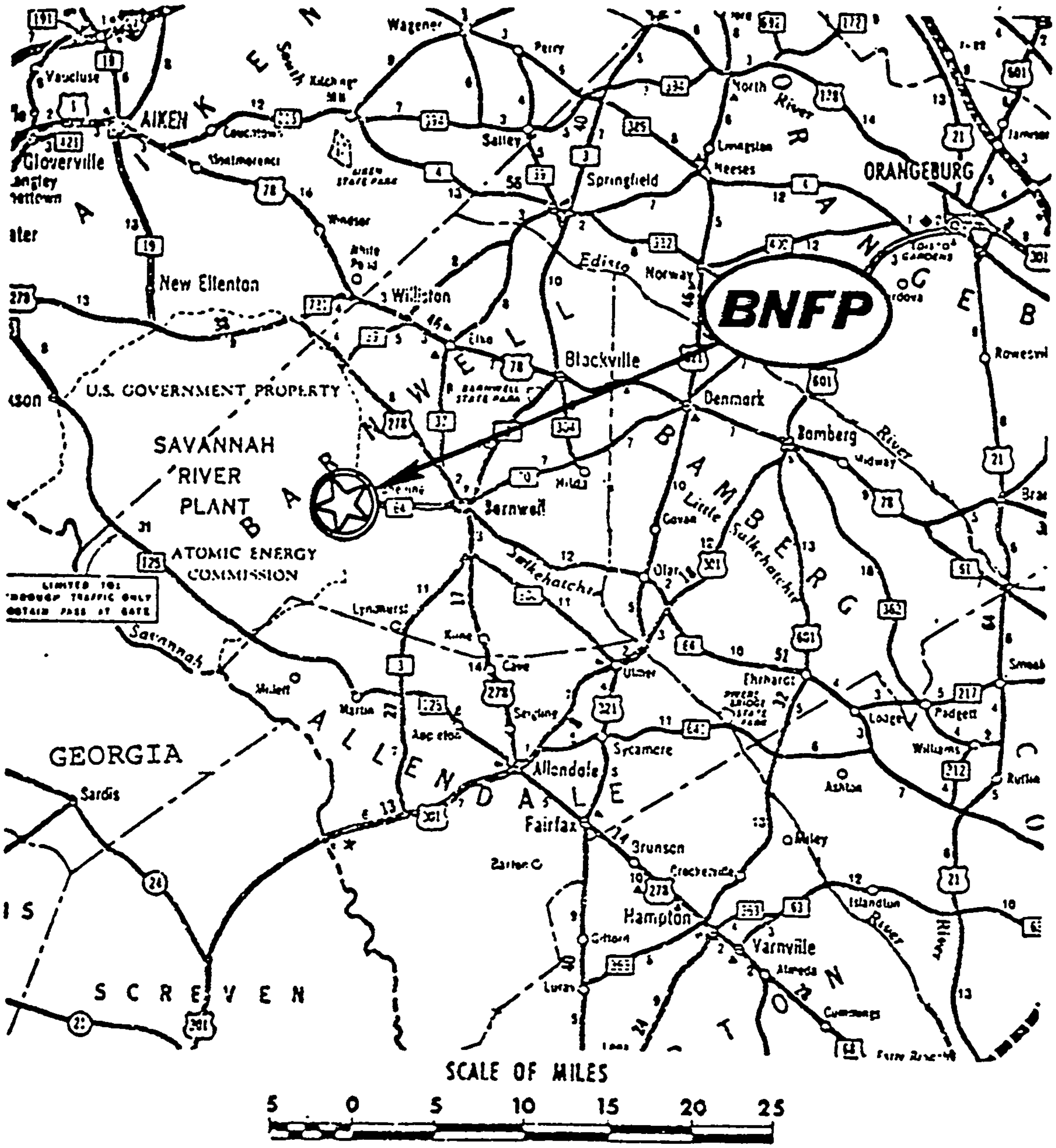


Figure 3 - 2
BNFP Location

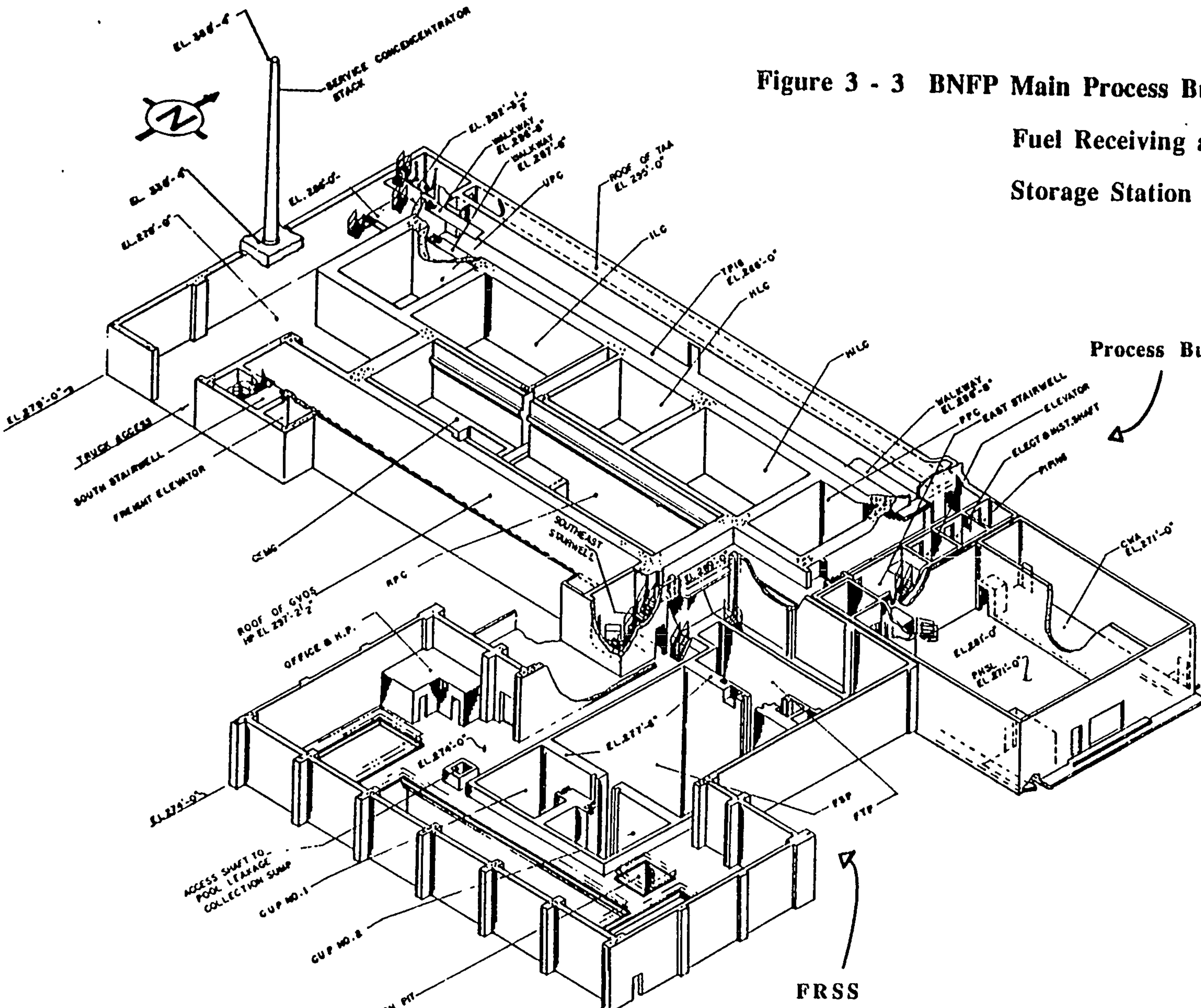


Figure 3 - 3 BNFP Main Process Building and Fuel Receiving at Storage Station

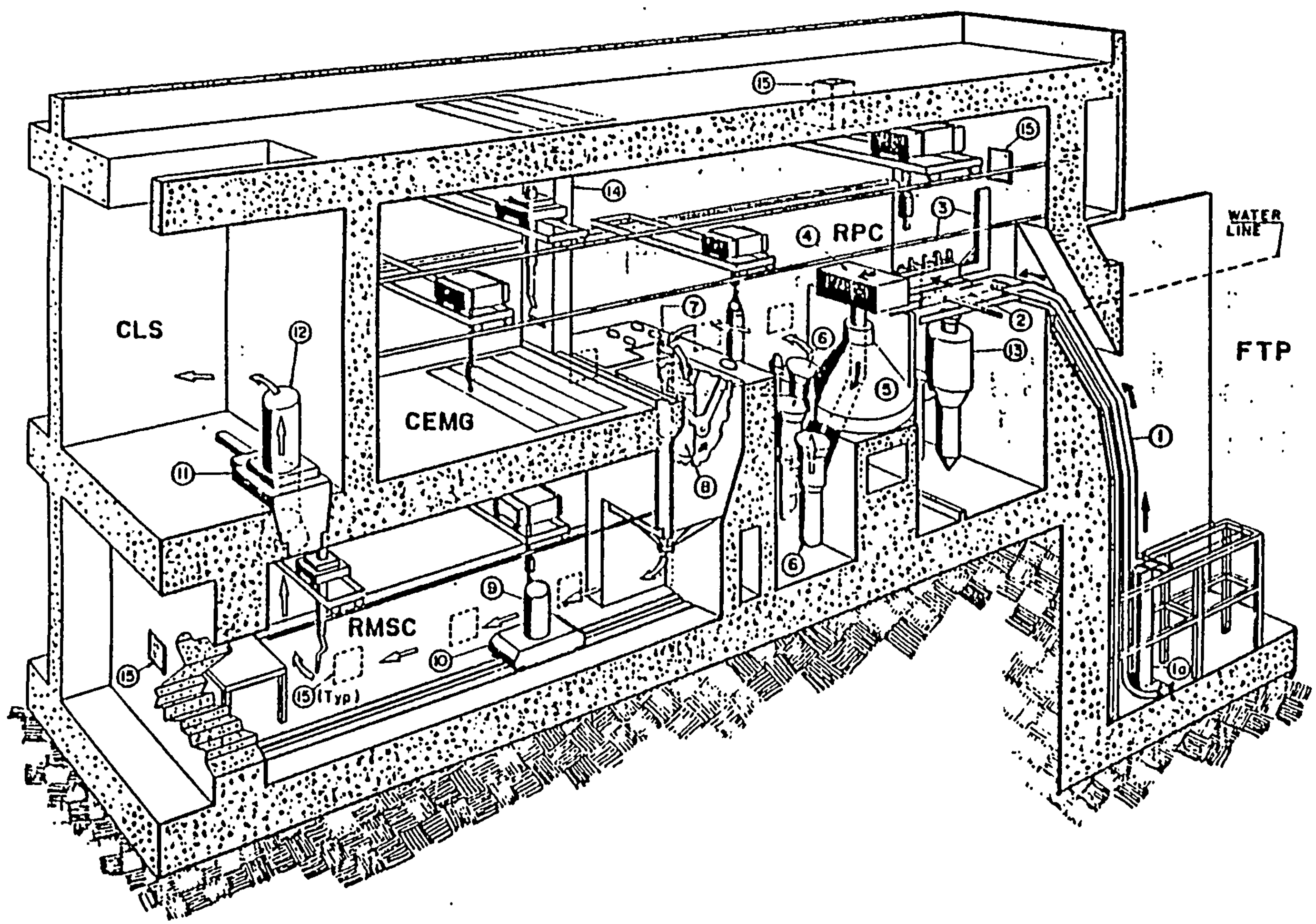


Figure 3 - 4 BNFP Main Process Building

TABLE 3-1
PRIMARY FUNCTIONS OF MAIN PROCESS CELLS

Cell	Primary Process Functions	Remarks
Remote process cell (RPC)	Shear and dissolve fuel; concentrate high level liquid waste	Stainless steel floor pan; remote maintenance
Remote maintenance and scrap cell (RMSC)	Package leached hulls and other solid waste; remotely maintain contaminated equipment	Stainless steel walls and floor
High level cell (HLC)	Accountability for dissolver solution; chemically adjust dissolver solution; centrifuge dissolver solution	Stainless steel floor pan; contact maintenance; centrifuge replaceable without cell entry
High-intermediate level cell (HILC)	Separate uranium and plutonium from high level waste; separate uranium from plutonium, treat dissolver off-gas; solvent cleanup; concentrate intermediate level waste	Stainless steel floor pan; contact maintenance
Intermediate level cell (ILC)	Treat vessel off-gas; recover nitric acid; concentrate low level waste; burn used solvent	Stainless steel floor pan; contact maintenance
Uranium product cell (UPC)	Purify uranium stream; clean up solvent	Stainless steel floor pan; contact maintenance
Plutonium product cell (PPC)	Purify plutonium stream	Stainless steel floor pan; contact maintenance
Plutonium nitrate storage and load-out (PNL)	Store plutonium nitrate solutions; transfer plutonium nitrate to Plutonium Oxide Conversion Facility	Stainless steel floor pan; contact maintenance

The following describes these cells as they were originally intended for use.

3.2.1 The Remote Maintenance and Scrap Cell (RMSC)

The Remote Maintenance and Scrap Cell (RMSC) was to be used primarily for handling leached hulls and other radioactive scrap in preparation for transport to storage, and for decontaminating and repairing equipment. All operations and maintenance within this cell were to be performed remotely. The RMSC is located on the lowest level of the plant. The east end of the RMSC extends beneath the west end of the RPC as described in the next section. The floor and walls of the RMSC are lined with 3/16-inch stainless steel. The ceiling is finished with acid and radiation-resistant paint.

The RMSC ceiling contains three hatches. An unshielded hatch cover in the ceiling of the northeast corner of the RMSC leads from the Remote Process Cell (RPC). A shielded hatch constructed of stepped cover blocks in the ceiling of the center of the cell leads to the Crane Equipment &

Maintenance Gallery (CEMG). A shielded hatch in the southwest corner of the ceiling of the cell leads to the Cask Loading Station (CLS). The hulls basket dumper is located in the concrete structural materials between the RPC and RMSC. A waste chute penetrates the RMSC north wall from the Sample and Analytical Cells (SAC).

There are four viewing windows in the RMSC. A pass-through port is located in the northwest corner of the cell for introducing small items into the RMSC from the Lower Viewing and Operating Station (LVOS).

A 10-ton maintenance bridge crane and a power manipulator are located on rails at the top of the cell. A transfer cart for movement of hulls containers moves on rails embedded in the floor of the cell extending along the south side of the cell from the hulls basket dumpers in the east end to the scrap hatch in the west end. A movable work bench is located beneath the shielding window at the west end of the cell. A shallow trench runs the length of the transfer cart rails and empties into a sand trap and sump in the southwest corner of the cell. The floor of the entire RMSC drains to this trench and sump.

The hatch to the CEMG allows the crane and power manipulator to be brought from the RMSC to the CEMG. Large pieces of equipment from the RPC cell could have been placed into the RMSC, through the unshielded hatch, for decontamination and repair. Large pieces of equipment could also be passed from the RMSC into the CEMG through the RMSC-CEMG hatch.

3.2.2 The Remote Process Cell (RPC)

The Remote Process Cell (RPC), located in the southwest corner of the main process building, was to be used for headend mechanical process operations and, as such, contains the following equipment: shear, diverter, dissolvers, high activity waste concentrators, and access openings to the hull monitor and hull dumper. The majority of the cell is taken up by the shear and dissolver system. The driving mechanisms for the shear and the fuel transfer conveyor penetrate the RPC from the Grade Viewing and Operating Station (GVOS). The diverter, located directly below the shear, is mounted on a ledge in the cell; the three dissolvers are located below the diverter in a circular pattern centered about the diverter.

The west end of the cell is a raised ledge which forms the ceiling of the remote maintenance and scrap cell (RMSC). This ledge contains four dissolver basket storage positions: the hull monitor, the dissolver basket dumper, and a transfer hatch into the RMSC. There is a penetration below the dissolver basket dumpers into the RMSC. The hull monitor entrance consists of a circular hole in the ledge that accommodates a filled dissolver basket. A recess beneath the concrete support structure of the ledge, accessible from the GVOS, housed the detection device of the hulls monitor.

The west wall of the RPC above the ledge is a wheel-mounted shield door which opens and closes with a horizontal motion. This door separates the RPC from the crane equipment maintenance gallery (CEMG). The east end of the RPC houses the high activity waste (HAW) concentrator. This portion of the RPC is segregated from the remainder of the cell by a partial wall.

Three windows from the GVOS, one from the FRSS and one in the RPC ceiling from the cold chemical station provide visual inspection capacity in the RPC. The RPC is served by three cranes and a power manipulator that run on two pairs of rails. These rails extend the entire length of the cell above the equipment. A 35-ton capacity maintenance bridge crane and the power manipulator with a 3-ton crane share the upper rails. Two periscopes penetrate the RPC wall for added viewing, one between the two shielding windows near the dissolver basket dumper and the second above the shielding window in the east end of the cell (from the FRSS). A pass-through port for small equipment is located in the ceiling of the RPC leading from the cold chemical station.

The cell floors and lower walls are lined with stainless steel. The walls are finished with an acid and radiation-resistant paint. The ceiling is covered with stainless steel plates.

3.2.3 The Crane and Equipment Maintenance Gallery (CEMG)

The Crane and Equipment Maintenance Gallery (CMEG) is located in the south side of the process building, immediately adjacent to the RPC (see Section 3.2.2). The RPC and CEMG are separated by a horizontal moving shielded door. Roughly half of the floor and ceiling areas of the CEMG are made up of removable shield plugs which provide access to the RMSC (see Section 3.2.1). Crane tracks at two elevations in the CEMG match those in the RPC. A viewing window located in the south wall of the CEMG permits viewing from the GVOS (see Section 3.2.4). An air lock and a shielded door permit access from the GVOS to the CEMG.

The floor is covered with stainless steel and the walls and ceiling are covered with radiation-resistant paint.

3.2.4 The Grade Viewing and Operation Station (GVOS)

The Grade Viewing and Operation Station (GVOS) is located on the south side of the process building on the second level. It bounds the RPC and CEMG. The GVOS provides a viewing and operating station for the RPC and CEMG. The three shielding windows for the RPC and one shielding window for the CEMG and the associated pairs of manipulators are located in the GVOS. The principal functions to be performed from the GVOS were the operation of the shear and subsequent transport of leached hulls to the hulls dumper.

The following equipment is located in the GVOS:

- Shear hydraulic units
- Fuel conveyor drive units
- Shear control units
- Fuel conveyor control units
- RPC cranes and power manipulator controls
- Power supply for ultrasonic cleaner in CEMG
- RPC/CEMG shield door control panel
- Sand measuring system

Access to the GVOS is provided from the south stairwell, the southeast stairwell, and the Cask Loading Area (CLA). A freight elevator stop is provided next to the south stairwell. The shielded access door to the CEMG is located in the GVOS.

3.2.5 The Cask Loading Area (CLA)

The Cask Loading Area is located on the west end of the process building. Except for a fenced storage area and a 480V switch-gear box, this area is clear of equipment. Access to the CLA is from the GVOS through a personnel door and a roll-up equipment door and from the LPIG. Truck access is provided through the roll-up door (16 ft. x 22 foot galvanized vertical steel door) in the south wall of the CLA. A hatch in the CLA floor is provided for movement of the filter cask from the LVOS to the CLA.

3.2.6 The Analytical Viewing and Operating Station (AVOS)

The Analytical Viewing and Operating Station (AVOS) is located on the upper level of the process building along the north side. It bounds the SAC compartments. The AVOS provides a viewing and operating station for the Sample and Analytical Cells (SAC) compartments and sampling glove-boxes. The SAC viewing windows and associated manipulators and the controls for the samplers and analytical instruments in the SAC compartments and sampling glove-boxes are located in the AVOS. Access to the AVOS is provided from the east stairwell and from the equipment maintenance station. Access to the manipulator repair station is from the AVOS. The AVOS contains a number of ventilation filters as follows:

Equipment Number	Equipment Function
75-K-736	UPC sample glove-box inlet filter
75-K-737	UPC sample glove-box exhaust filter
75-K-739	SAC niches exhaust filter
75-K-744	PPC sample glove-box inlet filter
75-K-745	PPC sample glove-box exhaust filter

All of these filters contain a single stage of HEPA filtration. These filters are flanged in-line units except for the SAC niche filter which is a caisson type filter.

3.2.7 Office Space

The office space, El. 304'9", is located adjacent to the control room. This area provided general office and meeting space for the operations personnel.

3.2.8 The Hot and Cold Laboratory Area (HCLA)

The Hot and Cold Laboratory Area (HCLA) is contained in a separate structure contiguous to the process building. Access to the HCLA on the first floor is from the change facilities and a door on the east end of the building. Access on the second floor is from the stairwell adjacent to the process building and from the stairwell on the east end. The HCLA laboratories were intended to provide analytical services for all samples except the high gamma activity samples.

3.2.9 The Lower Viewing and Operating Station (LVOS)

The Lower Viewing and Operating Station (LVOS) is located on the south side and west end of the process building on the lowest level. It bounds the RMSC on the south side and west end and the lower portion of the RPC on the south. The LVOS provides a viewing and operating station for the RMSC and the ventilation filters located in the niches below the floor. Four RMSC viewing windows and associated parts of manipulators are located in the LVOS.

Pre-filters, absorbers, and final filters are located in niches beneath the LVOS floor. The RPC ventilation filters (75-K-705A through V) and the RMSC ventilation filters (75-K-715A through R) are also located in the filter niches below the LVOS floor. These filters are arranged in pairs of one pre-filter and one HEPA filter in series. Ten such pairs are associated with the RPC and eight with the RMSC. Two manifolds carry the exhaust air from each cell to half of the respective filter pairs. These filter pairs receive exhaust air from the respective cells. They exhaust air to the ventilation filter station.

Access to the LVOS is provided from the south stairwell, the southeast stairwell, and the west end of the FPIG. A freight elevator stop is provided next to the south stairwell. Access to the Service Concentrator Gallery is possible from the LVOS. A ceiling hatch leads from the LVOS to the cask loading station above. A crane on a fixed monorail is provided above the filter niches located in the west end of the LVOS.

3.3 The Waste Tank Equipment Gallery (WTEG)

The Waste Tank Equipment Gallery (WTEG) is a building approximately 100 feet square, connected to the Process Building by an underground tunnel (see Figures 4-3 and 4-4 at the end of Chapter 4). The WTEG houses the utilities and service systems required for the operation of the liquid waste storage complex, i.e.:

- The instrumentation to operate and monitor the waste tank complex
- The services required by the waste storage complex such as the tank heat cooling systems, the sampling system, the air-lift circulator controls, and the ballast tank air supply system.
- The off-gas treatment system of the liquid waste storage complex such as the HLW condenser, the knowckout pots, the super-heaters and filter modules.

The WTEG contains the main following equipment (the equipment that has been sold is, of course, not included in this list):

Equipment Number	Equipment Function
75B 0729	HVAC unit
40C 0484	HLLW off-gas iodine absorber
40D 0415	Fuel oil tank
40D 0427	HLLW off-gas pot
40D 0428	Cooling water break tank
40D 0429A	HLLW air receiver
40D 0429B	HLLW air receiver
40D 0435	De-mineralized water break tank
40D 0469, 0470, 0473	Head pots
40E 0423	HLLW off-gas condenser
40E 0433A,B,C,D,E,F	8 HLLW CIPC coolant exchangers
40E 0434A,B	
40E 0435	HLLW off-gas superheater
75E 0799	WTEG control room air heater
40G 0405A,B,C,D	HLLW arc coolant pumps
40G 0409, 0410	Emergency fuel oil pump/pump for emergency steam generator
40G 0430	Emergency steam generator blower
80H 8304	Ejector
40K 0406	HLLW off-gas filter
75K 0718A,B	WTEG filters
98Q 9113	Fire detection system
40T 0443A,B	Lift hoist frames
40Z 0403	Shot feeder rack

3.4 Other BNFP Facilities

AGNS also built a facility for the conversion of uranium nitrate to UF_6 and proceeded with plans to design and build adjacent facilities for solidifying radioactive liquid wastes and for converting the plutonium nitrate to a solid product. However, because changes in the U.S. nuclear policy (as indicated in Appendix A) have resulted in the indefinite deferment of commercial fuel reprocessing, construction of these buildings has not been initiated, the Generic Environmental Statement on Mixed Oxide (GESMO) and the BNFP activities for obtaining an operating license from the NRC were terminated.

Nevertheless, it should be noted that although the BNFP plant has never operated, a series of tests, with and without natural uranium, were run both in 1976 and in 1978 to provide data in support of DOE contract studies in the areas of safeguards (nuclear materials control and accountability) and alternative fuel cycles. The integrated uranium campaign started on August 11, 1978 and ended on September 30, 1978 and consisted of uranium transfer from the UF_6 Conversion Facility to the Separations Plant, startup and operation of the Separations Plant at flow-sheet values, and maximum rate equilibrium operation at flow-sheet value and at maximum rate, simulated dissolver operations, plutonium column efficiency tests, concentrator tests, transfer test to the UF_6 plant, shutdown and inventory.

4.0 MOX Fuel Fabrication Equipment

This chapter describes the overall design concept for the CANDU MOX fuel fabrication facility at BNFP. The description includes the scope of required equipment items and the layout of the equipment in the modified BNFP facility. The chapter also includes an estimate of associated costs for the system design, equipment procurement, installation and facility start-up and operation.

4.1 Summary of Concept For CANDU MOX Fuel Facility

A concept is developed by the study team for the manufacture of CANDU MOX fuel at the BNFP facility. This concept is based on the process steps for fabricating CANDU MOX fuel bundles. The process steps were developed in the CANDU plutonium consumption study conducted by AECLT in 1994 and is shown in Figure 4-1. The process steps describe the nature and sequence of activities and material requirements. Based on these process steps, an overall configuration of the process equipment at the BNFP site is developed. Figure 4-2 shows the layout of equipment groups at BNFP. The scope of equipment items within each equipment group is described in detail in the following sections.

None of the process equipment currently in place at the Barnwell facility can be used in the manufacture of CANDU MOX fuel. New equipment will need to be procured and installed. Both the existing Process building and the WTEG building will be used for MOX fuel fabrication. An existing hardened tunnel between the two buildings will be used for material transfer. In order to obtain enough space for all of the process equipment needed for the production of CANDU MOX fuel, a hardened building will be constructed to join the Process and WTEG buildings (see Figure 4-3). This new structure also contains controlled main gate for personnel access to the MOX facility and docking/staging area for SST or other vehicles for material receiving and shipment.

Figure 4-4 shows a manufacturing flow chart for CANDU MOX fuel at BNFP. On the flow chart, the equipment that will be located in the WTEG is identified. All equipment not identified as being located in the WTEG will be located in the Process Building or the new structure which connects the two existing buildings. The Figure is also indexed (e.g., A,B, C1.2, etc. in boxed notes) so the identified equipment groups can be traced to more detailed drawings shown and discussed in later sections.

Preparation of powder process batches, pellet finishing and assembly of the Ring 3 elements containing 2% PuO_2 will be carried out in the Lower Viewing and Operating Station (Elevation 257'6") of the Process Building. These same operations for the Ring 4 elements containing 1.2% PuO_2 will be located in the Grade Viewing and Operating Station and Cask Loading Station areas (Elevation 278') of the Process Building. Pellet pressing and sintering for both lines will be carried out in the WTEG building. Completed elements will be assembled into completed bundles and stored in the Analytical Viewing and Operating Station (Elevation 314'6") of the Process Building.

PuO_2 powders will be received and stored in the Remote Maintenance and Scrap Cell (RMSC) of the Process Building. Access to the cell will be via the Scrap Removal Hatch at the 278' Elevation level. A master blend powder processing station will be installed at the 278' Elevation level in the Crane and Equipment Maintenance Gallery (CEMG) of the Process Building. This station will blend and condition batches of PuO_2/DUO_2 for supply to the two fuel element production lines. A powder recycling facility will be installed in the Remote Process Cell (RPC).

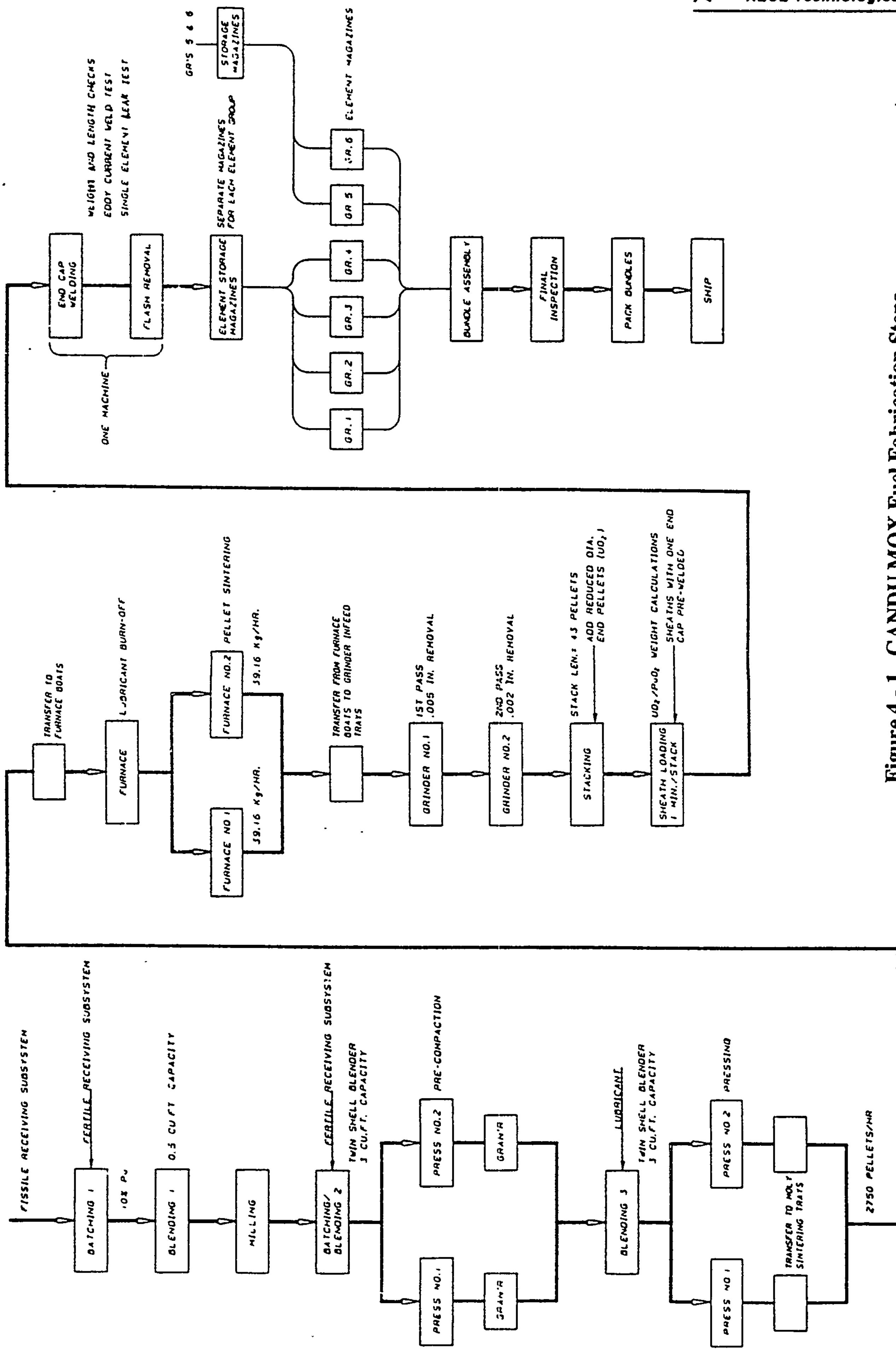
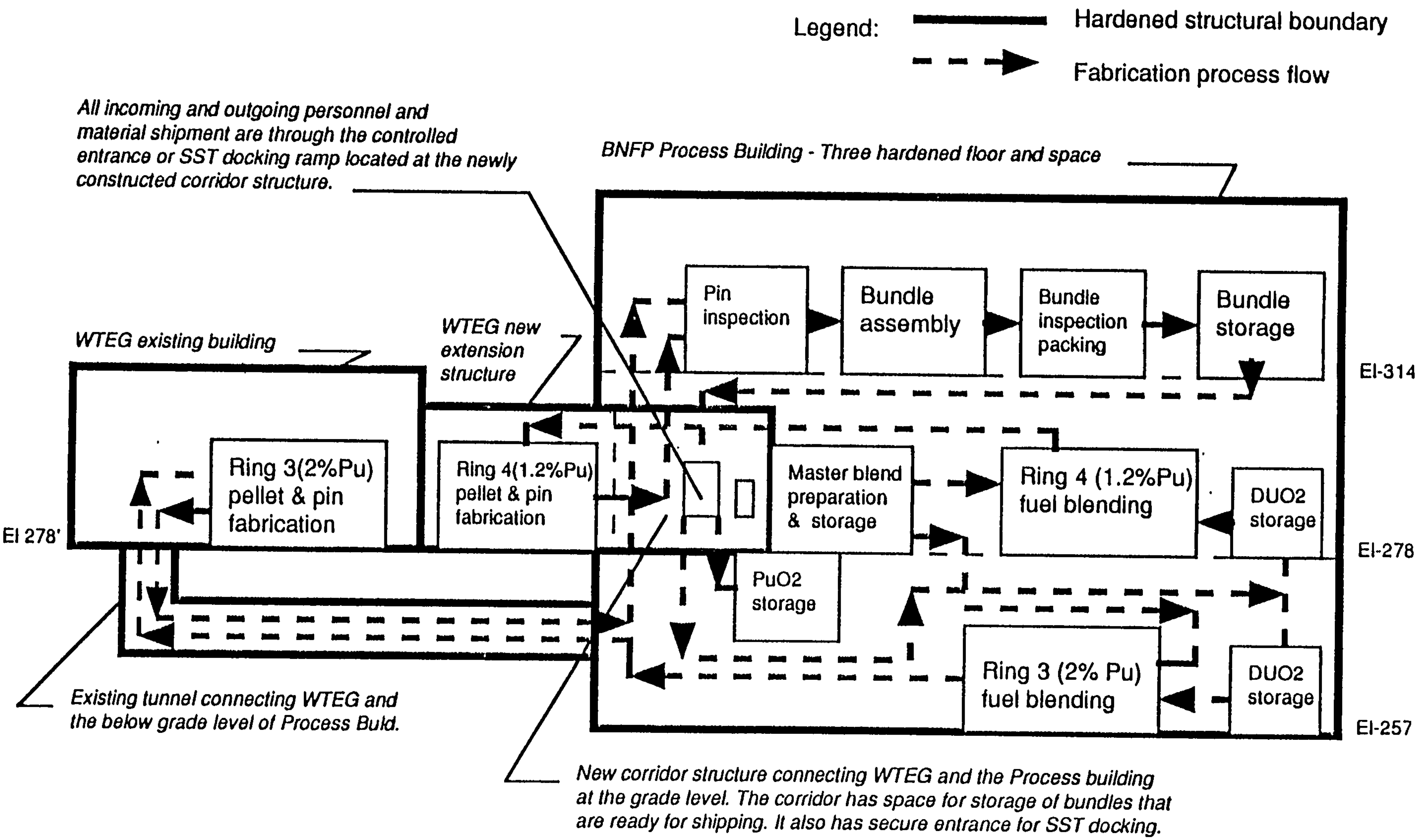


Figure 4 - 1 CANDU MOX Fuel Fabrication Steps

Figure 4 - 2 Schematic of BNFP Facility Layout for CANDU MOX Fuel Fabrication



Note: Sketch not to scale.

Material transfer between the Ring 4 (1.2% Pu) process areas of the Process Building and the WTEG will be at grade level through the hardened structure that will be constructed to join the two buildings. Material transfer between the Ring 3 (2% Pu) process areas of the Process Building and the WTEG will be through an existing hardened tunnel that joins the two buildings. Material transfer between floors in the Process Building will be via the existing elevator in the south-west corner of the building and a new elevator to be constructed in the north-west corner of the building.

The Ring 3 and Ring 4 pin lies will be located on separate floors of the Process Building and in separate parts of the WTEG Building. This physical separation will provide a high degree of assurance that no unintended mixing of materials of different Pu enrichments will occur. Material containers used in the two lines will be physically different for the same reason.

All shipping of finished fuel bundles and receipt of all materials and supplies will be by way of a truck dock that will be part of the new hardened structure to be constructed to join the Process Building and the WTEG (see Figure 4-3).

A more detailed discussion of the equipment arrangement and process flow routing is described in the following sections.

4.2 General Design Considerations

Assured supply of 157 net tonnes of CANDU MOX fuel per year will demand high reliability and maintainability of the process equipment. The process equipment will utilize advanced design features but will be based on proven designs from other oxide pellet fuel production lines such as Zircatec's UO_2 line. It will be essential to minimize unplanned outages for equipment repairs due to breakdowns, as these can impact deliveries, unit costs and personnel radiation exposure. For example, rebuilding a MOX sintering furnace due to hearth plate slumping (internal deformation) required 20 days during FFTF MOX production. For the large CANDU MOX furnaces, a longer period might be needed. Accordingly, the furnaces will be over-designed and operated conservatively to prolong life and cut down on long maintenance outages. In addition, the capacity of each of the two furnaces in each fuel element line will exceed 50% of the required total. This will reduce the impact of having one furnace unavailable due to a maintenance outage. In other areas, redundant equipment and installed spares may be appropriate.

Equipment that has not yet been proven in UO_2 or MOX service will need to be tested before being put into service. The first test will be at the factory using surrogate materials as feed. The equipment will be tested again at the plant site using first surrogates and then depleted UO_2 as required to demonstrate acceptable working behavior. Vital material handling devices for powder transfers, weighing, blending, homogenization, milling, ceramic pellet fabrication and inspection will be accepted for in-line use only after operating and maintenance personnel, together with vendors, have tested and agreed on adequate demonstration of performance.

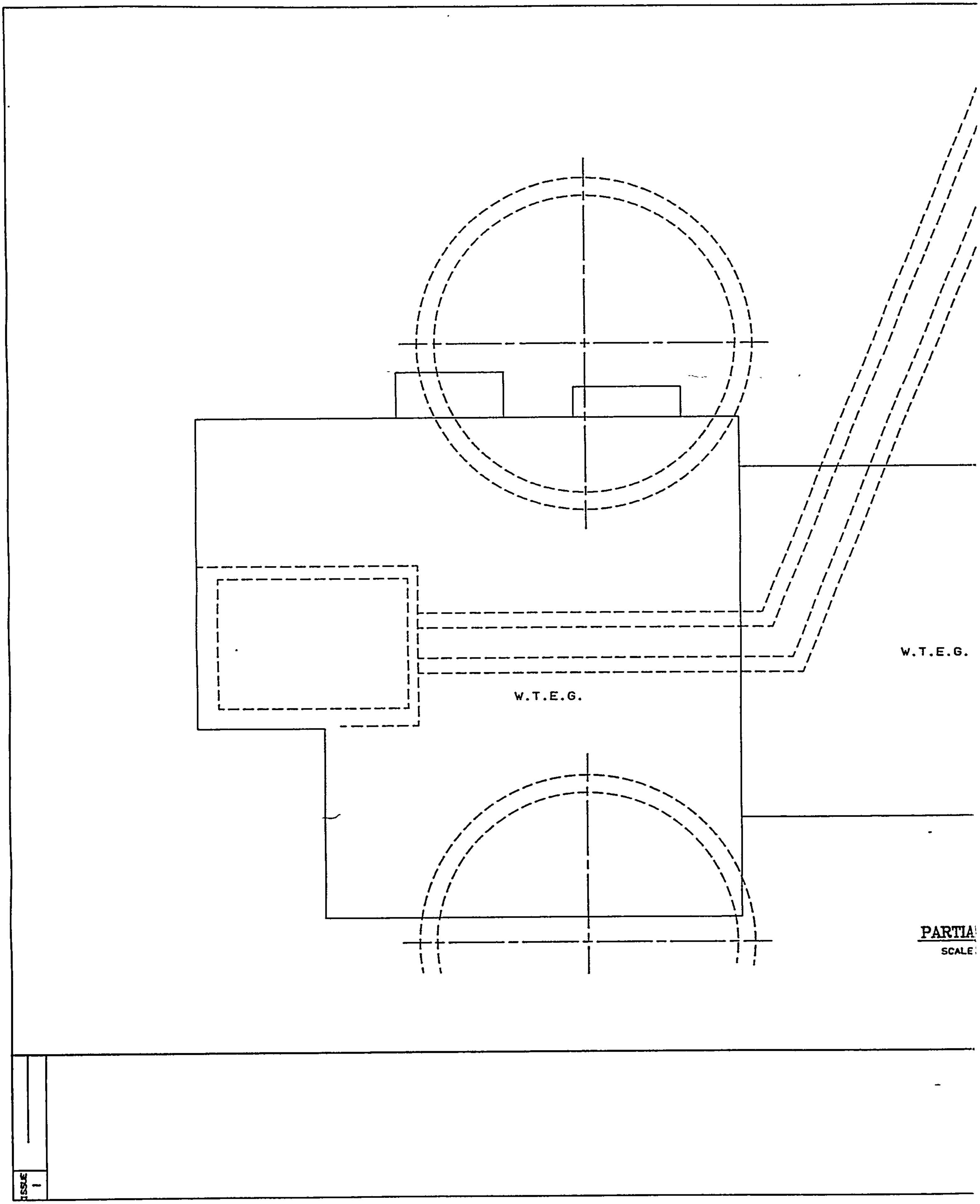
Auxiliary equipment will be tested and formally accepted in the same way. Examples are:

Off gas treatment for removal of MOX fines downstream from milling. Removal, as used here, includes recovery and re-introduction of dust load to HEPA's and pre-filters.

Closed circuit cooling loops, vacuum systems, gas supply systems, electrical and control systems, emergency power and safety related systems.

Remote viewing and monitors for automated systems.

Close coupled quality control and process control measuring systems, especially for Pu and



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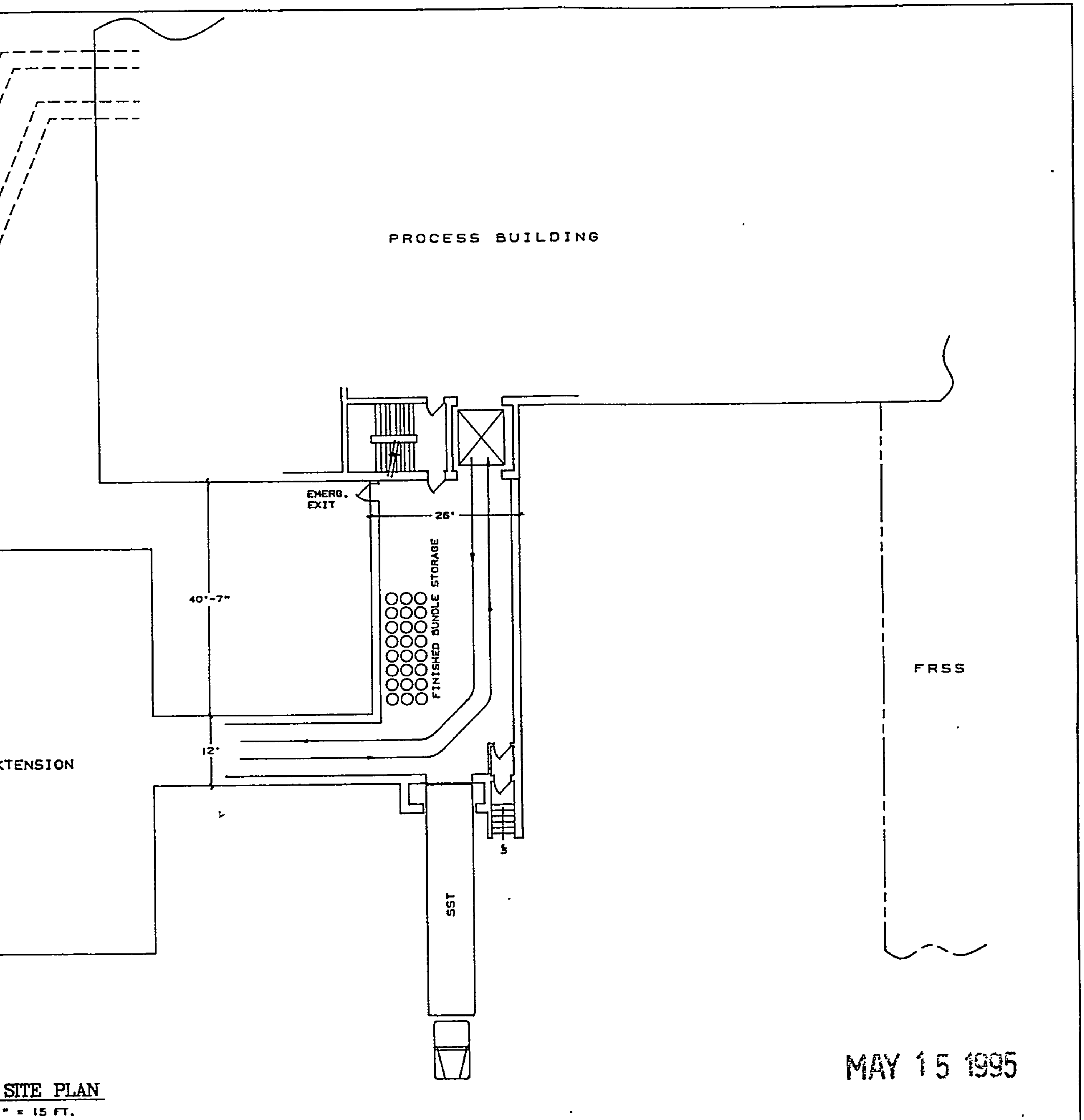

Figure 4 - 3 MOX Fuel Fabrication Plant

FD-8870

ZIRCATEC PRECISION INDUSTRIES INC.

TITLE MOX FUEL FABRICATION PLANT

BARNWELL, SOUTH CAROLINA

PARTIAL SITE PLAN

REVISIONS: 2 — ENLARGED V.T.E.S. EXTENSION. ADDED UNDERGROUND TUNNEL. REVISED SHIPPING DOCK AND RECEIVING AREA. BRB 2 MAY'95

SCALE 1" = 15 FT. ISSUE 2

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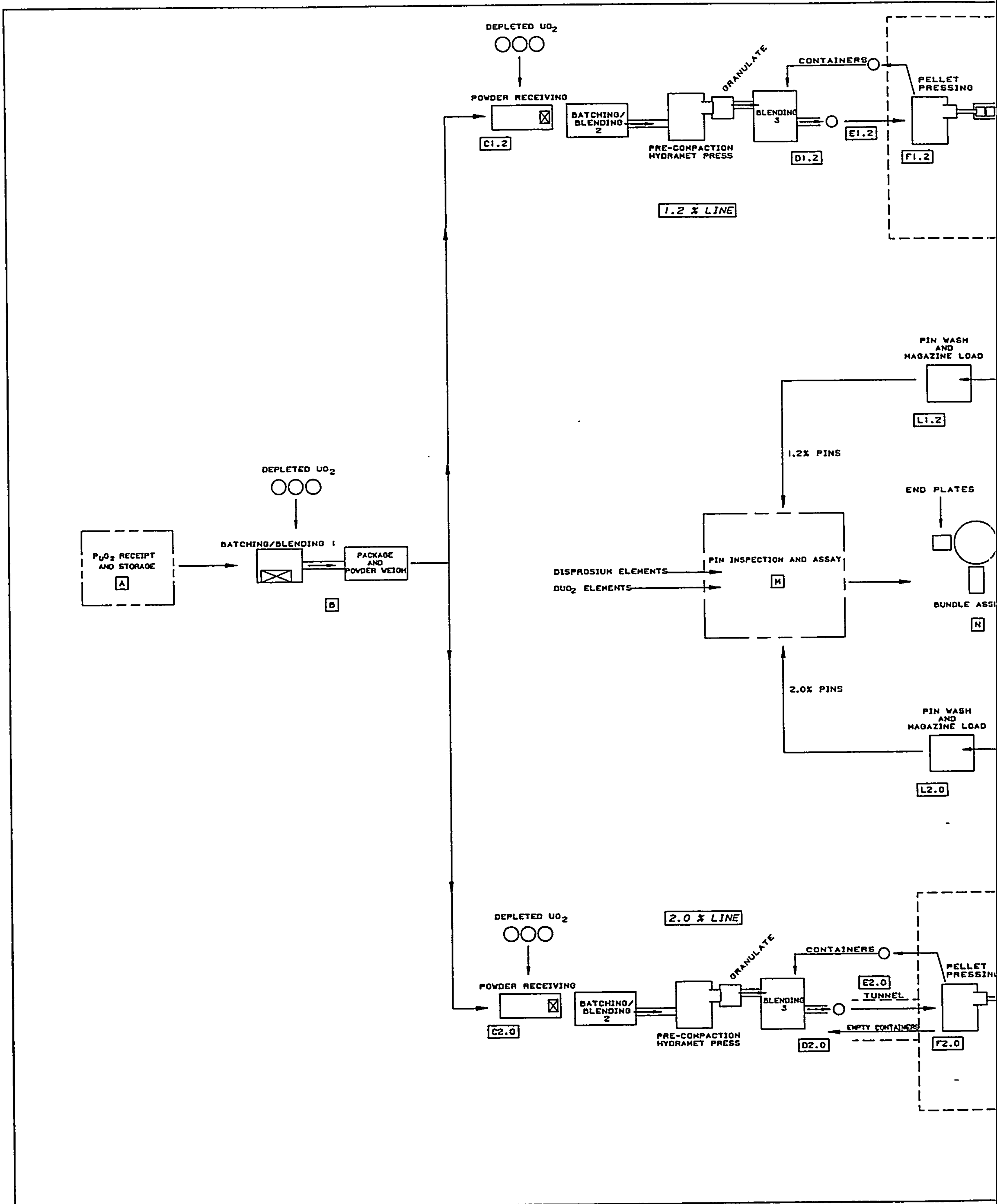
DEPLETED UO_2
POWDER RECEIVING
C1.2
BATCHING/ BLENDING 2
PRE-COMPACTION HYDRAMET PRESS
GRANULATE
CONTAINERS
BLENDING 3
D1.2
E1.2
PELLET PRESSING
F1.2
1.2 % LINE
PIN WASH AND MAGAZINE LOAD
L1.2
1.2% PINS
END PLATES
P_uO_2 RECEIPT AND STORAGE
A
DEPLETED UO_2
BATCHING/BLENDING 1
PACKAGE AND POWDER WEIGH
B
DISPROSIUM ELEMENTS
DUO_2 ELEMENTS
PIN INSPECTION AND ASSAY
M
BUNDLE ASS
N
2.0% PINS
PIN WASH AND MAGAZINE LOAD
L2.0
DEPLETED UO_2
2.0 % LINE
POWDER RECEIVING
C2.0
BATCHING/ BLENDING 2
PRE-COMPACTION HYDRAMET PRESS
GRANULATE
CONTAINERS
BLENDING 3
D2.0
E2.0
TUNNEL
EMPTY CONTAINERS
PELLET PRESSIN
F2.0

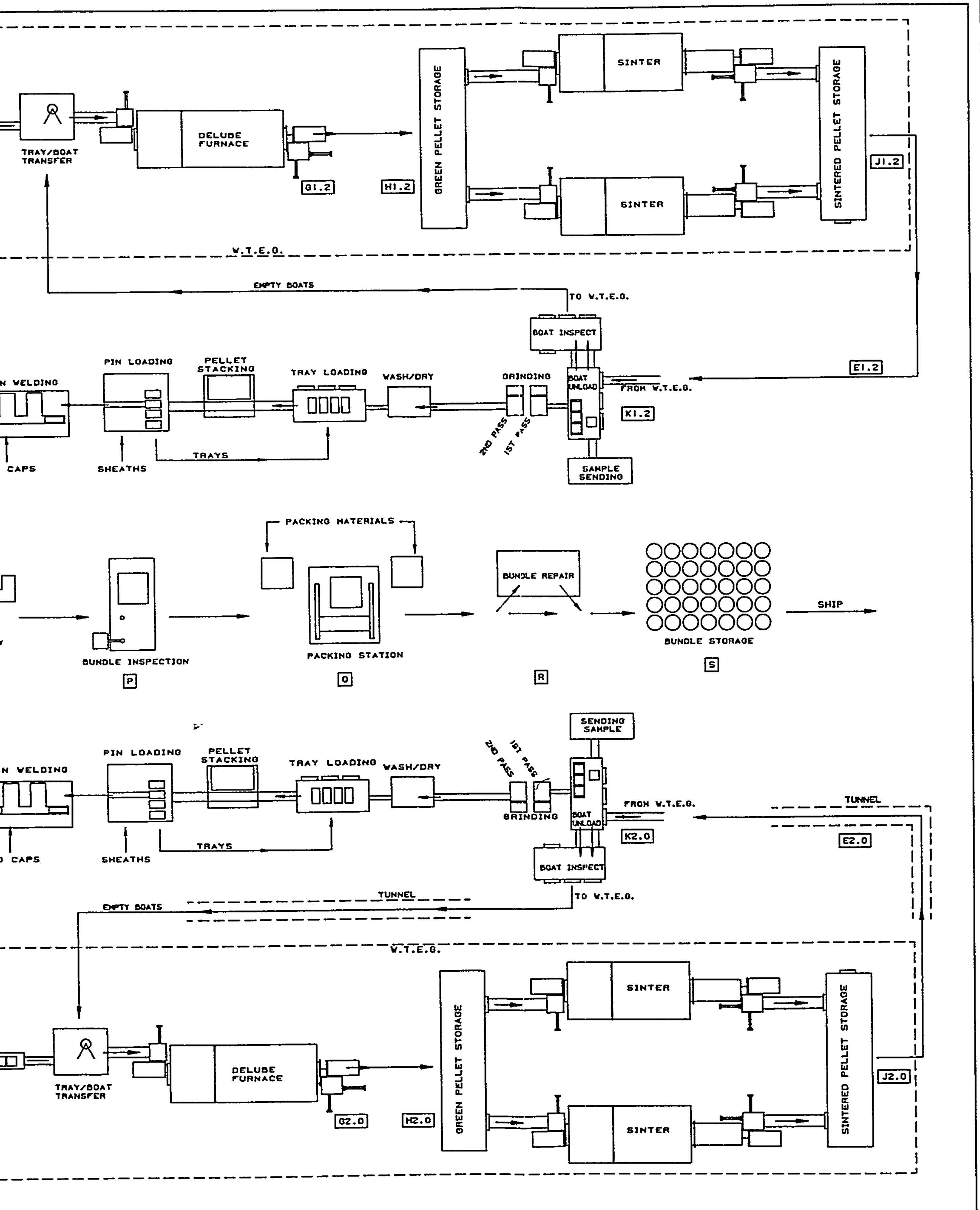

Figure 4 - 4 Manufacturing Flow Chart

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U assay, critical impurities and material control and accountability measurements.

Operator training and qualification will include methods for improving equipment performance and lifetime, spotting early warning signals for preventive maintenance scheduling, and cross-communication to aid manufacturing engineers with information from direct observation of equipment behavior.

The Ring 3 and Ring 4 fuel element lines will both use the same proven process equipment and containment designs in order to help standardize operating and maintenance procedures. Routine maintenance operations will be included in the hands-on training program. Enough mock-up maintenance operations will be done prior to hot startup to debug access and tooling setups and to permit a rough estimate of maintenance worker radiation exposure.

The system design also incorporated proper shielding of work stations and process equipment to minimize radiation dose to operators. Shielding around the finished fuel bundle will be designed to ensure that the contact dose rate will be in the range of 15-25 mRem/hour to the operators. At a distance of one foot without shielding, the radiation dose rate would be in the range of 3-5 mRem/hour gamma plus neutron. With the shielding design as described in AECLT's 1994 Plutonium consumption study, the dose rate would be a few tenths of a mRem/hour.

These design and pre-operational training measures will be rigorously pursued in order to achieve ALARA goals less than 500 mRem/year average radiation dose for operators and the extremity dose limits.

4.3 CANDU MOX Fuel Manufacturing Equipment

The following sections describes the process steps for fabricating CANDU MOX fuel. The steps are organized based on material flow as well as equipment groups that perform the needed functions. The equipment groups are also identified in the overall process schematic diagram shown in Figure 4-4.

4.3.1 PuO_2 Receipt and Storage

As shown on Figure 4-5, the Remote Maintenance and Scrap Cell will be utilized for receipt and storage of all feed PuO_2 material. Access to the special nuclear material (SNM) storage vault will be via the scrap removal hatch on the 278' Elevation level. This will be a remote controlled storage and retrieval system monitored by vision systems. Material will be retrieved and delivered to the master blend facility, described in the following section, on an as needed basis.

4.3.2 Master Blend Station

As shown on Figure 4-6, the Crane and Equipment Maintenance Gallery will house a station to blend and condition batches of PuO_2/UO_2 prior to distribution to the start of the fuel element production lines. PuO_2 material will be received from the SNM storage vault and blended with depleted UO_2 to produce "master blend" batches containing plutonium at a nominal 10 wt% level. Master blend batches will be stored until required by the fuel element production lines.

Master blend batches will be milled to ensure micro-homogeneity prior to further blending with depleted UO_2 to create batches of the appropriate PuO_2 wt% content for each of the production lines. Removal of PuO_2 agglomerates from the MOX powder will improve consistency of pellet formation during pressing and the quality of the sintered pellets. This will reduce the amount of processing scrap that must be recycled during normal operation of the production facility. In addition, good performance of the MOX fuel in the reactor dictates there not be PuO_2 agglomerates that would create hot spots in the fuel matrix. Creation of a master blend is key to both good performance of the fuel production process and the performance of the fuel in the reactor.

The master blend facility will consist of six major stations: Fissile Receiving, Fertile Receiving, Batching, Blending, Milling and PuO_2 Powder Finishing. Each of these stations is designed to operate remotely with appropriate sensors monitoring process conditions. The equipment is designed for contact maintenance consistent with personnel exposure limits and safety requirements. A more detailed description of each of these stations is contained in the following sections.

4.3.2.1 Fissile Receiving

The fissile receiving station will receive PuO_2 , contained in double canisters, from the storage vault located in the Remote Maintenance and Scrap cell. The handling system in the fissile receiving glove-box will remove the lid from the double-door port, remove the inner canister containing the PuO_2 from the outer canister and locate it on the weigh station. The inner canister will have a permanent identification code which includes it's tare weight. Canister identification and gross and tare weights will be recorded for material balance and material control purposes. The canister will be stored or transferred to the batching operation as required.

The design of this station will be very similar to the one contemplated in the study of a CANDU MOX fuel production line at the FMEF at Hanford. It will be designed with more than enough capacity for the daily requirements in order to keep its duty cycle light and allow for maintenance downtime.

4.3.2.2 Fertile Receiving

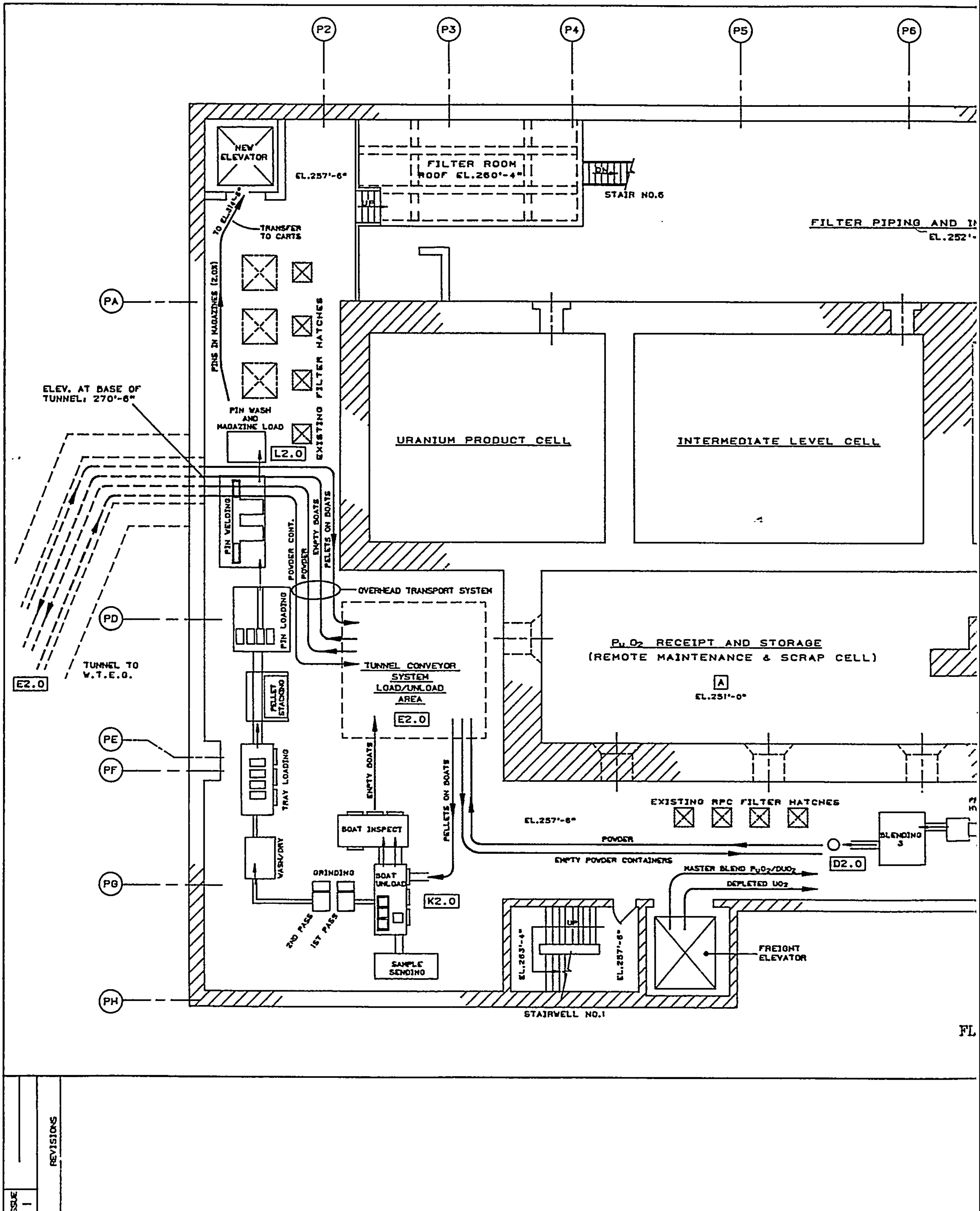
This station will receive depleted UO_2 powder from the storage area, weigh it and transfer it to the batching station. The container of depleted UO_2 will be manually loaded into an elevator which will raise it to an enclosure above the batching station. The container will be manually weighed and identified before being placed inside the enclosure airlock. A motor operated tilting mechanism is provided to empty the contents of the container into the batching hopper.

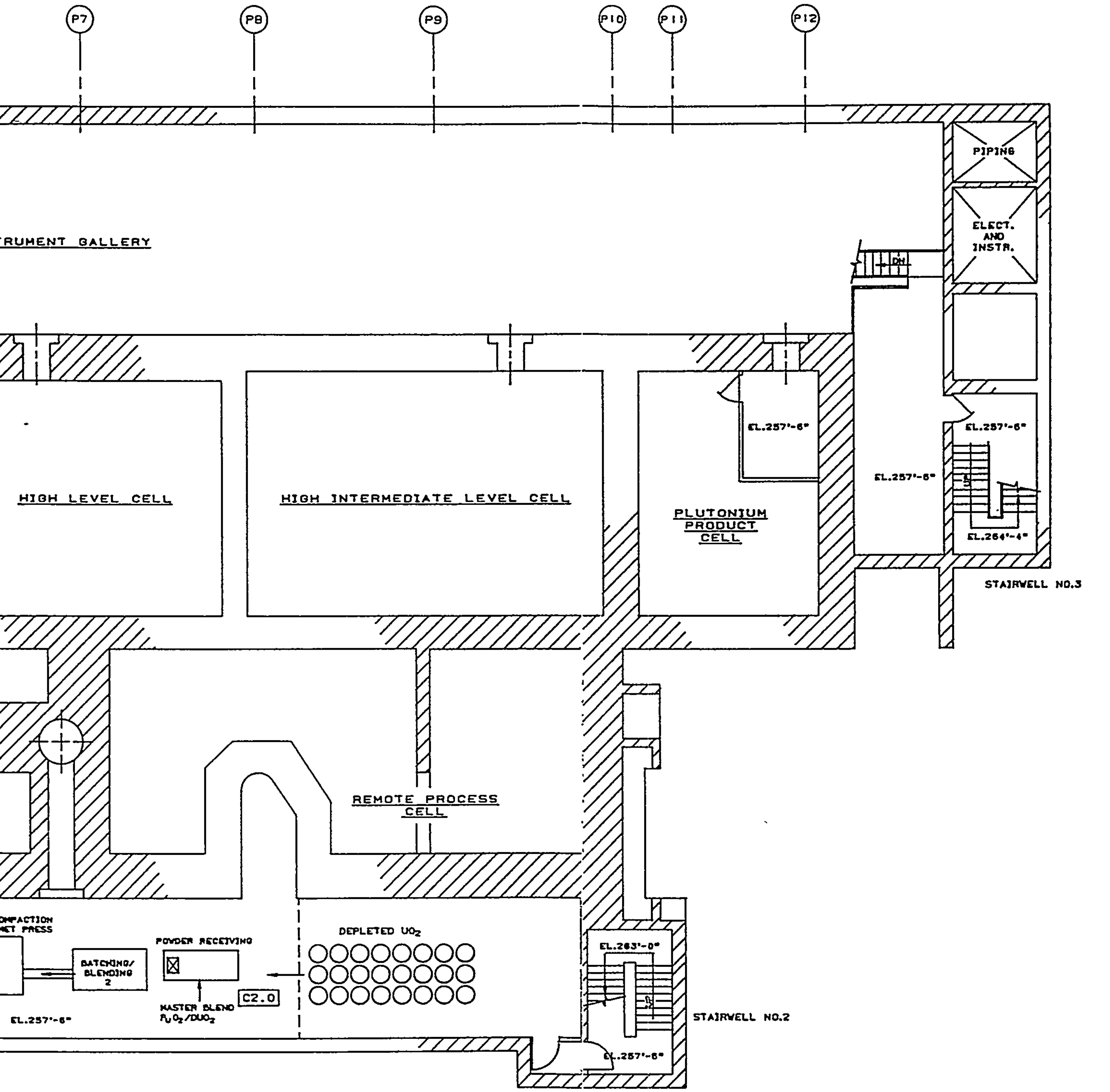
The design of this station will be very similar to the one contemplated in the study of a CANDU MOX fuel production line at the FMEF at Hanford. It will be designed with more than enough capacity for the daily requirements in order to keep it's duty cycle light and allow for maintenance downtime.

4.3.2.3 Batching

The batching station will receive PuO_2 and depleted UO_2, weigh the required quantity of each and transfer this material to the blending operation. The batches created will contain approximately 10% PuO_2 by weight.

The design of this station will be very similar to the one contemplated in the study of a CANDU MOX fuel production line at the FMEF at Hanford. It will be designed with more than enough capacity for the daily requirements in order to keep it's duty cycle light and allow for maintenance downtime.


P2
P3
P4
P5
P6
PA
PD
PE
PF
PG
PH
NEW ELEVATOR
EL.257'-6"
FILTER ROOM
ROOF EL.260'-4"
STAIR NO.6
FILTER PIPING AND I
TRANSFER TO CARTS
PINS IN MAGAZINES (2.0S)
EXISTING FILTER HATCHES
ELEV. AT BASE OF TUNNEL: 270'-6"
PIN WASH AND MAGAZINE LOAD
L2.0
URANIUM PRODUCT CELL
INTERMEDIATE LEVEL CELL
PIN WELDING
POWDER CONT.
POWDER
EMPTY BOATS
PELLETS ON BOATS
OVERHEAD TRANSPORT SYSTEM
PIN LOADING
TUNNEL CONVEYOR SYSTEM LOAD/UNLOAD AREA
E2.0
TUNNEL TO W.T.E.C.
PuO2 RECEIPT AND STORAGE
(REMOTE MAINTENANCE & SCRAP CELL)
A
EL.251'-0"
PELLET STACKING
TRAY LOADING
EMPTY BOATS
PELLETS ON BOATS
EXISTING RPC FILTER HATCHES
BOAT INSPECT
EL.257'-6"
POWDER
EMPTY POWDER CONTAINERS
BLENDING 3
D2.0
WASH/DRY
GRINDING
BOAT UNLOAD
MASTER BLEND PuO2/DUO2
DEPLETED UO2
K2.0
2ND PASS
1ST PASS
UP
EL.263'-4"
EL.257'-6"
FREIGHT ELEVATOR
SAMPLE SENDING
STAIRWELL NO.1
FL
REVISIONS
ISSUE
1



MAY 15 1995

2.0% LINE

R PLAN EL. 257'-6" AND 260'-4"

Figure 4 - 5 2% Fuel Pin Line (Ring 3) Equipment Layout

FD-8870

REVISIONS: ADDED NEW ELEVATOR TO AREA AT COLUMN PA/P2; UTILIZED TUNNEL FOR 2% LINE MATERIAL TRANSFER; REVISED MATERIAL FLOW PATTERN; BRB 2 MAY'95; N

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ZIRCATEC PRECISION INDUSTRIES INC.

TITLE MOX FUEL FABRICATION PLANT ZPI

BARNWELL, SOUTH CAROLINA

ELEVATIONS 257'-6" & 260'-4"

DIMENSIONS IN INCHES UNLESS OTHERWISE SPECIFIED | SCALE 1/8"=1 FT. | ISSUE 2

DRAWN BRBoord | DATE 7 APR'95 | APP. BY | DATE | SHT.3 OF 6

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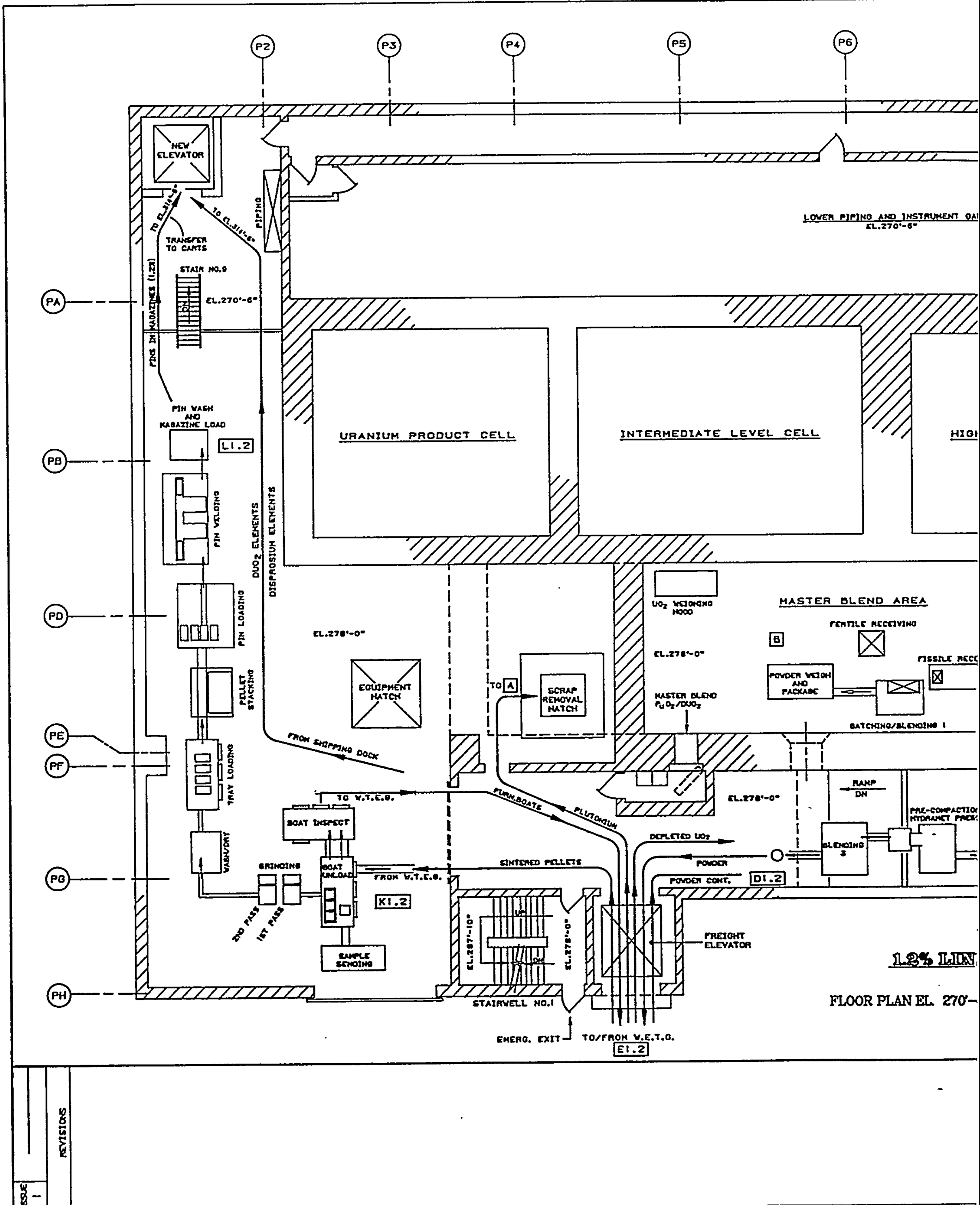
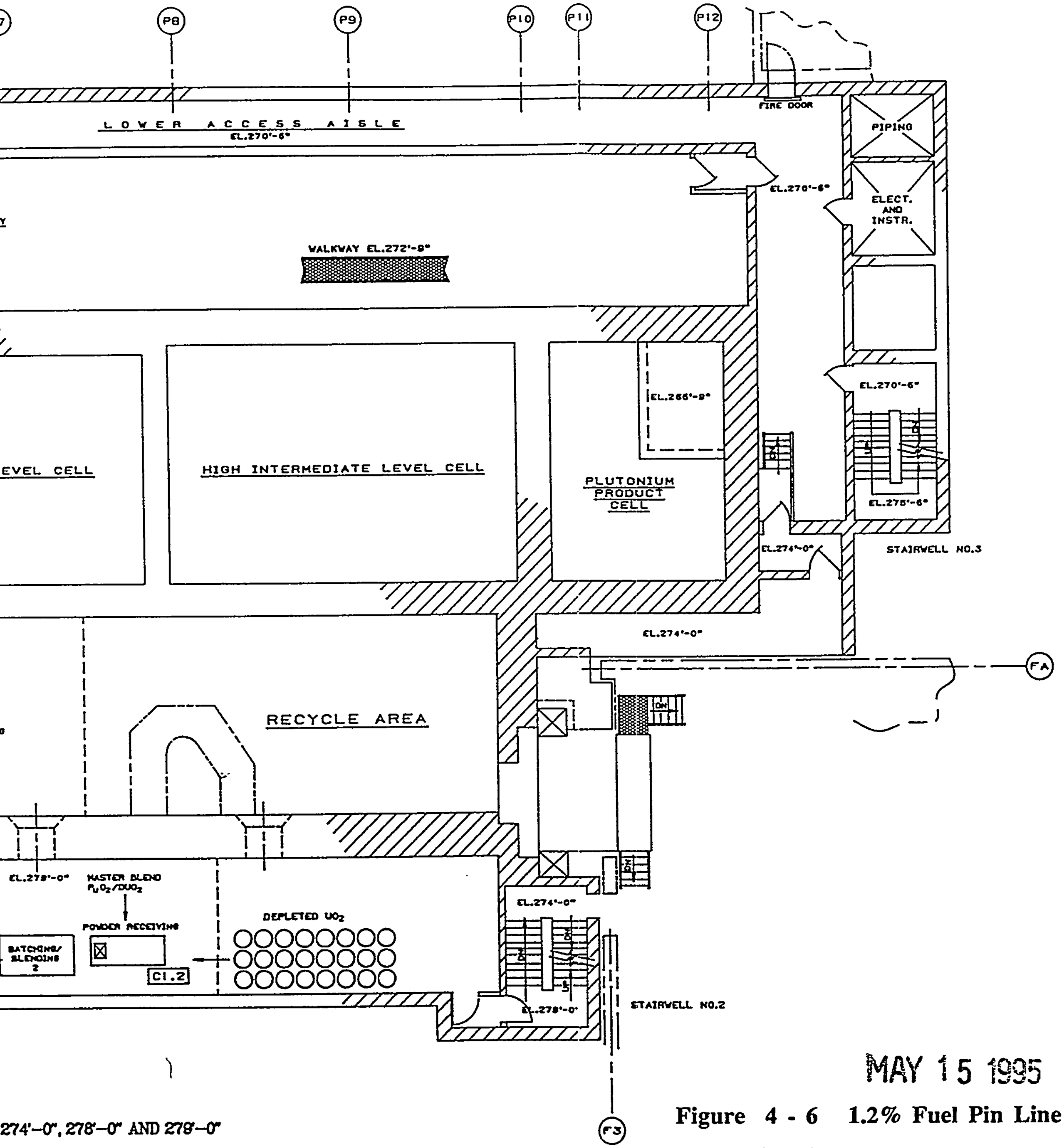

NEW ELEVATOR
TRANSFER TO CARTS
STAIR NO.9
EL.270'-6"
PINS IN MAGAZINES (1.23)
PIN WASH AND MAGAZINE LOAD
L1.2
PIN WELDING
PIN LOADING
PELLET STACKING
TRAY LOADING
WASH/DRY
GRINDING
2ND PASS
1ST PASS
BOAT INSPECT
BOAT UNLOAD
K1.2
SAMPLE SENDING
TO W.T.E.G.
FROM W.T.E.G.
FROM SHIPPING DOCK
DUO2 ELEMENTS
DISPROSIUM ELEMENTS
PIPING
LOWER PIPING AND INSTRUMENT GA
EL.270'-6"
URANIUM PRODUCT CELL
INTERMEDIATE LEVEL CELL
HIGH
EL.278'-0"
EQUIPMENT HATCH
TO A
SCRAP REMOVAL HATCH
UO2 WEIGHING HOOD
MASTER BLEND AREA
FERTILE RECEIVING
FISSILE REC
B
POWDER WEIGH AND PACKAGE
MASTER BLEND PuO2/DUO2
BATCHING/BLENDING 1
RAMP DN
PRE-COMPACTION HYDRANET PRES
BLENDING 3
FURN.BOATS
PLUTONIUM
SINTERED PELLETS
DEPLETED UO2
POWDER
POWDER CONT.
D1.2
EL.287'-10"
UP
DN
STAIRWELL NO.1
EMERG. EXIT
TO/FROM W.E.T.G.
E1.2
FREIGHT ELEVATOR
1.2% LIN
FLOOR PLAN EL. 270'-
ISSUE
1
REVISIONS



MAY 15 1995

Figure 4 - 6 1.2% Fuel Pin Line (Ring 4) Equipment Layout

FD-8870

REVISIONS

2 ADDED NEW ELEVATOR TO AREA AT COLUMN FA/F2 · REVISED MATERIAL FLOW PATTERN · BRB 2 MAY'95

ZIRCATEC PRECISION INDUSTRIES INC.

TITLE MOX FUEL FABRICATION PLANT

BARNWELL, SOUTH CAROLINA

EL.270'-6", 274'-0", 278'-0" & 279'-0"

ZPI

DIMENSIONS IN INCHES UNLESS OTHERWISE SPECIFIED | SCALE 1/8"=1 FT. | ISSUE 2

DRAWN BRBeard | DATE 7 APR'95 | APP. BY | DATE | SHT.2 OF 6

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95D018

4.3.2.4 Blending

The blending operation will receive pre-weighed quantities of UO_2 and PuO_2 from the batching operation and blend these powder components to achieve macro homogeneity. Blended powder will be transferred to the milling operation.

The design of this station will be very similar to the one contemplated in the study of a CANDU MOX fuel production line at the FMEF at Hanford. It will be designed with more than enough capacity for the daily requirements in order to keep it's duty cycle light and allow for maintenance downtime.

4.3.2.5 Milling

The milling operation will receive MOX powder from the blending operation and prepare a micro-homogeneous powder batch for transfer to storage or to one of the fuel element production lines as required. The milling operation will be designed to break up any agglomerates of PuO_2 that may be present in the blended batch of DUO_2/PuO_2 to ensure a micro-homogeneous mixture.

The design of this workstation will be based on a multistage "micronizer" hammer mill. It will be designed with more than enough capacity for the daily requirements in order to keep it's duty cycle light and allow for maintenance downtime.

4.3.2.6 PuO_2 Powder Finishing

A PuO_2 finishing station consisting of a calcining furnace and other equipment will be provided to facilitate minor adjustment of the issued PuO_2 powder if needed. Calcining will provide capability to address powder that is high in moisture or organics. Calcining followed by milling will enhance the sinterability of some oxides which are low in surface area, such as those produced from dry metal conversion routes.

4.3.2.7 Cost Estimate For Master Blend Line

The estimated cost of equipment procurement is $3,072,000. This includes the cost of a PuO_2 receiving, storage, and retrieval station and associated material handling equipment. The station will be equipped with computerized material tracking capability and software. The estimated cost for glove-boxes is $357,000. The estimated cost to install and hook up the equipment to existing services is $214,000. The total of these three cost items is $3,643,000.

4.3.3 Ring 3 (2% PuO_2) Pellet and Element Production Line

This line will receive batches of ceramic grade mixed oxide powder from the master blend facility and process it into sintered pellets containing 2% PuO_2 by weight. These pellets will then be encapsulated into fuel elements meeting all of the requirements of CANDU MOX fuel. Figures 4-5 and 4-7 show the layout of this production line and it's material flow. It will be located partially in the Lower Viewing and Operating Station on the 257'6" Elevation of the Process Building and partially in the WTEG Building.

The line will operate predominantly by remote control with all process equipment contained in glove-boxes. Material transfer within the production line will be either by automatic conveyance within enclosures joining adjacent glove-boxes or by transfer of material to a double-walled container for transfer by manual cart or automatic conveyor to the next workstation. Completed fuel elements will be transferred to the CANDU fuel bundle assembly line located in the Analytical

Viewing and Operating Station at the 314'6" Elevation in the Process Building.

This production line will consist of 14 stations which are described in the following sections. All stations will be designed to be operated remotely with monitoring by sensors built into the operating equipment. Vision systems will be provided to aid the operating personnel in the control room. The equipment will be designed for contact maintenance consistent with personnel exposure limits and safety requirements. In general, the equipment for each station will be designed with more than enough capacity for the daily requirements in order to keep it's duty cycle light and allow for maintenance downtime.

4.3.3.1 Batching

The batching station will receive master blend MOX powder and depleted UO_2 powder, weigh the required quantity of each and transfer this.material to the blending operation. The batches created will contain 2% PuO_2 by weight. Closed-circuit television cameras at the enclosure will allow the operating technician to observe the operation. This station will be the same type as the one used in the master blend operation but will be at higher capacity to process the required larger batch sizes.

4.3.3.2 Blending

The blending operation will receive pre-weighed batches of MOX powder from the batching operation and blend this material to achieve macro homogeneity. The blended powder will then be transferred to the pre-compaction and granulation operation. This station will be the same type as the one used in the master blend operation but will use higher capacity equipment to process the larger batch sizes required.

4.3.3.3 Pre-compaction and Granulation

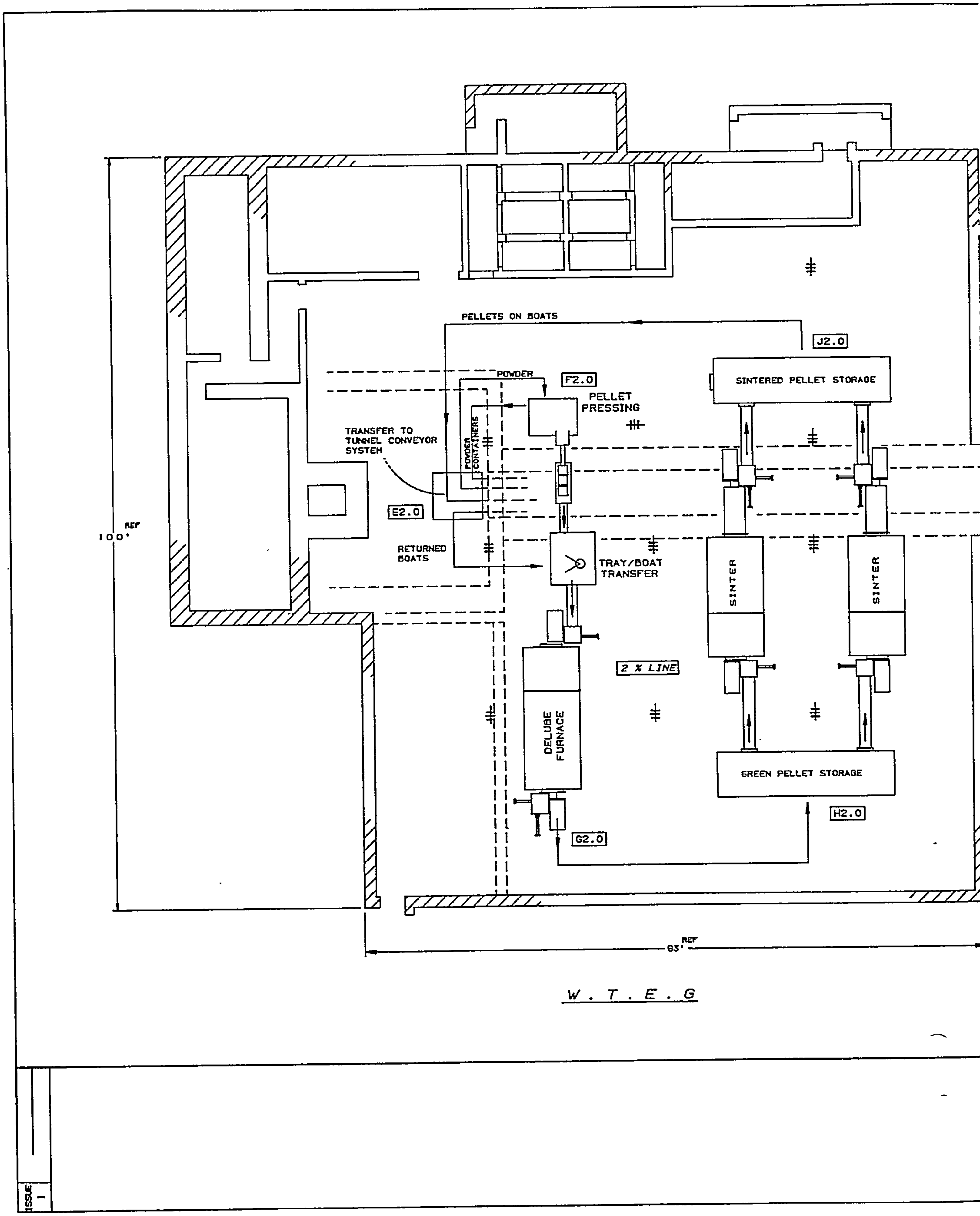
Free flowing MOX powder is essential to the successful pressing and sintering of the fuel pellets. To increase the flowability of the MOX powder, it has been found advantageous to add a process to compress the powder and then granulate the resultant compacts. Batches of MOX powder will be received from the blending operation and, after processing, will be transferred to the lubricant addition and blending operation. This operation will use the same type of pressing equipment used in the final pellet pressing operation (see Section 4.3.3.5) and the same type of granulation equipment used in existing natural UO_2 CANDU fuel production facilities.

4.3.3.4 Lubricant Addition and Blending

To reduce pellet press tooling wear rates, it is necessary to add a lubricant (such as zinc stearate) to the MOX powder. This station will add the required quantity of lubricant to granulated MOX powder and blend to achieve macro homogeneity. This station will use the same type of blending unit as the one used to blend the MOX powder batch earlier in this production line (see Section 4.3.3.2 above).

4.3.3.5 Pellet Pressing and Boat Loading

This station will receive granulated and blended MOX powder containing lubricant and press it into pellet form ready for sintering. Pressed pellets will be transferred onto formed molybdenum trays which will in turn be stacked onto molybdenum slabs to form the sintering boats. These boats will then be transferred to the lubricant removal station. The presses in this station will be of the hydraulic type designed for quick change of tooling cartridges and ease of contact maintenance. An existing and proven design of pellet handling equipment will be modified for this application to improve ease of maintenance in a glove-box environment.



PELLETS ON BOATS
J2.0
SINTERED PELLET STORAGE
POWDER
F2.0
PELLET PRESSING
TRANSFER TO TUNNEL CONVEYOR SYSTEM
POWDER CONTAINERS
E2.0
REF 100'
RETURNED BOATS
TRAY/BOAT TRANSFER
SINTER
SINTER
2 % LINE
DELUBE FURNACE
GREEN PELLET STORAGE
H2.0
G2.0
REF 83'
W . T . E . G
ISSUE 1

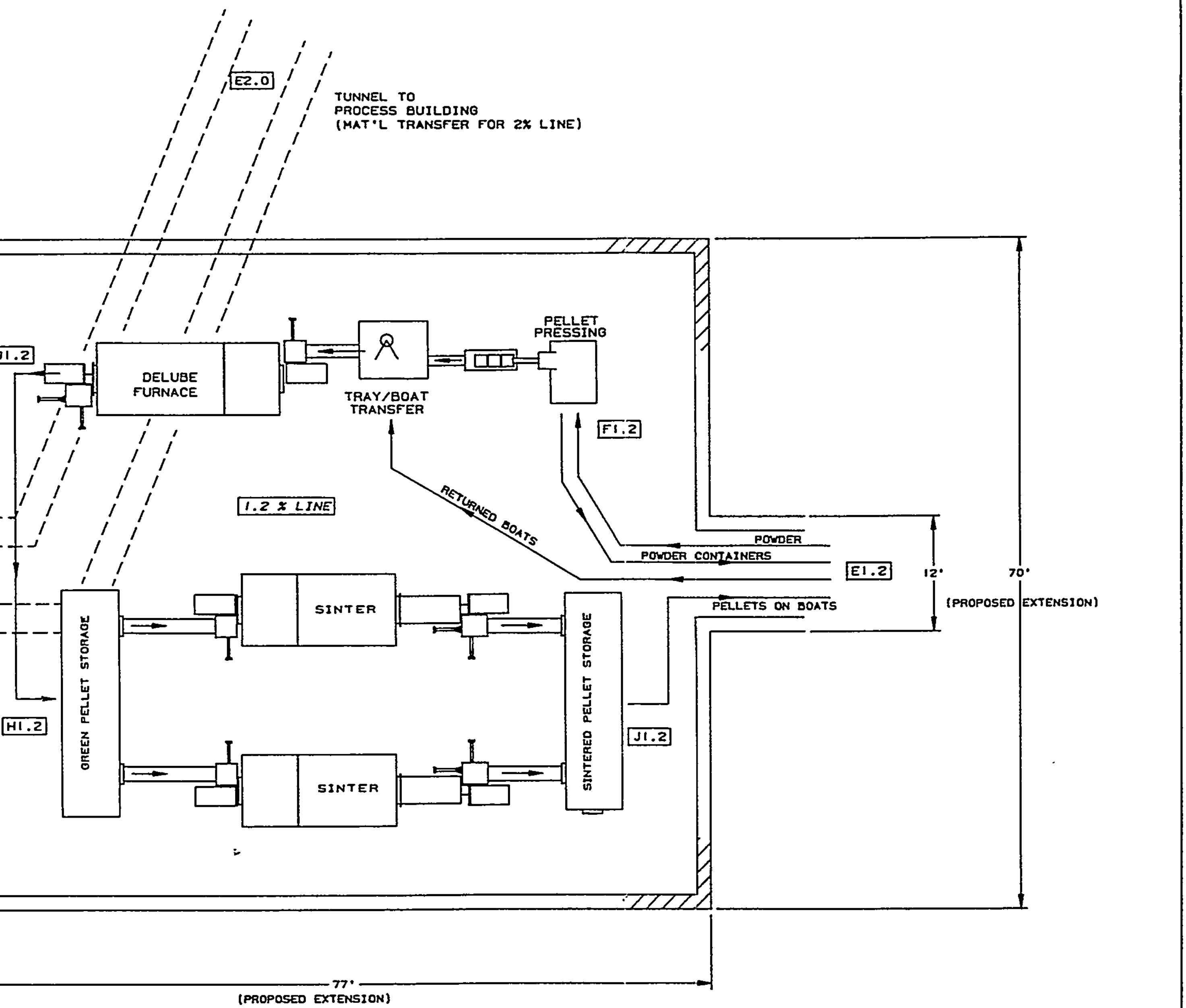


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Figure 4 - 7 Equipment Layout in WTG

FD-B870

REVISIONS	
2	ENLARGED BUILDING EXTENSION. SEPARATED LINES INTO TWO BUILDINGS. UTILIZED TUNNEL FOR 2% LINE MATERIAL TRANSFER
	BRB 2 MAY'95

ZIRCATEC PRECISION INDUSTRIES INC. ZPI

TITLE MOX FUEL FABRICATION PLANT
BARNWELL, SOUTH CAROLINA
WASTE TANK EQUIPMENT GALLERY BLDG.

DIMENSIONS IN INCHES UNLESS OTHERWISE SPECIFIED	SCALE 1/8"=1 FT.			ISSUE 2
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4.3.3.6 Lubricant Removal

The lubricant added to the MOX powder to improve pellet press tooling life will be removed from the pressed pellets prior to sintering. This will reduce contamination of the sintering furnaces by the condensed products off-gassed from the lubricant and therefore reduce the requirement for maintenance clean-up of the sintering furnaces. Boats of pellets will be received from the pressing operation and, after thermal treatment in the continuous furnace, will be transferred to the green pellet storage facility.

4.3.3.7 Pellet Sintering

Pressed pellets will be heated in a reducing atmosphere to achieve the high density required for the CANDU MOX fuel design. Boats of pellets that have been subjected to the lubricant removal process will be received from the green pellet storage facility and, after being sintered to the required density, will be transferred to the sintered pellet storage facility. The furnaces used in this operation will be the same type as used in existing natural UO_2 CANDU fuel production facilities with appropriate modifications for use in a glove-box environment.

4.3.3.8 Boat Unloading

Boats of sintered pellets will be transported from the sintered pellet storage facility in the WTEG to the boat unloading station located on the 257'6" elevation of the Process Building. At this station pellets will be transferred from the sintering boats and fed to the pellet grinding operation. Empty boats will be transferred to the boat inspection and cleaning station.

4.3.3.9 Boat Inspection and Cleaning

This is a manual work station where the molybdenum trays and slabs used to make up the sintering boats are inspected for damage and distortion and cleaned as necessary prior to being returned to the pellet pressing and boat loading operation.

4.3.3.10 Pellet Grinding

Sintered pellets must be ground on their cylindrical surface to bring surface finish and diameter to within specification tolerances. Sintered pellets will be received from boat unloading station and, after being centerless ground, will be transferred to the pellet washing and drying operation. The grinding equipment used in this operation will be the same type as used in existing natural UO_2 CANDU fuel production facilities with appropriate modifications for use in a glove-box environment.

4.3.3.11 Pellet Washing and Drying

Ground pellets will be washed to remove residual material from the grinding operation and then dried to remove moisture. Ground pellets will have their diameter measured to provide process feedback control. Washed and dried pellets will be transferred to the pellet stacking station.

4.3.3.12 Pellet Stacking

Pellets received from the pellet washing and drying operation must be assembled into a columnar stack for loading into the fuel sheath. Stack length adjustment will be made by adding pellets at each end of the stack of an appropriate length to bring the total stack length into specification requirements. These end pellets will be made from natural UO_2 and supplied by a qualified source external to the CANDU MOX fuel facility. An inventory of end pellets in a number of different lengths will be stored at this station until needed for stack length adjustment. Completed pellet stacks will be transferred to the pellet stack loading station.

4.3.3.13 Pellet Stack Loading

The pellet stack loading facility will receive prepared fuel stacks from the stacking station and empty fuel sheaths, with one end cap attached, supplied from a qualified external source. The pellet stacks will be loaded into the fuel sheath and then this assembly will be transferred to the end cap welding station. The fuel sheath will be weighed before and after stack loading to provide material accountability information.

4.3.3.14 End Cap Welding

The end cap welding facility will receive fuel sheaths containing the pellet stack and weld a cap to the open end of the fuel sheath to encapsulate the fuel element. This facility will also perform a minor machining operation to remove excess metal resulting from the resistance welding process. The completed weld will be tested for soundness using a non-destructive method and the element integrity will be verified using a helium leak testing technique. After verification that the fuel elements are free of surface contamination, they will be removed from the glove-box system. Completed fuel elements will be subjected to SNM assay and loaded into magazines for transfer to fuel bundle assembly. The end cap welding process equipment used in this operation will be the same type as used in existing natural UO_2 CANDU fuel production facilities with appropriate modifications for use in a glove-box environment.

4.3.3.15 Cost Estimate For Ring 3 (2% Pu) Line

The estimated cost for processing equipment for this production line is $10,429,000. Glove boxes for this equipment are estimated to cost $1,786,000. Equipment installation and hook-up to existing services is estimated to cost $2,086,000. This amounts to a total estimated cost for this fuel element line of $14,301,000.

4.3.4 Ring 4 (1.2% PuO_2) Pellet and Element Production Line

This line will receive batches of ceramic grade mixed oxide powder from the master blend facility and process it into sintered pellets containing 1.2% PuO_2 by weight. These pellets will then be encapsulated into fuel elements meeting all of the requirements of CANDU MOX fuel. Figures 4-6 and 4-7 show the layout of this production line and it's material flow. It will be located in the Grade Viewing and Operating Station on the 278' elevation of the Process Building and in the WTEG Building.

The line will operate predominantly by remote control with all process equipment contained in glove-boxes. Material transfer within the production line will be either by automatic conveyance within enclosures joining adjacent glove-boxes or by transfer of material to a double-walled container for transfer by manual cart or automatic conveyor to the next workstation. Completed fuel elements will be transferred to the CANDU fuel bundle assembly line located in the Analytical Viewing and Operating Station at the 314'6" Elevation in the Process Building.

This production line will consist of 14 stations that will be designed to be operated remotely with monitoring by sensors built into the operating equipment. Vision systems will be provided to aid the operating personnel in the control room. The equipment will be designed for contact maintenance consistent with personnel exposure limits and safety requirements. In general, the equipment for each station will be designed with more than enough capacity for the daily requirements in order to keep it's duty cycle light and allow for maintenance downtime.

Even though the fuel element throughput rate of this line is 50% higher than the Ring 3 production line, identical equipment will be used in both lines. This will allow interchangeability of parts with a resultant reduction in the number of spare parts that need to be stocked. In addition, the training requirements for production and maintenance personnel will be substantially reduced and it will allow more operational flexibility since personnel can be assigned to either production line.

The description of the 14 stations in this production line is the same as given in Section 4.3.3.

The estimated cost for processing equipment for this production line is $10,429,000. Glove boxes for this equipment are estimated to cost $1,786,000. Equipment installation and hook-up to existing services is estimated to cost $2,086,000. This amounts to a total estimated cost for this fuel element line of $14,301,000.

4.3.5 Bundle Assembly Line

A CANDU bundle assembly line will be located in the Analytical Viewing and Operating Station on the 314'6" elevation of the Process Building (see Figure 4-8). It will receive completed fuel elements from the two element production lines. Completed fuel elements containing burnable poison (dysprosium) will be received from a qualified external source. Assembly of the fuel elements into CANDU fuel bundles and inspection of the completed bundles will be carried out in a semi-automated line operated predominantly by remote control with all operations contained in shielded workstations. The production line will consist of four subsystems which are described in the following sections.

4.3.5.1 Bundle Assembly

The bundle assembly facility will receive completed fuel elements from each of the two element assembly lines, described in the preceding sections, and burnable poison elements from a qualified external source. These fuel elements will be assembled into CANDU bundle form by welding each end of each element to Zircaloy end plates supplied from a qualified external source. This is accomplished by first inserting the fuel elements into a custom designed fixture which ensures the correct location and orientation of each fuel element. This is possible because the appendages attached at the center plane of each CANDU fuel element have a size and geometry unique to each ring in the fuel bundle. This ensures that fuel elements containing different levels of PuO_2 or the burnable poison can not be inadvertently placed in the wrong location in the bundle. Once inserted into the fixture, each end of each fuel element is attached by resistance welding to the Zircaloy end plate. Completed fuel bundles will be transferred to the bundle final inspection facility.

This facility will be designed to be operated remotely with monitoring by sensors built into the operating equipment. This equipment will be designed for contact maintenance consistent with personnel exposure limits and safety requirements. The equipment used in this operation will be the same type and will use the same proven process technology as in existing natural UO_2 CANDU fuel production facilities with appropriate modifications for use in a shielded workstation environment.

4.3.5.2 Bundle Final Inspection

A number of non-destructive tests and inspections are required to certify a completed CANDU fuel bundle meets all specification requirements. The equipment to perform the required functions will be shielded to provide operator protection from radiation exposure and will be predominantly remotely operated . Functions that require manual intervention will be performed by the operating technician using manipulators and other assisting devices. Bundles successfully passing all tests will be transferred to the bundle packing and storage facility. Those failing to pass a test will be transferred to the bundle repair station for processing.

This equipment will be designed for contact maintenance consistent with personnel exposure limits and safety requirements. The equipment used in this operation will be the same type and will use the same proven process technology as in existing natural UO_2 CANDU fuel production facilities with appropriate modifications for use in a shielded workstation environment.

4.3.5.3 Bundle Packing and Storage

Bundles received from final bundle inspection will be packed for shipment and stored until their scheduled shipping date arrives. This station will be designed to be operated remotely with monitoring by sensors built into the equipment. The equipment in this station will be designed for contact maintenance consistent with personnel exposure limits and safety requirements.

Finished bundles will be stored in their shipping containers which have shielding designed to reduce radiation levels below 5 mR/hr.

4.3.5.4 Bundle Repair Station

Bundles rejected at final inspection will be disassembled in this station. Fuel elements that are acceptable for rebuild into bundles will be prepared and transferred to the bundle assembly station. Fuel elements not acceptable for rebuild into a bundle will be transferred to the scrap recovery station.

This equipment in this facility will be designed to be operated predominantly remotely but with some functions requiring intervention by the operating technician using manipulators and other assisting devices. The equipment will be designed for contact maintenance consistent with personnel exposure limits and safety requirements.

4.3.5.5 Cost Estimate

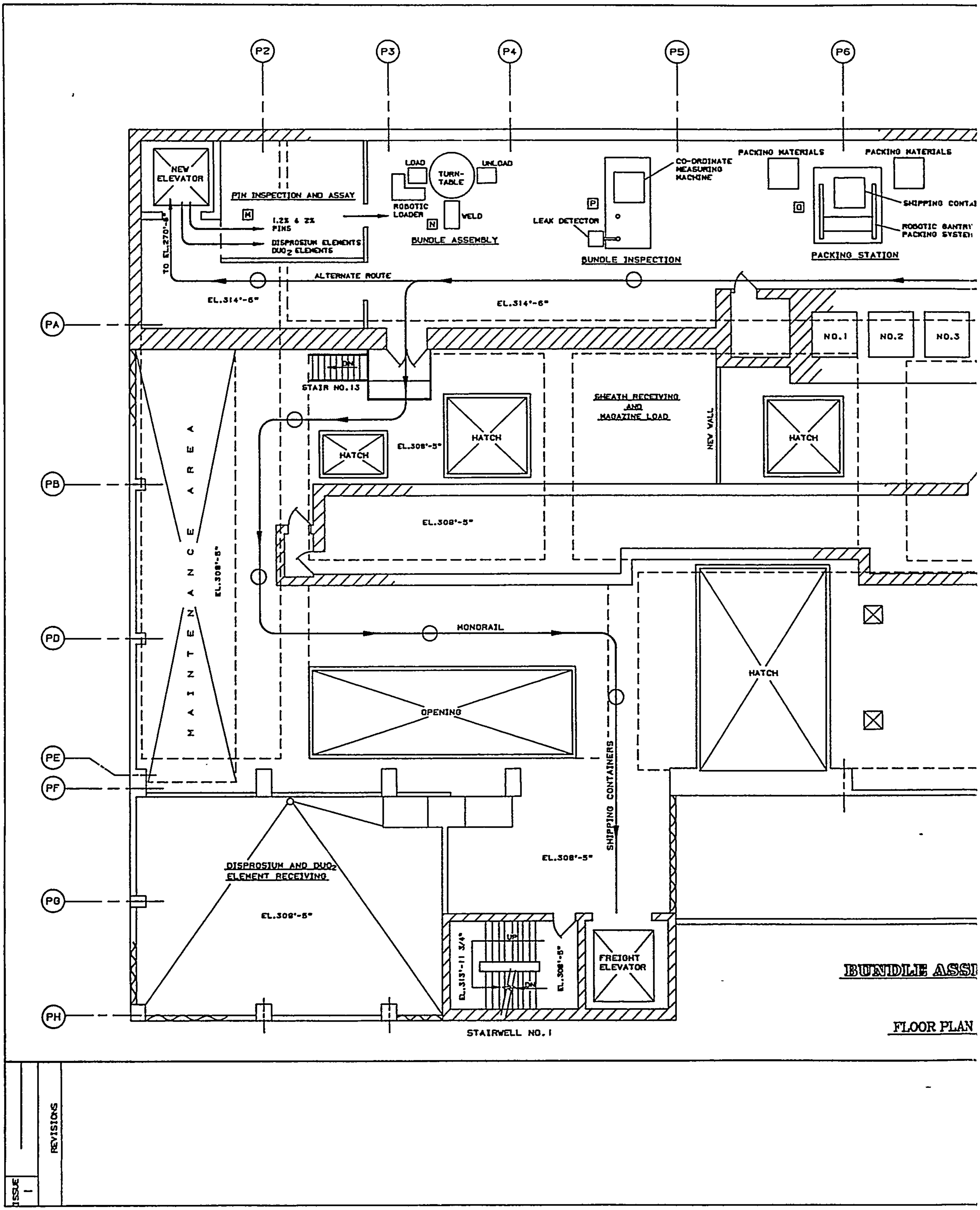
The estimated cost for the equipment for the fuel bundle assembly line is $2,429,000. Installation and hook-up to existing services is estimated to cost $479,000. The estimated cost of shielded work stations is $786,000. This gives a total estimated cost of $3,694,000.

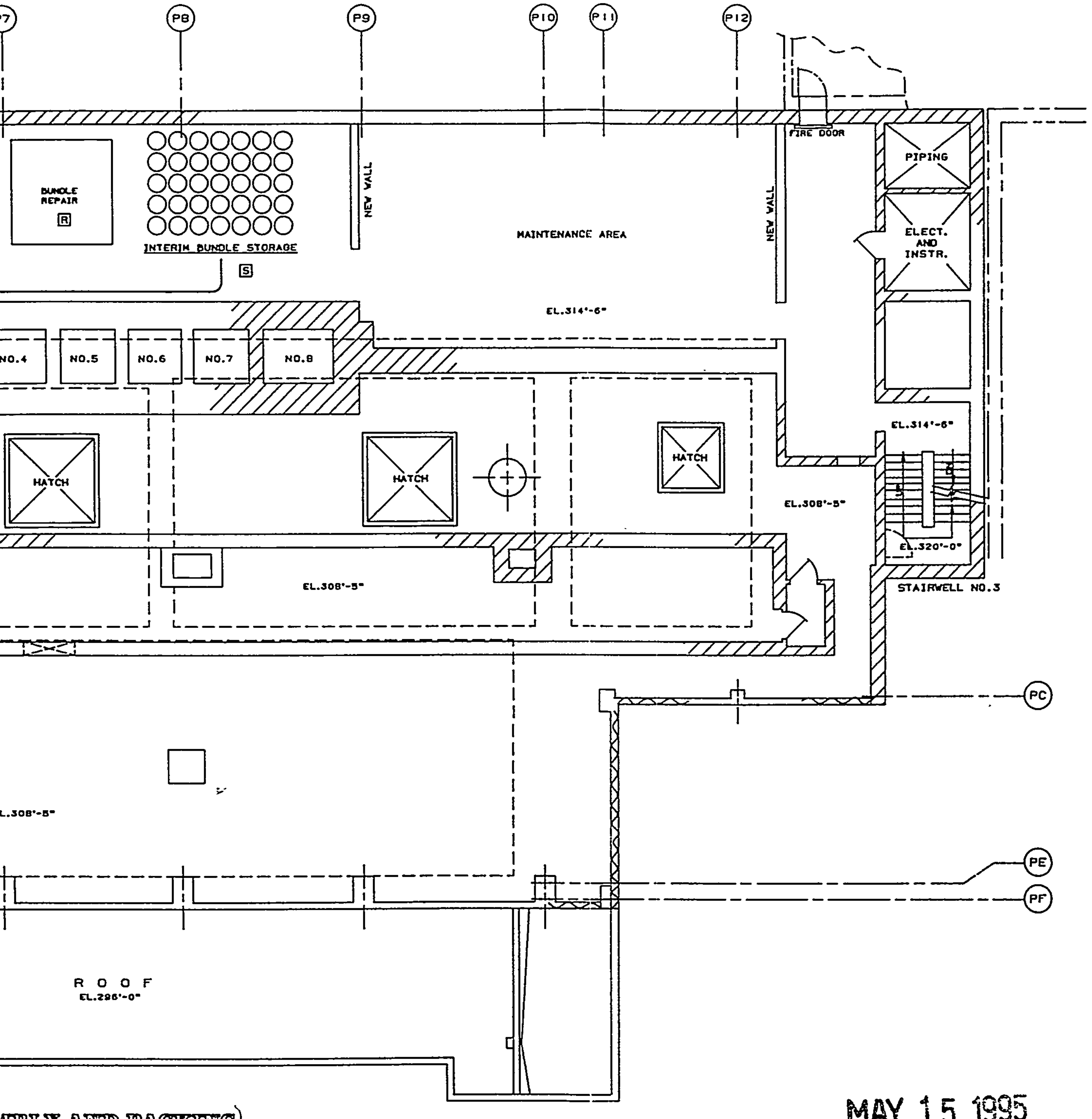
4.4 Manufacturing Equipment Cost Summary

The following Table 4-1 shows a summary of the estimated cost of the manufacturing equipment, its installation and hook-up to services, the cost of the required glove boxes for the equipment and the cost to do the detailed design of the equipment.

Table 4-1 Summary of MOX Fuel Fabrication Equipment Costs

Manufacturing Equipment Cost For AGNS CANDU MOX Facility	1994 US Dollars
1. Ring 3 Pin Line (2% Pu)	
1.1 New equipment	10,429,000
1.2 Installation and hook-up to services	2,086,000
1.3 Glove-boxes for equipment	1,786,000
Total	**14,301,000**
2. Ring 4 Pin Line (1.2% Pu)	
2.1 New equipment	10,429,000
2.2 Installation and hook-up to services	2,086,000
2.3 Glove-boxes for equipment	1,786,000
Total	**14,301,000**
3. Bundle Assembly Line	
3.1 New equipment	2,429,000
3.2 Installation and hook-up to services	479,000
3.3 Glove-boxes &/or shielding for equipment	786,000
Total	**3,694,000**
4. Master Blend Facility	
4.1 New equipment	3,072,000
4.2 Installation and hook-up to services	214,000
4.3 Glove-boxes for equipment	357,000
Total	**3,643,000**
5. Grand total of Items 1 to 4	**35,939,000**
6. Recycle & Pu finishing station	**5,100,000**
7. Equipment design cost	**4,871,000**
8. Contingency at 15%	**6,900,000**
9. Total facility equipment costs	**52,810,000**


P2
P3
P4
P5
P6
PA
PB
PD
PE
PF
PG
PH
NEW ELEVATOR
PIN INSPECTION AND ASSAY
1.2% & 2% PINS
DISPROSIUM ELEMENTS DUO2 ELEMENTS
TO EL.270'-8"
LOAD
TURN-TABLE
UNLOAD
ROBOTIC LOADER
WELD
BUNDLE ASSEMBLY
CO-ORDINATE MEASURING MACHINE
LEAK DETECTOR
BUNDLE INSPECTION
PACKING MATERIALS
PACKING MATERIALS
SHIPPING CONTA
ROBOTIC GANTRY PACKING SYSTEM
PACKING STATION
ALTERNATE ROUTE
EL.314'-6"
EL.314'-6"
NO.1
NO.2
NO.3
DN
STAIR NO.13
SHEATH RECEIVING AND MAGAZINE LOAD
NEW WALL
HATCH
HATCH
HATCH
EL.308'-5"
EL.308'-5"
MAINTENANCE AREA
EL.308'-5"
MONORAIL
OPENING
HATCH
SHIPPING CONTAINERS
DISPROSIUM AND DUO2 ELEMENT RECEIVING
EL.308'-5"
EL.308'-5"
UP
DN
EL.313'-11 3/4"
EL.308'-5"
FREIGHT ELEVATOR
STAIRWELL NO.1
BUNDLE ASS
FLOOR PLAN
REVISIONS
ISSUE
1



MAY 15 1995

BLY AND PACKING

308'-5" AND 314'-6"

Figure 4 - 8 Bundle Assembly and Packaging Equipment Layout

FD-8870

REVISIONS
2 — ADDED NEW ELEVATOR TO AREA AT COLUMNS PA/P2 — REVISED MATERIAL FLOW PATTERN — DRB 2 MAY'95

ZIRCATEC PRECISION INDUSTRIES INC.

TITLE MOX FUEL FABRICATION PLANT
BARNWELL, SOUTH CAROLINA
ELEVATIONS 308'-5" & 314'-6"

ZPI

DIMENSIONS IN INCHES UNLESS OTHERWISE SPECIFIED | SCALE: 1/8"=1 FT. | ISSUE 2

DRAWN BRBoard | DATE 7 APR'95 | APP. BY D.Newington | DATE | SHT. 1 OF 6

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5.0 Facility Modifications

This section identifies the buildings at the BNFP site selected for the CANDU MOX fuel fabrication, and describes the modifications required to convert the existing facility to a condition that is suitable for MOX fuel fabrication. The section also presents an estimate of costs associated with the modifications.

The modification activities include ripout of existing, not-needed equipment, piping and ducts; removal of access barriers or walls that are not structural-load bearing; reconditioning of the cleared area; and construction of a new structure that is required for the MOX fuel fabrication facility.

5.1 BNFP Facility Selected for CANDU MOX Fuel Fabrication

To fabricate CANDU MOX fuel in the BNFP, the study team evaluated over a dozen different configurations of available building space, and decided to utilize the following BNFP areas. This decision represents the most optimum configuration based on the need of floor space required by process equipment, work flow path, and safeguards and security measures. If the project goes forward in the future, the study team recommends that a more detailed assessment should be made to include other considerations such as MOX fuel fabrication expansion requirement and potential other use of the facility at the BNFP site.

(1) The Process Building Below Grade for the SNM Storage Vault and portions of Ring 3 Pin Fabrication Line, including the following equipment:

- Lower Viewing and Operating Station (LVOS) for the fissile/fertile receiving, batching, blending, boat unloading, grinding stacking, pin loading and pin welding

- Remote Maintenance and Scrap Cell (RMSC), El. 251', for storage of special nuclear materials (SNM), where PuO_2 powders will be received into and stored in a storage vault.

(2) The Process Building at Grade Level for the Master Blend Station, portions of Ring 4, including the following equipment:

- Remote Process Cell (RPC), El. 252', and the Crane & Equipment Maintenance Gallery (CEMG), El. 278', for the Master Blend area including UO_2 weighing hood, fissile receiving, powder weight and package, batching and blending

- Grade Viewing and Operating Station (GVOS), El. 279', for the depleted UO_2 storage, SNM receiving assay and powder receiving, batching/blending, pellet pressing area

- Cask Loading Area, El. 278', for boat loading and inspection, and sample sending

- Area north of the Cask Loading Area, El. 278', for pellet grinding/washing/drying/tray loading and pellet stacking/pin loading and end cap welding stations, as well as pin wash and magazine loading

(3) The Process Building at Top Level for the final assembly of fuel bundles and the interim bundle storage, including the:

- Analytical Viewing and Operating Station (AVOS), El. 314'6", for the final assembly of fuel bundles including pin inspection and assay, bundle assembly station, bundle inspection station, bundle packing station and bundle repair station as well as the interim bundle storage.

- Office Space (OS) for the safeguards office and computer area.

(4) The Hot and Cold Laboratory Area, El. 286', located outside the northeast corner of the Process Building, for the MOX Close Coupled Analysis Station (CCA).

(5) The Waste Tank Equipment Gallery (WTEG), located outside of the Process Building for portions of the Ring 3 Pin Fabrication Line including pellet pressing, tray/boat transfer, delube furnace and sintering. The Waste Tank Equipment Gallery building would be supplemented by an additional building (see Figure 4-7) to house portions of the Ring 4 Pin Fabrication Line including pellet pressing, delube and sintering. The new WTEG extension is linked to the Process Building by a hardened structure (12' wide from the WTEG extension, and 26' wide for the entrance to the Process Building, see Figure 4-7). The Process building and the WTEG has an existing underground trench (elevation 260', 6' x 6' cross section with a stainless steel lined wall) that connects the two buildings.

5.2 Modifications Required to Support CANDU MOX Fuel Fabrication Within BNFP

The Study Team toured the BNFP facility and based on the information gathered, the team agreed on an overall strategy for the configuration of process equipment. The strategy is as follows:

(1) Process Building Below Grade Level (see Figure 4-5 at the end of Chapter 4)

- SNM storage vault
- portions of Ring 3 (2% Pu) Pin Fabrication Line including fissile/fertile receiving, batching, blending, boat unloading, grinding, stacking, pin loading & pin welding

(2) Process Building Grade Level (see Figure 4-6 at the end of Chapter 4)

- Master Blend Station including fissile/fertile receiving, batching, blending and packaging
- portions of Ring 4 (1.2% Pu) Pin Fabrication Line including fissile/fertile receiving, batching, blending, boat unloading, grinding, stacking, pin loading & pin welding
- material recycle station

(3) Process Building Top Level (see Figure 4-8 at the end of Chapter 4)

- Final Assembly of Fuel Bundles including pin inspection & assay, bundle assembly station, bundle inspection station, bundle packaging station & bundle repair station
- interim bundle storage

(4) Waste Tank Equipment Gallery (see Figure 4-7 at the end of Chapter 4)

- portions of Ring 3 Pin Fabrication Line including pellet pressing, delube and sintering

(5) Proposed Addition to Waste Tank Equipment Gallery (see Figure 4-7)

- portions of Ring 4 Pin Fabrication Line including pellet pressing, delube and sintering

The facility will have only one entry point for all fissile and fertile powders into the CANDU MOX fuel fabrication line (which will also serve as an exit point for the fresh CANDU MOX fuel) at the ground level in lieu of the cask loading area.

In order to utilize the BNFP facility for the new proposed mission, it will be necessary to (i) remove part of the installed equipment, (ii) modify existing BNFP cells, (iii) harden specific areas of the BNFP facility, such as the Waste Tank Equipment Gallery, (iv) provide for new facilities such as the SST truck loading area and an addition to the WTEG building, (v) reinstall utilities, HVAC, and process control piping and wiring, (vi) provide services such as nitrogen and an argon cryogenic storage tanks and recycle systems, and (vii) establish a new physical security system.

- The CANDU MOX fuel fabrication facility's new physical security system will be based on a layered approach with physical barriers (including a double fenced isolation zone meeting the requirements of a protected area), and intrusion detection devices such as infrared detectors, microwave detectors, ultrasonic detectors along with their associated CCTV systems. To accommodate the needs of the proposed BNFP mission, a totally new system, using current technology, is to be installed.

- Power to BNFP was originally supplied by SCE&G. However, BNFP's electrical switchgear, substation, motor control centers and cable runs were either removed over the years or scavenged by metal scrap dealers. A complete equipment replacement and refurbishment of the electrical systems is therefore needed.

- The HEPA filter banks are still in place but individual HEPA filters require replacement. In addition, a new HVAC system needs to be purchased and installed.

- All unneeded equipment will be removed from areas that will be used for MOX fuel fabrication. Areas that are not expected to be used will be sealed off to minimize potential spread-off of contamination.

A summary listing of the BNFP modification is provided in Table 5-1.

TABLE 5-1

SUMMARY OF BNFP MODIFICATIONS

Cell	Equipment Removal	Modification
Remote Maintenance and Scrap Cell EL 250'6"	·small crane with chain fall (10 tons) ·hull transfer car ·hull monitor ·sump and sand trap ·sump and jet base ·dissolver hull cask ·SAC waste retainer ·SAC waste chute outlet ·monitor sump jet base ·MSM wall tubes (8) ·power manipulator and trolley ·passing port ·HP decon unit ·workbench ·dumper maintenance stand ·RMSC periscope ·wall sleeves (8)	·Convert viewing window west wall into vault door ·Seal 3 viewing windows, south wall ·Plug 32 hole penetrations 1' diameter (south wall and west wall) ·Add SS liner on ceiling 70'L x 23'W ·Provide HVAC ·Provide lighting system ·Add alarm system ·Provide door monitoring ·Install dumbwaiter ·Install PuO_2 storage rack, vault doors at both ends of the cell ·Install PuO_2 retrieval systems/automatic transfer conveyor system
Hall after SST Receiving Area EL 270'6" (above LVOS)	·Remove miscellaneous equipment (shear magazine, hulls casks, platform, wire cage 20' x 13', cask platform, shear lid, hopper) ·Cut pipes on wall, remove steam, utility piping ·Remove rolling door 16' wide	·Install SST docking area on south wall ·Provide air lock system ·Install transfer system from south wall to RMSC entrance 32' (North) by 16' (East) ·Create door to GVOS East ·Seal equipment hatch 12' x 30' above ·Add new ceiling ·Line wall 12' high
Remote Process Cell (RPC) Note that some of the equipment maybe uranium contaminated.	Using Hanford Jumpers ·dissolver exchanger ·HAW exchanger ·sump transfer jet ·dissolver screen pot ·1" remote clamp ·jumper rack ·jumper gasket changeout tools ·maintenance tool racks ·lifting yoke dissolver ·dissolver transfer stand ·MSM wall tubes (9) ·grapple for hull monitor ·monitor removal support ·platform ·wall support ·off-gas pipe from concentrator	·Seal 6 viewing windows, 18 penetrations ·Add emergency exits in place of window on east side ·Add false ceiling ·Install SS lining 90' x 22" width, grading subfloor, install SS plates to level floor ·Install electricity
Analytical Viewing and Operating Station (AVOS) EL 314'6"	·3 lab benches and 10 cabinets ·2 gloveboxes close to wall "contaminated" ·16 manipulators ·Upper pipe gallery	·Seal off 8 windows ·Add 10' high ceiling 180' x 19_'
Grade Viewing and Operating Station (GVOS)	·misc. equip. (ß meter), diverter valve, roll-up door	·Add new ceiling, 10 ft. high ·Lining on walls/ceiling 126' long x 16' wide
Waste Tank Equipment Gallery (WTEG)	·HVAC units, fuel oil tank ·iodine absorber ·cooling water break tank ·air receivers ·demineralized water break tank ·off-gas pots, condensers ·coolant exchangers and pumps ·steam generators ·off-gas filters, sample cells	·Replace or cover grated floor with steel decking

TABLE 5-1 (continued)

SUMMARY OF BNFP MODIFICATIONS

Addition to WTEG Building		New building with 20 ft. ceiling height and 224 ft. linear length of walls (1.5 ft. thickness)
Section of Building joining WTEG and Process Building		Ceiling height 12 ft., linear length of walls 209 ft., and thickness of wall: 1.5 ft.
Other Facility Modifications	Piping from underground trench (elevation 260', 6' x 6' cross section) between Process Building and WTEG	·Safeguards/security, including criticality alarm systems and fence on-site perimeter ·HVAC installation systems ·Utilities (electricity, water, argon, nitrogen) ·Fire control system ·Seal or vault all doors in building ·Monitoring capabilities (Pu storage, masterblend storage) ·Doors ·SST loading dock ·Effluent monitoring ·New diesel generators ·New control room ·New fan motors ·Vault door on PuO_2 storage area ·Liner (or paint over) ·Stainless steel floors ·Conveyors for bundle storage ·Install elevator in northwest corner of process building (El 257 to El 314) ·Seal both ends of vault bundle storage area and all unused areas of BNFP ·Repatch floors ·Monorail, rabbit system ·Battery powered systems

5.3 Estimates of Costs

Calculations were made of the costs involved in modifying the BNFP Process Building, the WTEG building and in providing an addition to the WTEG building, for containing a 157 tonnes/year CANDU MOX fuel supply facility.

5.3.1 Assumptions

The following assumptions were made in formulating the cost calculations:

- Contractor overhead and profit is calculated at 32.6% of both labor and materials for consistency with current experience and practice.
- A contingency of 25% on the overall construction/modification estimate has been included to reflect uncertainties in the conceptual design that will affect construction.
- All construction subcontracts are fixed price contracts.
- Savannah River area labor rates, shown in Table C-1 (Appendix C) are assumed.
- Material pricing is based on estimates supplied by vendor's actual quotes.
- Man-hour units are based on JAI historical data, DOE contractor estimates for similar work and Guidelines for Decommissioning Cost Estimates.
- All concrete is 5,000 psi; and all form-work is used twice.
- Ten percent (10%) is added to quantities of rebar, welded wire mesh, and metal deck for lap. Five percent (5%) is added to concrete quantities for over-pour.

5.3.2 Unit Factor Development

Tables C-2 through C-10 (Appendix C) present routine unit factors used in determining the expenditures associated with the removal of process piping, valves, concrete walls, HVAC ductwork, and miscellaneous equipment such as tanks and pumps. These items are assumed to be transferred to a local staging area for release from the work site. All demolition work has been priced as laborers and no crew mix (apprentice, journeyman, foremen mix) has been developed for the equipment removal. However, the proper number of personnel has been carefully considered.

5.3.3 Systems Modifications and Refurbishment Costs

Complete modifications and refurbishment of BNFP to serve as a CANDU MOX fuel fabrication facility would cost approximately $71.8-million. This cost estimate can be broken down into four major cost elements: facility modifications, systems refurbishment, physical security equipment and facilities, and new building construction -- which are illustrated in Table 5-2. The total estimated cost for the BNFP facility modifications were estimated at $20.4-million, the total estimated cost for systems refurbishment was estimated at $14.2-million, while the total estimated cost for physical security would be approximately $7.0-million. The cost for constructing the new WTEG extension is estimated at $24.5 million. Of the four major cost elements, facility new building construction is the most significant single cost item.

TABLE 5-2
TOTAL ESTIMATED MODIFICATION COST FOR BNFP

Major Cost Element	Cost
Facility Modifications	$ 20,449,077
Systems Refurbishment	14,201,524
Physical Security	7,000,000
Miscellaneous (health physics, radiation monitoring, criticality alarm, fire control)	5,631,065
Sub-Total	$47,281,666
New building construction	24,500,000
Total	$71,781,666

5.3.3.1 Facility Modifications

Tables 5-3 through 5-6 on the following pages provide specific breakdowns of the facility modification costs.

5.3.3.2 Systems Refurbishment

System refurbishment costs were estimated by PRC Environmental Management Inc. for the U.S. DOE Savannah river Operations Office in the March 1995 study, "Transuranic and Mixed Waste Management Existing Facility Options". Specific component costs for the BNFP systems refurbishment, i.e., the HVAC system, the electrical system and the air pollution control systems are shown below:

System	Cost ($)
HVAC System (units, blowers; steam and drilled water	4,801,524
Electrical System	8,100,000
Air Pollution Control System	1,300,000
Total	$14,201,524

The total estimated cost for HVAC refurbishment at BNFP is $4.8-million. A breakdown of this total is shown below, while Table C-12 presents a detailed evaluation of the HVAC unit costs to confirm the estimate made by PRC Environmental Management Inc.

System	Cost ($)
HVAC Units	451,524
Electrical System	2,450,000
Chilled Water System	1,200,000
Blowers System	700,000
Total	$4,801,524

TABLE 5-3

FACILITY MODIFICATIONS

EL 250'6", 251', 252', 257'.6", 260'.4"

Description	Quantity	Unit	Material Unit Cost	Material Cost	Manhours Unit Manhours	Total Manhours	Labor Rate	Labor Cost	Subcontract Unit Rate	Subcontract Total Cost	Total Cost
Equipment Removal (Process Building)											
Piping	5,000	LF	0.125	625	0.465	2,325	13.82	32,131	0	0	$ 32,756
Equipment	50	EA			4.05	202	13.82	2,791	0	0	2,791
	5	EA			11.2	56	13.82	773			773
Equipment Removal (WTEG)											
Piping	10,000	LF	0.125	1,250	0.465	4.650	13.82	64,263	0	0	65,513
Equipment	45	EA			11.2	504	13.82	6,965	0	0	6,965
Modifications											
Convert viewing window to entrance of SNM storage vault	1	EA	0	0	0	0	0	0	10,000	10,000	10,000
Seal viewing windows	200	SF	2.95	590	1.65	330	15.35	5,065	0	0	5,655
Transfer system (conveyor)	250	FT	56.50	14,125	28,50	7,125	25.75	183,468	0	0	197,593
Steel liner panels	8,000	SF	0	0	0	0	0	0	3.1	24,800	24,800
Install vault doors on PuO_2 storage areas	2	EA	40,900	81,800	650	1,300	25.75	33,475	0	0	115,275
Conveyor for bundle storage (manual/robotic)	1	EA	180,000	180,000	300	300	24.74	7,422	0	0	187,422
Seal both ends of bundle storage	2,000	SF	2.95	5,900	1.65	3,300	15.35	50,655	0	0	56,555
Install elevator at NW corner of Process Bldg.	1	EA							53,000	53,000	53,000
Structural excavation	10,000	CY	0	0	0.05	500	17.55	8,775	0	0	8,775
Place foundation slab, elevated slab & walls	CY 21,300	51	1,086,300	2	42,600	17.55	747,630	0	0	1,833,930	
Form walls	9,600	SF	0.85	8,160	0.55	5,280	17.55	92,664	0	0	100,824
Rebar at elevated slab, foundation slab	850	TN	395	335,750	30	25,500	17.55	447,525	0	0	783,275
Structural steel	600	TN	1,300	780,000	22	13,200	24.74	326,568	0	0	1,106,568
Liner plate 1/4" stainless steel	200	TN	5,000	1,000,000	60	12,000	25.75	309,000	0	0	1,309,000
Angles, stainless steel	9	TN	5,000	45,000	9	81	25.75	2,085	0	0	47,085
Welds full penetration	14,000	LF	0	0	0.33	4,620	25.75	118,965	0	0	118,965
				$3,539,500				$2,440,220		$87,800	$6,067,520

TABLE 5-4

FACILITY MODIFICATIONS

EL 270'6", 276', 278', 279'

Description	Quantity	Unit	Material: Unit Cost	Material: Material Cost	Manhours: Unit Manhours	Manhours: Total Manhours	Labor: Labor Rate	Labor: Labor Cost	Subcontract: Unit Rate	Subcontract: Total Cost	Total Cost
Equipment Removal											
Piping	10,000	LF	0.125	1,250	0.465	4,650	13.82	64,263	0	0	$ 65,513
	7,000	LF	0.04	280	0.19	1,330	13.82	18,300	0	0	18,580
Equipment (pumps, hull cask, etc.)	60	EA	0	0	11.2	672	13.82	9,287	0	0	9,287
Misc. (rolling door, wire cage, etc.)	40	EA	0	0	9.96	398	13.82	5,509	0	0	5,509
Modifications											
Remove walls	190	CY	39.57	7,518	2.24	425	13.82	5,881	0	0	13,399
Install doors for personnel access	30	EA	835	25,050	10	300	17.55	5,265	0	0	30,315
Install ceiling	440	CY	0	0	0	0	0	0	350	154,000	154,000
Level floor RPC	600	CY	51	30,600	2	1,200	17.55	21,060	0	0	51,660
SS liner	24,000	SF	29.93	718,320	0.43	10,320	25.75	265,740	0	0	984,060
Hardened structure (16'x22' rolling door)	30	CY	0	0	0	0	0	0	350	10,500	10,500
Install elevator	1	EA	0	0	0	0	0	0	53,000	53,000	53,000
External access to elevator hardened	20	CY	0	0	0	0	0	0	350	7,000	7,000
Provide air locks	10	EA	22,000	220,000	785	7,850	22.18	174,113	0	0	394,113
Install transfer system to RMSC	1	EA	120,000	120,000	200	200	24.74	4,948	0	0	124,948
Seal hatch 12'x30'	360	SF	2.95	1,062	1.65	594	15.35	9,118	0	0	10,180
Line-up walls	500	CY	51	25,500	2	1,000	17.55	17,550	0	0	43,050
Seal windows	600	SF	2.95	1,770	1.65	990	15.35	15,196	0	0	16,966
Sampling lines to CCA rabbit system	1	EA		83,500		1,475	22.18	32,715	0	0	116,215
Seamless epoxy floor	12,000	SF	0	0	0	0	0	0	6.85	82,200	82,200
Steel liner panels	6,000	SF	0	0	0	0	0	0	3.1	18,600	18,600
				$1,234,850				$648,945		$325,300	$2,209,095

TABLE 5-5

FACILITY MODIFICATIONS

EL 308'5", 314'6", 325', 331'

			Material		Manhours		Labor		Subcontract		
Description	Quantity	Unit	Unit Cost	Material Cost	Unit Manhours	Total Manhours	Labor Rate	Labor Cost	Unit Rate	Total Cost	Total Cost
Modifications											
Install elevator NE corner	1	EA	0	0	0	0	0	0	53,000	53,000	$ 53,000
Hardened structure rooF over EL 308'	2,000	CY							350	700,000	700,000
Hardened sructure for 35'x10' hatch	17	CY							350	9,450	9,450
Ceiling 10' high	3,600	SF	9.63	34,668	6.03	21,708	17.55	380,975			415,643
				$34,668				$380,975		$762,450	$1,178,093

TABLE 5-6

OTHER FACILITY MODIFICATIONS

Description	Quantity	Unit	Material		Manhours		Labor		Subcontract		
			Unit Cost	Material Cost	Unit Manhours	Total Manhours	Labor Rate	Labor Cost	Unit Rate	Total Cost	Total Cost
Paint masonry	360,000	SF	0.09	32,595	0.012	4,320	21.14	91,324	0	0	$123,919
Seal concrete floors	60,000	SF	0.06	3,600	0.012	720	17.55	12,636	0	0	16,236
Seal concrete walls	150,000	SF	0.06	9,000	0.012	1,800	17.55	31,590	0	0	40,590
				$45,195				$135,550			$180,745

Total Direct Cost for Facility Modifications	$9,635,453
Contractor Overhead & Profit (32.6% labor + materials)	2,757,928
Engineering (20%)	2,478,676
Project Management (10%)	1,487,205
Contingency (25%)	4,089,815
Total Cost for Facility Modifications	$20,449,077

The complete cost of electrical refurbishment would be approximately $8.1-million. This total may be broken down further into two major cost components: $7.6-million for electrical equipment replacement and refurbishment such as switchgears, substations, motor control centers, and diesel generators (this estimate was developed by an independent nuclear and electric industry supplier and contractor in the form of a firm fixed price offer); and $506,000 for supplying SCE&G service to the facility.

The total estimated cost for all air pollution control system related modifications would be $1.3-million as shown below:

Component	Cost ($)
Boiler Upgrades	400,000
Stack Modifications for Sampling Ports	150,000
Cooling System Modifications	250,000
CCA Laboratory Building Exhaust Controls	500,000
Total	$1,300,000

5.3.3.3 Physical Security

Table 5-7 presents the estimated cost for physical security equipment and facilities at BNFP to service CANDU MOX fuel fabrication purposes. The total estimated cost of an initial analysis is $4.1-million as shown in Table 5-7.

This estimate and scope of equipment groups were compared to other source of facility installation experience and was found to be conservative. The study team re-evaluated the likely costs of the physical security requirements for the BNFP MOX facility, and decided that the cost would be at the level of about $7 million. The $7 million number is used in the final cost summary for the physical security modification and installation of the BNFP facility.

5.3.3.4 New Structure Construction

The construction of the extension structure which connects the main Process building and WTEG structure will cover an added floor area of about 7,400 square feet. Based on an estimated of $3,300 per square feet construction cost for category 1 hardened building for nuclear related application, the estimate of the new structure construction at BNFP MOX facility is $24.5 million. This cost estimate includes building support systems such as NEPA air filtration, SST docking ramp, and controlled gate for personnel and material access.

The $24.5 million cost represents the most significant single cost item in the facility modification costs. The need of this new structure construction should be evaluated in more detail if the BNFP MOX fuel supply option is to go forward in the future. Other options such as make use of the Fuel Receiving and Storage Station should be analyzed. The study team did not consider the use of FRSS building in this study because the building is not hardened in the upper wall and roof sections. Another reason is that the FRSS has significantly more space than the CANDU MOX fuel facility requires.

5.3.3.5 Miscellaneous Costs

Table 5-8 presents the estimated costs for health physics radiation monitoring, fire control, and criticality alarm systems. The total estimated cost is $5.63-million.

TABLE 5-7

PHYSICAL SECURITY EQUIPMENT AND FACILITIES

Description	Quantity	Unit	Material: Unit Cost	Material: Material Cost	Manhours: Unit Manhours	Manhours: Total Manhours	Labor: Labor Rate	Labor: Labor Cost	Subcontract: Unit Rate	Subcontract: Total Cost	Total Cost
Physical Security Equipment & Facilities											
Perimeter Protection											
Reshape Berm									100,000	100,000	$100,000
Outside Fence	2,500	LF							7.5	18,750	18,750
Outer Perimeter Fence	2,200	LF							12	26,400	26,400
Securing Outer Perimeter Fence Base										20,000	20,000
Inner Perimeter Fence	2,000	LF							12	24,000	24,000
Microwave Detectors System	10	EA	15,000	150,000	40	400	26.47	10,588	50,000	50,000	210,588
Infra-red Intrusion System	10	EA	15,000	150,000	40	400	26.47	10,588	50,000	50,000	210,588
Fence Alarm Detection Zone				12,000		600	26.47	15,882			27,882
Remote Gates, 15' sliding, elect. op.	4	EA							4,000	16,000	16,000
Remote Gates, 30' sliding, elect. op.	2	EA							8,000	16,000	16,000
Vehicle Barrier	2,200	LF							32	70,400	70,400
Outside Lighting	50	LF							3,000	150,000	150,000
Anti-Helicopter Cable Tower & Cable System	1	EA							100,000	100,000	100,000
Closed Circuit TV	10	EA	10,000	100,000	40	400	26.47	10,588	0	0	110,588
Computer Printer	1	EA	5,000	5,000	4	8	26.47	211	0	0	5,211
Computers	1	EA	50,000	50,000	160	160	26.47	4,235	0	0	54,235
				$467,000				$52,092		$641,550	$1,160,642
Access Control											
Guard House (inc. SAS)	1,650	SF							80	132,000	132,000
CAS	500	SF								40,000	40,000
Metal Detector	2	EA	5,000	10,000	30	60	22.18	1,330	0	0	11,330
Explosive Detector	2	EA	30,000	60,000	80	160	22.18	3,548	0	0	63,548
SNM Detector	5	EA	40,000	200,000	100	500	22.18	11,090	0	0	211,090
X-Ray Unit	1	EA	45,000	45,000	120	120	22.18	2,661	0	0	47,661
Photo Badge Unit				5,000							5,000
Patrol & Response Vehicles	2	EA	26,000	40,000							40,000
TV Units	10	EA	10,000	100,000	40	400	26.47	10,588			110,588
Locking Turnstyles	4	EA	4,000	16,000	30	120	22.18	2,661	0	0	18,661
				$476,000				$31,878		$172,000	$679,878

TABLE 5-7 (Continued)

PHYSICAL SECURITY EQUIPMENT AND FACILITIES

			Material		Manhours		Labor		Subcontract		
Description	Quantity	Unit	Unit Cost	Material Cost	Unit Manhours	Total Manhours	Labor Rate	Labor Cost	Unit Rate	Total Cost	Total Cost
Physical Security Equipment & Facilities											
Vehicle Inspection System	1	EA	30,000	30,000	240	240	22.18	5,323	0	0	35,323
Radio Equipment	1	EA							50,000	50,000	50,000
Antenna	1	EA							25,000	25,000	25,000
Telephones (cellular)	4	EA							500	2,000	2,000
Armament Systems	25	EA	3,000	75,000							75,000
				$105,000				$5,323		$17,000	$187,323
				$1,040,000				$89,293		$890,550	$2,027,843

Total Direct Cost	$2,027,843
Contractor Overhead & Profit (32.6% labor + materials)	370,758
Engineering (20%)	479,720
Project Management (10%)	287,832
Contingency (25%)	949,846
Total Cost	$4,115,999

Note: The total estimated cost for physical security requirement is adjusted to become $7,000,000 based on comparison with other source of costing. The $7 million estimate is used in the final cost summary.

TABLE 5-8

MISCELLANEOUS COSTS

Description	Quantity	Unit	Material Unit Cost	Material Cost	Manhours Unit Manhours	Total Manhours	Labor Rate	Labor Cost	Subcontract Unit Rate	Subcontract Total Cost	Total Cost
Health Physics Radiation Monitoring											
Computer Display System	1	LT	250,000	250,000	100	100	26.47	2,647	0	0	$ 252,647
Portable Personnel Monitors	1	LT	23,740	23,740	0	0	0	0	0	0	23,740
Radiation Monitor Area	20	EA	52,200	1,044,000	170	3,400	26.47	89,998	0	0	1,133,998
Radiation Monitor, Body Burden Analyzer	1	EA	125,000	125,000	400	400	26.47	10,588	0	0	135,588
Radiation Monitor HVAC Process	2	EA	98,600	197,200	330	660	26.47	17,470	0	0	214,670
Radiation Monitor Portal	6	EA	22,346	134,076	70	420	26.47	11,117	0	0	145,193
Radiation Monitor Waste Segregator	1	EA	55,000	55,000	180	180	26.47	4,764	0	0	59,764
											$1,965,600
Fire Protection System											
Halon System									400,000	400,000	400,000
Preaction Valve, Deluge Type	6	EA	1,275	7,650	30	180	26.47	4,764	0	0	12,414
Spray Heads Pendant	150	EA	4.5	675	0.5	75	13.82	1,036	0	0	1,711
Fire Extinguisher, CO_2 Wall Bracket	10	EA	130	1,300	2	20	13.82	276	0	0	1,576
Fire Alarm Control Panel	1	EA	1,500	1,500	12	12	26.47	317	0	0	1,817
Fire Alarm Horn	10	EA	30	300	1	10	26.47	264	0	0	564
Smoke Detectors	150	EA	53	7,950	1	150	26.47	3,970	0	0	11,920
											$430,002
Criticality Alarm Systems	10	EA	25,000	250,000	100	1,000	26.47	26,470	0	0	276,470

Total Direct Cost	$2,672,072
Contractor Overhead & Profit (32.6% labor + materials)	740,695
Engineering (20%)	682,553
Project Management (10%)	409,532
Contingency (25%)	1,126,213
Total Cost	$5,631,065

6.0 License, Permit, and Regulatory Requirements

This section addresses the major licensing and regulatory requirements that must be met as a prerequisite for conversion of BNFP to fabricate MOX fuel for existing water reactors. It is divided into three sections, addressing the requirements resulting from the National Environmental Protection Act (NEPA), State Regulations, and NRC licensing requirements . Comparisons are also made to the prior report on licensing and permitting of FMEF, where appropriate.

6.1 National Environmental Policy Act Requirements

Review is required for all "...major Federal actions significantly affecting the quality of the human environment..." per section 102 (2) of the National Environmental Policy Act of 1969. Since BNFP would be a privately owned facility, NRC licensing is required as a matter of law. One of the major advantages of licensing with the NRC is that it is their action that becomes the Federal action, therefore NRC is responsible for compliance with NEPA. It is the responsibility of the licensee to provide them with an "Applicant's Environmental Report" which will become the basis for the NRC to prepare an Environmental Assessment (EA) and Finding of No Significant Impact (FONSI) or an Environmental Impact Statement (EIS). After consulting with the NRC staff, it is concluded that a full, project specific EIS will be required. Further review confirmed, according to §51.20(b)(7), an EIS is clearly required to use special nuclear material for fuel fabrication. To support the EIS preparation, the Applicants Environmental Report will take about 12 months to complete with about 24 man-months of labor since much information will have been developed in the Plutonium Disposition Programmatic Environmental Impact Statement (PDPEIS) and prior environmental studies of the BNFP site performed as part of the 1970's licensing activities by AGNS and NRC. Since this is a cost associated with licensing, it is included as a part of the NRC licensing costs.

It is possible that the programmatic EIS being prepared by DOE Headquarters for plutonium disposition could envelope the major Federal Decision required to convert BNFP for MOX fabrication, and thus serve to meet the NEPA requirements. It certainly would obviate the need for NRC to conduct a "programmatic" assessment, such as the GESMO effort of the 1970's, since DOE PEIS will provide the "policy and programmatic" basis for the decision, as required by NEPA. By DOE identifying itself as a "Cooperating Agency" it may be possible to tie the two efforts together and avoid duplication. A more thorough evaluation of this approach is required.

Because the design of the MOX facility located at BNFP would avoid the use of any hazardous materials, there would be no Resource Conservation and Recovery Act (RCRA) permitting requirements, per 40 CFR Parts 260 through 271, associated with the project. Even if hazardous materials were included in the operations, the licensing/permitting would be handled through NRC, similar to the NEPA requirements.

All other federal regulations are permitted through state agencies.

6.2 State Regulatory Requirements

AIR PERMITTING REQUIREMENTS PER 1990 CLEAN AIR ACT: The proposed activities have the potential of emitting regulated pollutants (both radio-nuclides and non-radionuclides). As such, the potential emissions must be permitted through State of South Carolina regulators. Air emissions in South Carolina are regulated by the Bureau of Air Quality (BAQ). BAQ acts as a delegated authority for EPA.

Once the emissions are estimated, air permits and notifications will be required. These may include: New Source Performance Standards (NSPS), Prevention of Significant Deterioration (PSD), Lowest Achievable Emission Rate (LAER) and, National Emissions Standards for Hazardous Air

Pollutants (NESHAPS), depending on the details of the processes to be used and their expected emissions. In addition, an Operating Permit is required under Title V of the Clean Air Act before plant modifications can begin. Registration of any new stacks, with the Department of Health, will also be required.

Requirements for continuous measurement of effluent from the facility are specified in 40 CFR Part 61, National Emissions Standards for Hazardous Air Pollutants (NESHAPs), Subpart H, "National Emission Standards for Emissions of Radionuclides Other Than Radon From Department of Energy Facilities." The requirements directly address those radio-nuclide emission points at DOE Facilities which, according to the methods specified at 40 CFR 61.93(b)(4), are estimated to provide a potential exposure of greater than 0.1mRem/yr effective dose equivalent to any member of the public. The emission potential of the facility, if used for the proposed project, could exceed the specified 0.1mRem/yr effective dose equivalent. The original effluent monitoring system for the BNFP facility exhaust stack was designed long ago and has not received the necessary "point by point" comparison needed to establish compliance with the requirements of 40 CFR Part 61.

It is estimated that it will take from one to two years to complete air permitting, at a cost of $500,000.

CLEAN WATER ACT OF 1963 AND SAFE DRINKING WATER ACT REQUIREMENTS:

Water pollution in South Carolina is regulated by the South Carolina Department of Health and Environmental Control (SCDHEC) Bureau of Water Pollution Control (BWPC). BWPC is responsible for a variety of permits, approvals, and certifications related to water pollution.

It is believed that industrial waste water (i.e., liquid effluents) from the production operation will not be discharged to the ground, surface waters, or into municipal sewage systems. Instead, it is projected that waste water (from the pellet grinding and washing operations) will be evaporated and discharged through a stack. Therefore, additional discharge permitting requirements including the National Pollutant Discharge Elimination System, will not apply.

A permit from Barnwell County Health department must also be obtained prior to the construction of any septic system or modifications to the existing system. The existing sanitary sewer at BNFP can be utilized for sanitary sewage. It is assumed the existing sanitary sewer is up to current requirements. Based on the design, there should not be any liquid discharges from the MOX plant so no additional cost or impact on the schedule is projected.

It is estimated that the total cost for permits associated with Clean Water Act will be $200,000 and that the permits can be obtained within one to two years of the project initiation.

ENDANGERED SPECIES APPROVAL: A site assessment should be made to determine whether the proposed new activities will disturb critical habitat. This should only take a few months to complete and cost less than $15,000.

EXCAVATION PERMIT: For this proposed project, excavation will be necessary and an excavation permit will be required. This permit will only take a month to complete and cost less than $5,000

PERMITTING PLAN: A Permitting Plan would also be completed for this project. Development of this plan would take less than a month and cost less than $10,000. The Permitting Plan would coordinate and initiate the permit applications and NEPA documentation, and would provide more detailed schedules and costs for permitting the new process of BNFP.

SUMMARY OF STATE PERMITTING: At this time, and with the information provided in the current work scope, permitting for the BNFP proposed project is estimated to take about 2 years to complete, and cost about $ 730,000.

COMPARISON WITH STATE OF WASHINGTON: The prior study of FMEF concluded that about $ 2.5 million would be required to achieve all of the permitting and licensing required by the State of Washington. The study team recognizes the large difference between these estimates and believe some of the difference may be justified based on different laws and practices in the two states. Further study is required to determine if the entire difference is justified.

6.3 NRC Licensing

Private use of BNFP to produce nuclear fuel requires NRC licensing under 10CFR70. This regulation is currently in revision and the NRC staff has recommended to the study team that the new NRC guidance documents be used for an application, even if the current regulations are not changed.

Three documents are required to secure an appropriate NRC license. The first is a detailed Safety Analysis Report (SAR), prepared in accordance with Regulatory Guide 3.52, draft Standard Format and Content Guide for the Health and Safety Sections of License Applications for Fuel Cycle Facilities. The NRC's draft Standard Review Plan for a SAR to 10CFR70 is contained in NUREG 1530.

In addition to estimating the costs to file and defend the required document, a review of the schedule for such actions was also performed and reviewed with the NRC staff. This included review of the public hearing process and schedule.

Table 6.1 shown at the end of this chapter is a detailed estimate of the time and manpower required to prepare and defend the SAR. The SAR preparation will require 12 months and the NRC review will occur over a minimum of 18 months and a maximum of 24 months. During this time it is estimated that the applicant will require 256 man-months of technical personnel at a cost of $3.9M. All of the work would be performed by applicant staff and contractors. The resources to prepare the application are available in the nuclear industry marketplace.

After the SAR is submitted to NRC, the staff reviews the analysis, interacts with the applicant where questions arise, and prepares a Safety Evaluation Report. Under current NRC regulations, the cost of this review is to be recovered from the applicant. The study team estimates this review will require no more than 24 months. It could occur in as few as 18 months if a priority was requested for the review by the DOE, as an interested agency, to disposition plutonium which has been characterized as a "clear and present danger". The NRC review is estimated to require about 10 man-years and, at $135/hr, will cost about $2.5 million. These cost and schedule estimates were reviewed with the NRC staff currently assigned responsibility for licensing a facility such as BNFP, and their feedback has been included in the estimates.

Upon receipt of application a notice of intent for an informal public hearing would be given. Following issue by the NRC staff of the SER and EIS, the hearing would be held. Granting of the license takes place in a relatively short period of time after the hearing for a Part 70 license. Subpart L of Section 2 defines the hearing notice and adjudication process. Support to this process is difficult to estimate but is projected to be from nothing to less than $1.6M, based upon having a staff of 4 for up to two years.

Thus, the study team estimates that it will require about 3 years, from initiation of SAR preparation to license issuance, for an NRC operating license, with a total cost of $ 8 million. This amount has been included in our capital cost estimate. This estimate is somewhat less than that provided earlier for licensing of the Hanford FMEF facility for MOX fuel fabrication and, consequently, we

have revised the FMEF estimates down to $ 8 million to be consistent. If either project were to proceed, close interaction with NRC Nuclear Material Safeguards and Security (NMSS) would minimize delays.

In this regard, the study team notes that NMSS has recently begun a complete revision to their rules and regulations for licensing nuclear materials facilities, and is seeking review of the proposed revisions currently (A public meeting was held on May 2, 1995). The proposed amendment to part 70 takes "a performance-oriented, systems approach to regulation, with requirements graded according to risk, rather than the narrowly prescriptive, compartmentalized approach that comprises the present requirements." This revision will not be expected to affect the schedule since we have assumed that application will meet the requirements of the current regulations as well as proposed revised regulation. Indeed, it appears that the resulting regulatory regime will afford an improved basis for licensing of BNFP. The Regulatory Guide 3.52 and its amendment Standard Review Plan, NUREG 1352, clearly define the required safety and environmental evaluation submittals for license application. The study team recommended in the earlier report on FMEF that DOE inform NRC that DOE supports the formal publication of the new rules and the associated regulatory guidance, on the schedule defined in SECY-94-057A, and request Commission support in meeting this new schedule. The study team again urges DOE to formally take such a position.

The study members met with NRC staff in May. The purpose of the meeting was to present the general system design concept of the BNFP MOX fuel fabrication facility to NRC, and to obtain inputs from NRC on the licensing requirements and regulatory process. The meeting was held with positive exchange of information. The inputs provided by NRC staff contributed to a higher confidence in the results of this study in the licensing area.

An important finding from meeting with the NRC staff is that depending on the final NRC decision on the regulatory process for the BNFP MOX facility, the procedural requirements of public hearings under Subpart L of Part 70 are quite modest, as compared to requirements normally applicable to licensing of nuclear power plants.

6.4 Facility Conversion and Operation as Related to Licensing

The schedule for facility conversion assumes that building modifications, equipment procurement and installation can proceed in parallel with the NRC licensing review. This assumption was confirmed as reasonable by NRC staff. A specific request per §70.73(b) would be required to commence conversion activities prior to license approval..

This study assumed that the BNFP would be privately owned and require licensing by the Nuclear Regulatory Commission for operation as a MOX fabrication facility. Once the license is issued, an annual fee of $3,000.000 must be paid to retain the license. Periodic reviews by the NRC staff are charged at $135 per hour and the study team has anticipated that an on-site inspector would be employed by the NRC. The periodic review could cost an additional $300,000 for a total annual cost of $3,300,000. This cost has been included in the annual operating costs in chapter 9.

6.5 Summary of Regulatory and Licensing Costs

SAR preparation and submittal;	$3.9	million
NRC licensing application;	2.5	
Public hearing process;	1.6	
State permitting;	0.73	
Sub-Total;	$8.73	million
Contigency at 30%	2.62	
Total;	$11.349	million

Table 6.1
10CFR 70 Application for Group C License

		Prepare SAR				Application	Comment Resolution						Total
	Quarter:	1	2	3	4		1	2	3	4	5	6	
													0
1.0	**General Information**												**15**
1.1	Facility and Process Description	2						1					3
1.2	Institutional Information	1						1					2
1.3	Site Description	4	4						2				10
2.0	**Management Organization**												**3**
2.1	Organization and Administration (O/A)	2											2
2.2	Safety Comittees	1											1
3.0	**Conduct of Operations**												**33**
3.1	Configuration Management		2					1					3
3.2	Maintenance		2	1					1				4
3.3	Quality Assurance		1	2	2			1					6
3.4	Training and Qualification			2	2				1				5
3.5	Human Factors		1	2				1					4
3.6	Audits and Assessments			1									1
3.7	Incident Investigations			2									2
3.8	Records Management		2	2				1					5
3.9	Procedures				2					1			3
4.0	**Integrated Safety Analysis**												**51**
4.1	Site Description		1										1
4.2	Facility Description		1		1					1			3
4.3	Process Description		1	1					1				3
4.4	Process Safety Information		1										1
4.5	Training and Qualifications of ISA Team		3										3
4.6	ISA Methods		1										1
4.7	Results of the ISA			12	12				3	3		2	32
4.8	Controls for Prevention/Mitigation of Accidents				3						1	2	6
4.9	Administrative Control of the ISA				1								1
5.0	**Radiation Safety**												**19**
5.1	As Low as Reasonably Achievable (ALARA)	1											1
5.2	Organizational Relationships and Personnel Qualifications	1											1
5.3	Radiation Safety Procedures and Radiological Work Permits (RWP)	1											1
5.4	Training		1										1
5.5	Ventilation Systems		1										1
5.6	Air Sampling		1								1		2
5.7	Contamination Control			1							1		2
5.8	External Exposure			1									1
5.9	Internal Exposure			1									1
5.10	Summing Internal and External Exposure			1									1
5.11	Respiratory Protection			1									1
5.12	Instrumentation				1						1		2
5.13	Integrated Safety Analysis				3						1		4

Note: Estimates in Man-months for each time segment in quarters. Section totals in bold. Totals in right column and bottom.

Table 6.1
10CFR 70 Application for Group C License

6.0	**Nuclear Criticality Safety**												**34**
6.1	NCS Technical Practices	3	3	4	5						2	2	19
6.2	Administrative Practices	3	3	3	3						2	1	15
7.0	**Chemical Safety**												**6**
7.1	Chemical Safety Program		1										1
7.2	Chemical Safety Controls		1										1
7.3	Reliability of Controls		1										1
7.4	Consequence Estimates			2							1		3
8.0	**Fire Safety**												**12**
8.1	Organization and Conduct of Operations		3										3
8.2	Fire Protection Features and Systems			2							1		3
8.3	Manual Fire-Fighting Capability			1									1
8.4	Fire Hazard Analysis				3							2	5
8.5	References												0
9.0	**Emergency Management**												**25**
9.1	Description of On-site and Off-site Emergency Facilities			2									2
9.2	Types of Accidents			1									1
9.3	Classification of Accidents			1									1
9.4	Detection of Accidents			1									1
9.5	Mitigation of Consequences				1								1
9.6	Assessment of Releases				2							1	3
9.7	Responsibilities of Licensee and Other Organizational Personnel				2							1	3
9.8	Notification and Coordination				1								1
9.9	Description of the Emergency Operational Center				1								1
9.10	Information to be Communicated and the Parties to be Contacted				1								1
9.11	Public Notification				1								1
9.12	Training				1								1
9.13	Procedures for Safe Shutdown and Recovery				2							1	3
9.14	Drills and Exercises				2							1	3
9.15	Procedures for Identifying, Locating, and Controlling Hazardous Chemicals				1								1
9.16	Responsibilities for Developing and Maintaining Current the Emergency Program and its Procedures				1								1
10.0	**Environmental Protection**												**42**
10.1	Environmental Report			12	12						2	2	28
10.2	Environmental Safety Program			4	10								14
11.0	**Decommissioning**												**16**
11.1	Conceptual Decommissioning Plan (CDP)		3	3	6								12
11.2	Decommissioning Funding Plan and Financial Assurance Mechanisms			1	3								4
	Total:	19	38	67	85	0	0	6	8	5	13	15	
					209							**47**	**256**

Note: Estimates in Man-months for each time segment in quarters. Section totals in bold. Totals in right column and bottom.

7.0 Safeguards and Accountability

Safeguarding and securing plutonium materials during storage and processing in the CANDU MOX facility will be a major consideration. While these considerations were taken into account in the original design of the BNFP, neither the accounting systems or the security systems are in place to perform these functions. It is anticipated that the CANDU MOX facility would be operated under full international safeguards by the IAEA. The following sections provide an overview of the systems and outline the steps that are anticipated to bring these systems on-line and or upgrade them to current standards.

7.1 Accountability System

An accountability computer system will be required to administer all SNM transfers within the BNFP. The system must provide near real-time records of the location and quantity of all SNM in the facility in order to meet NRC requirements. NUREG-1280 , "Standard Format and Content Acceptance Criteria for the Material Control and Accounting (MC&A) Reform Amendment", presents criteria that can be used by an applicant and will be used by the NRC license reviewers in the preparation and subsequent review of the fundamental nuclear material control (FNMC) plan. Such a plan is required to be submitted in accordance with 10 CFR 74. The cost of this plan has been included in the total estimate for the accountability system.

Movements of SNM must be traced by accumulating both automatic and manual data entries from various facility locations. The system must also maintain a history of transactions including a holdup account for all loose SNM for each hood, glove-box, enclosure, or storage location. Periodic NDA and/or process operation calculations must be used to verify the accuracy of holdup estimates. In addition to performing the MC&A function, the accountability computer can be designed as part of the criticality control system by limiting the amount of material outside of fixed storage locations. Secondary functions for this system could also include providing supervisory control of the automated SNM Storage System and interfacing with the Security System to protect fuel materials from diversion.

To accomplish these objectives, near real-time data from the process would be utilized to establish the compositions of SNM, by isotope and the net weight of each batch, item, or container. As materials moved through the process, it would be mixed with other materials (dry scrap, MOX powder, organic binder, lubricant, etc.) and changed by processes such as sintering, all of which change the composition and weight of the material. The system must be designed to model these changes and track the quantity of each accountable isotope based on measured parameters (usually weight and an identification number).

7.2 Summary of IAEA Requirements

Safeguarding of a facility under IAEA oversight is a part of the NRC review. The IAEA must also be satisfied that the system meets their requirements. There is a specific protocol that the NRC International Safeguards Branch goes through for such applications and a MOX facility at BNFP would probably be placed "under agreement" and subject to actual IAEA inspections. It is recommended that appropriate interactions with NRC and IAEA staff be maintained during the early design stages of the MOX fuel facility, and inputs on regulatory requirements may be timely implemented into the system design before it is finalized.

NRC will include the facility on the IAEA database list and submit this to the Senate. The Senate would have 60 days to act on the proposal to add the facility to the IAEA list. If ratified, the initial inventory declaration including the forms, quantities, and locations of SNM located (or to be located) within the facility must be offered up within 30 days. The facility operation would prepare the Design Information Questionnaire (DIQ) to be submitted within 45 days of Senate ratification. The DIQ includes information such as:

description of the facility,
overall process parameters,
Nuclear Materials flow,
protection and security measures,
proposed nuclear material accountancy, and
key measurement points (KMPs).

The IAEA would utilize the DIQ to develop a draft Safeguards Approach. The Safeguards Approach prepared by the IAEA would include proposals for the frequency of inspection, verification measurements (both non-destructive and destructive), containment/surveillance measures (C/S), and records and reports. The Design Information Verification is performed by IAEA with the assistance of the facility operation and includes tours, consultations, and review of the facility drawings. In the case of a new process line, as is the case for BNFP, it is expected that the Design Information Verification phase would be spread out over a longer period of time with the information provided to the IAEA as it is developed. The U.S. Government (State Department) and the IAEA negotiate to agree on the Facility Attachment. The Facility Attachment specifies the provisions necessary to implement the safeguards approach at the facility. It includes a short facility description, change provisions which are required to accommodate the IAEA Safeguards (if any), MC&A and C/S description, Records and Reports system, administrative procedures, NM termination/exemptions and summarizes routine inspections.

To implement the Safeguards Approach agreed to in the Facility Attachment, the IAEA and facility will install safeguards equipment as necessary including any additional Non-destructive Assay (NDA) equipment, facilities for NDA calibration and equipment for Containment/Surveillance (C/S). The IAEA may insist on using their own equipment for measuring and sampling associated with KMPs or they may allow "joint use" of facility equipment with some control over certification.

There are three types of IAEA inspections. The first is the Ad Hoc inspection whose goal is to independently verify the declaration for initial SNM inventory, changes in inventory or international shipments/receipts. These inspections are done prior to completion of the Facility Attachment. After completion of the Facility Attachment, routine inspections are performed to independently verify agreement between U.S. reports and Facility Records, operator SNM declarations (including form, quantity, and composition), discrepancies/uncertainties in facility MC&A system and continuity of knowledge (C/S system). Special inspections may be performed to verify special reports (facility report of NM loss, C/S failure, etc.) or investigate unusual situations. The IAEA Safeguards measures include examination of records and reports, item counting and identification, non-destructive assay (NDA), Destructive Analysis (DA), Containment/Surveillance (C/S) and authentication. IAEA routinely takes process samples to verify declared materials and operations. These samples are sent to IAEA's Safeguards Analytical Laboratory at Seiborsdorf, Austria, where they are either analyzed or sent on to IAEA's network of analytical laboratories. The Containment/Surveillance program is used for the safeguarding of "items" such as stored containers, pins or bundles. The objective is to maintain continuity of knowledge during inspector absence using techniques such as high reliability cameras and seals.

Of the four MOX fuel fabrication plants under IAEA safeguards, only one, the PFPF located in Japan, utilizes "Near Real Time Accountancy." In addition, the Siemens MOX II facility (not yet in operation) was designed to use Near Real Time Accountancy and is the only facility with a throughput capacity comparable to that of the proposed CANDU MOX facility. The majority of materials are either not contained, or are not static; therefore a Containment/Surveillance (C/S) system approach to safeguards may not be practical. Based on the required throughput and required availability, a near real-time approach may be preferred. It is also possible that IAEA inspectors would have to be located in the facility on a continuous basis. The KMPs which utilize HLNC or HRGS type instruments may have to be located at various points other than the feed material receiving and fuel assembly bundle shipping locations. For the purpose of this study, it is assumed that PuO2 feed material will not be under IAEA safeguards until it is received at the BNFP and will require assay at the point of receipt. It is also assumed that finished fuel bundles will require NDA before they are shipped from the facility and that completed elements will require NDA before they are sent from the Element lines to Bundle Assembly. It is assumed that other data requirements are accommodated using NDA and DA sampling of powder and pellets taken from the process.

It is anticipated that space will need to be provided for the following:

1) Space for a NDA lab for IAEA. It is possible that this could be a "Joint Use" facility, but for the purpose of the study, it is assumed that it will not be.

2) Office space for IAEA personnel.

3) Computer room for IAEA data collection and report generation.

4) Handling and shipping facility for shipping samples to Austria.

7.3 Accountability Data Collection System

Safeguards data collection for the facility will originate from the process control system, for example, from manual sampling stations located at various points in the building. Data which originates in the facility will be collected and maintained by the BNFP safeguards computer system. All SNM data collected on the BNFP site will be maintained by a Nuclear Materials Safeguards System similar to the one described in AECLT's previous study for the FMEF site. The system would receive data from the BNFP Facility Safeguards system. The Nuclear Materials Safeguards System in turn will transmit the information to the Nuclear Materials Management and Safeguards System which maintains records for the entire country. At the present time, Nuclear Materials Management and Safeguards System is being revised which may necessitate changes to the Nuclear Materials Safeguards System intended for the BNFP MOX facility.

The Data Center computers along with software development for the appropriate application software will be needed to facilitate the operation of the Nuclear Materials Safeguards System. Installation of the BNFP safeguards computer system is estimated to be approximately $60K for the central server and approximately $10K per station for a total of $100K. In addition, conversion and upgrade of the applications software is expected to cost an additional $275K.

The costs of bundle assay equipment will be about $400K each (it is likely that at least two will be required). In addition, assay equipment will be required for feed materials, process samples, etc.

7.4 Summary of Safeguards and Accountability Costs

Based on the costs reported for the PFPF located in Japan, a total programmatic cost of about $10 M should be expected. For purposes of this study, it is estimated that 80% of these costs will be incurred during the facility planning, design and licensing phases, with 20% during procurement and installation phases. With a contingency at 15% of the estimated cost, the total cost for safeguards and accountability provisions is $11.5 million.

8.0 Physical Security Requirements

This chapter describes the overall considerations and provisions for addressing the physical security of the BNFP MOX facility. An estimate of the costs associated with physical security provisions is also presented.

8.1 Overall Requirement

A security protection plan and a system to implement the plan is required for a Group C (Category 1) Part 70 license. NUREG-1456, "An Alternative Format for Category 1 Fuel Cycle Facility Physical Protection Plans" presents criteria that can be used by an applicant and will be used by the NRC license reviewers in the preparation and subsequent review of the Physical Security Plan. Such a plan is required to be submitted in accordance with 10 CFR 73.20, 73.45, and 73.46.

8.2 Existing Systems

The BNFP has no installed security protection systems and does not have the required site access control barriers for Group C Part 70 license.
However, the BNFP was designed with security in mind: it has no windows, its walls are two (2) foot thick concrete, and redundant power is provided. The interior of the building can be easily subdivided into security areas.

8.3 Perimeter Security

The BNFP has the necessary space for a 100-foot-wide double-fenced isolation zone surrounding the facility to meet the requirements for a protected area. Two 8-foot-high chain link security fences with barbed wire outriggers on top must be erected with an Israeli taut-wire intrusion detection fence system, integrated vehicle barrier and a line of microwave motion detectors. The isolation zone must be lighted by offset rows of lights around the inner and outer fences. Fixed lens cameras and pan-tilt-zoom-focus cameras will also be necessary to provide assessment capability of the isolation zone.

A protective guard station (PGS) is in place to control pedestrian and vehicular traffic into and out of the BNFP Protected Area. The PGS must be augmented to include metal detectors and X-ray units to screen personnel, truck lock equipped with sliding gates, movable crash beam, or microwave and infrared motion detectors.

8.4 Interior Security

Interior security systems will also be required. Intrusion detectors will be required including infrared detectors, microwave detectors, ultrasonic detectors, and balanced magnetic switches. These detectors, along with their associated CCTV systems (for assessment purposes), must be designed to have their alarm signals forwarded to the Central Alarm Station () and a Secondary Alarm Station (SAS) for monitoring, surveillance, guard deployment and backup.

8.5 Security Upgrade Costs

The total estimated cost to upgrade BNFP physical security to meet the above requirements is $7 million.

The estimated annual operating costs associated with BNFP security related functions are estimated to be $10M. With BNFP requiring a perimeter protection area (PA) plus three material access areas, the security staffing is estimated at 70 FTEs at a cost of $9M per year. Additional costs of

$1M are estimated to cover coordination activities, maintenance, security training and necessary compliance activities such as a yearly vulnerability analysis and Site Safeguards and Security Plan.

9.0 Operation Of CANDU MOX Fuel Facility At BNFP Site

This chapter describes the plan for the operation of the BNFP MOX facility after it is converted, and includes the estimated cots for annual materials procurement, operations, waste disposal, maintenance and capital replacement, and ultimate decontamination and decommissioning. Separate cost estimates are made for the base case of the reference fuel design, the CANFLEX design, and the hybrid approach in which a transition is made from reference to CANFLEX fuel after five years of operations. For the most part, costs were derived from the earlier 1994 study of FMEF operation, and were not changed for BNFP. Changes were only made for justifiable reasons, such as the different labor rates at the two sites.

9.1 General Operational Considerations

The operation of a CANDU MOX fuel manufacturing facility will involve a dedicated team of workers and management personnel thoroughly trained in CANDU fuel manufacturing skills as well as all the skills required to handle plutonium materials, including especially those important to occupational health, material security and accountability, and criticality concerns. The study team has estimated that a work force of about 135 workers will be required to conduct operations, on a two shift per day, five day per week basis. The sintering furnaces will be operated on a three shift, around the clock basis. This total work-force includes ten specialists in safeguards and material accountability. The work-force will need to be augmented by site security and outside facility support personnel and these costs are treated separately.

9.2 Materials and Supplies

9.2.1 UO_2 Feed material

The reference case of UO_2 feed material supply required for BNFP MOX fuel production is the same as the case for the FMEF site. The UO_2 will be supplied by converting UF_6 from the Oak Ridge stock material and conversion facility. The estimated cost of the UO_2 feed material conversion is $4.348 million, same as for the FMEF MOX facility.

An alternative exists at DOE's Savannah River nuclear site in the form of depleted uranium trioxide (UO_3). The material is partially hydrated crystalline UO_3 with U^{235} isotopic about 0.15 to 0.20% by weight and the available quantity (15,000 metric ton U) is more than enough to produce either 170 metric ton U (as DUO_2) per year or 340 metric ton per year, as the case may be, for 25 years. Further information on this material is contained in a Westinghouse Savannah River Company's report (WSRC-TR-95-0274) dated July 1995.

Should this material be considered in preference to using depleted UF_6 from Oak Ridge, the reference plan for converting the DUO_3 to DUO_2, would be to transport the requisite quantities to Cameco Corporations conversion operations at Port Hope, Ontario for conversion in the existing and currently operating 500 metric ton per year conversion plant which is designed to accept granular UO_3 as input and to produce high quality UO_2. The process would be to dissolve the DUO_3 in nitric acid followed by precipitation to ADU and reduction to DUO_2 by calcining in a hydrogen atmosphere, then followed by conditioning and blending. Most of the resulting UO_2 (80%) could be shipped to the BNFP facility or the Hanford FMEF facility, as the case may be, for blending with PuO_2 powder with the remainder sent to the manufacturer of the Dysprosium containing elements.

The foregoing is based on a preliminary analysis and the resulting assumption that the available DUO_3 can be used, without further refining, to produce DUO_2 that meets chemical impurity limits and pellet formation characteristics. More detailed chemical analysis and material characterization would be needed to confirm this assumption and the processing costs before committing to the use of this feed material. Costs for processing this supply of DUO_2 from DUO_3 should be significantly lower than for formation of DUO_2 from depleted UF_6, due to elimination of the need for a de-fluorination unit.

For the 170 metric ton U/year production case, the estimate of the cost Of UO_2 conversion is $15.75 per kgU. This cost including shipping of DUO_3 to Cameco and DUO_2 to FMEF or BNFP. For scheduling purposes, it is estimated that full production could begin within 6 months after a firm decision for going ahead.

Based on the 170 metric ton U/year throughput case above, the cost of providing the needed UO_2 feed material at the BNFP MOX facility will be $2.623 million per year; reflecting an annual cost reduction of about $1.7 million per year from the reference UF_6 case. It should be noted that this cost savings would also apply to the FMEF case; the determining factor is which source of depleted uranium the DOE wishes to use for its plutonium disposition program, and not which site the DOE decides to use for the MOX production operation.

9.2.2 Other Feed Materials and Fuel Components

Each CANDU fuel bundle contains structural related components including cladding, spacers and endplates. The annual costs of these components is estimated at $5.1 million. The inner two rings of each fuel bundle consist of seven dysprosium poison pins. The cost of these components is estimated to be $2.56 million. The CANDU MOX fuel uses natural uranium pellets at the end of each fuel pin before seal welding. The cost of these filler fuel pellets is estimated at $0.41 million. Other consumables are estimated at $2.0 million.

9.3 Facility Labor and Management

The total annual labor cost for the facility is estimated to be $12,150,000. This estimate is based on an average of $90,000 annual compensation per worker including benefits. The labor rate for the BNFP site was determined by comparing the 1994 labor classification and statistics data obtained for the U.S. Department of Labor for the Savannah River, SC region. The labor rate used in the FMEF operational cost analysis was $100,000 annual compensation per worker including benefits, and is also consistent with the data obtained from the Department of Labor.

The facility startup costs are included in the capitalized facility costs summarized in Chapter 10. These startup costs were derived by assuming a six month training program for the 135 personnel, amounting to a total startup cost of $6,075,000. In practice, the training will occur over a longer time period than six months with the actual staff building up gradually to the full complement in time for the commissioning of the equipment and processes.

Additional indirect costs of operation include general and administrative expenses and operating fees of about $4 million per year and technology transfer fees of $5 million per year. This is an estimate of fees for transferring both the fabrication technology and the fuel performance technology from the current owners of this technology.

The cost for disposing low level wastes generated in the MOX fuel fabrication process is estimated to be $3.56 million. The basis for these estimates are included in our 1994 report. The annual NRC licensing fee of the BNFP (and the FMEF) MOX facility will be about $3.3 million. The basis for this estimate is covered in section 6.4.

9.4 Facility Support Services

The cost of BNFP site security operation is estimated to be $10 million per year, same as the cost for the FMEF MOX fuel facility. The landlord cost which covers the utilities and other non-security site support services, have been estimated at $7 million per year, about $3 million per year less than at FMEF. This lower estimate results primarily from the lower anticipated costs for privatized services at the Barnwell site, as compared to the costs of Government services at the Hanford site.

9.5 Other Operational Related Activities and Costs

9.5.1 BNFP Facility Decontamination and Decommissioning

In order to minimize future decontamination and decommissioning costs, all sections of the Barnwell Fuel Plant that are not expected to be used for the MOX fuel fabrication will be sealed-off from the operating CANDU MOX fuel fabrication facility (including piping and duct) and all chemical reprocessing equipment will be removed from those areas that are expected to be used for MOX fuel production. In addition, the CANDU BNFP MOX fuel facility design will minimize the floor and space size requirement and stainless steel sheet covering of operational surfaces and areas will be used when appropriate. Other considerations to facilitate the decommissioning of the BNFP CANDU MOX fuel facility include:

- designing the glove-boxes and the process enclosures with removable shielding and polished interior surfaces
- locating process equipment within glove-boxes or other process enclosures
- minimizing of long runs, curves, and turns of ductwork that could be contaminated
- having modular and separable enclosures and finishing walls, ceilings and floors with stripable coverings where liners are not placed

At this time, very little documented decontamination and decommissioning experience exists on which to estimate costs for plutonium facilities:

- A plutonium-238 processing facility at the Savannah River Site (SRS) has been undergoing decontamination and decommissioning intermittently since 1984. A cost of $2,500 per square foot of plutonium facility has been reported, excluding the solid waste processing cost resulting from decommissioning activities. However, it should be noted that waste-related items may account for nearly 35% of decommissioning costs and that this plutonium facility was located within a fuel reprocessing canyon building.
- The NFS Erwin plutonium facilities for which a very conservative $2,500 per square foot has been reported.
- The B&W Apollo and Parks Township facility for which a rough estimate of $250/ft^2$ has been reported.

For purposes of this study, we have assumed that because of the design provisions taken, costs in the order of magnitude of $40-million should be anticipated for decontamination and removal of all contaminated equipment of the BNFP MOX fuel fabrication facility. This estimate includes an allowance for an increase in facility area from 41,000 square feet (at FMEF) to 44,000 square feet. This would recover the BNFP facility to a condition that is similar to current state instead of a green-field condition. This same assumption was applied in the FMEF MOX fuel supply study.

9.5.2 Capital Replacement

The BNFP MOX facility will require periodic replacement and upgrading of capital equipment and supporting systems. The cost of periodic capital replacement for the BNFP facility is estimated to be $1.5 million annually. The capital replacement cost was not included in the original FMEF facility study. This cost is now added to the FMEF cost summary which is presented in Chapter 11.

9.5.3 Insurance Costs

Two types of insurance costs have been included; liability and property insurance. Private nuclear accident liability insurance is required to qualify for full Federal Price Anderson coverage. Existing nuclear insurance pools provide this coverage up to a maximum liability of $200 million, which is estimated to cost $400,000 per year. The property damage insurance has been derived from the unit rates currently applicable to other U.S. nuclear fuel cycle facilities and amounts to $200,000 per year for a facility such as BNFP or FMEF. Thus the total insurance costs for BNFP or for FMEF is estimated at $600,000 per year.

9.6 Summary of Operation Costs of the BNFP MOX Facility

The following table summarizes the annual operating costs, exclusive of financing. CANFLEX costs have been estimated based on the increase in numbers of pins and pellets, and associated materials and supplies.

Table 9-1 Summary of Facility Annual Operation Costs

	Ref Fuel		CANFLEX
Materials & Supplies			
UO_2 conversion	4,348,000	(+8%) >	4,700,000
Cladding components	5,107,000	(+35%) >	6,900,000
Dysprosium pins	2,557,000	(+53%) >	3,900,000
Consumables	2,000,000	(+25%) >	2,500,000
Natural uranium pellets	410,000	(-20%) >	325,000
Total	14,422,000		18, 325,000
Labor, Fees, Management			
Production, direct & indirect	12,150,000	(+20%) >	14,580,000
Management, G & A, fees	4,000,000	(+20%) >	4,800,000
Waste disposal	3,560,000	(+20%) >	4,272,000
NRC licensing (I & E) fees	3,300,000	(+20%) >	3,960,000
Technology transfer fees	5,000,000	(+20%) >	6,000,000
Total	28,010,000		33,612,000
Facility Support Services			
Security	10,000,000		10,000,000
Landlord	7,000,000		7,000,000
Total	17,000,000		17,000,000
Annual Decontamination Fund	3,046,000		4,136,000
Capital Replacement	1,500,000		1,600,000
Insurance	600,000		600,000
TOTAL ANNUAL OPERATING COSTS(without financing/depreciation)	64,578,000		75,273,000

9.7 Cost for Transition from Reference Fuel to CANFLEX Fuel

The team evaluated the scope of work required, and the estimated cost and schedule, to convert the BNFP from reference fuel to CANFLEX fuel, if this was decided after several years of operation. There are two phases for such a transition, the design and equipment procurement phase and the facility shutdown and conversion phase.

The estimated cost of replacement equipment is shown on the following table:

New Ring 3 Pin Line	$2,514,000
New Ring 4 Pin Line	2,514,000
Bundle Assembly Line	818,000
Engineering and Project Mgmt	750,000
Subtotal - Equipment and Engineering	$6,596,000

The estimated cost of the shutdown and facility renovation is based on a six month shutdown, with full clean-out of glove-boxes and ancillary equipment, and reinstallation of the new equipment.

Labor costs	$4,000,000	
Management, admin.	2,000,000	
Waste disposal	300,000	
NRC licensing fees	1,500,000	
Security and landlord	8,500,000	
Subtotal - Shutdown, Conversion	$16,300,000	
Total Cost for CANFLEX Transition	$22,896,000	or **$23 million.**

10.0 Costs and Schedule for the Privatization of CANDU MOX Facility

At the request of DOE, AECLT's fuel supply team examined the costs and schedule of implementing a CANDU MOX fuel fabrication program at BNFP with private ownership and operation. This chapter presents the results of the privatization evaluation.

10.1 Overall Concept of Privatization

An essential prerequisite for the proposed CANDU plutonium disposition program is that the utility, Ontario Hydro, must be assured that:

(a) switching from their present natural uranium supply situation to this MOX supply will not disrupt their overall fuel supply plan (for Bruce A and their other 16 reactor plants) which has been developed and implemented at great effort over many years; and

(b) the MOX fuel supply for the Bruce A reactors which use MOX will be of sufficient quality and reliability (guaranteed supply) that they can fully depend on this supply to meet their customers' electricity needs.

To achieve this level of assurance by the utility, it is essential that the utility and its current fuel suppliers, be directly involved in the entire MOX fuel fabrication program, from inception through development and licensing, through production and transportation.

We have based this fuel supply study on the assumption that the MOX facility will be privatized. With the agreement of Ontario Hydro, a consortium of private companies would be established to finance, license, and manage the conversion, operation, and decontamination of the MOX facility. After the U.S. PEIS and Record of Decision (ROD), and any necessary international agreements between the Government of Canada and the United States (including appropriate Environmental reviews in Canada), the DOE would arrange contracts for a minimum level of plutonium disposition, assumed to be 50 tonnes over 15 to 25 years. Contractual arrangements for MOX fuel supply to the utility would also be required.

Privatization will require Government guarantees such as "take or pay" type contracts, or contracts with suitable cancellation penalties. These guarantees would require DOE to pay for all investments in the disposition program, even if U.S. Government policy (e.g. - DOE or NRC) should later require abandonment of the program prior to the full recovery of private investment. Congressional approval would be required for such an arrangement, and this would be part of the implementation plan.

The MOX consortium would require a price for CANDU MOX fuel production which includes all operational costs, financing of facility acquisition, conversion and licensing, and allowance for a reasonable return on investment. The primary risk involved in securing loans for acquisition, conversion and startup of the MOX facility, would then be the technological risk involved in converting and operating the MOX facility. These are expected to be manageable risks and therefore the program would be amenable to acquisition of private financing. A typical financing arrangement is described below, in the context of the overall schedule for implementing the MOX program.

After suitable DOE contracts for disposition and MOX fuel supply are arranged, including the necessary guarantees, the private Consortium would then secure financing, acquire ownership of the site, convert and license the facility for MOX production, operate the facility for the required 15 to 25 year period, and then decontaminate and decommission the facility.

10.2 - Phase I - From DOE ROD/PEIS to Definitive Contracts

This phase would start with the DOE ROD selecting the CANDU option, and the selection of a MOX fabrication site by DOE, (e.g. Hanford, Barnwell, Nevada Test Site, or other location based DOE evaluation of relevant factors such as pit storage, pit conversion, transportation, safeguards and security, etc.) In parallel with DOE's site selection activity, and with the agreement of Ontario Hydro, a private consortium involving both U.S. and Canadian firms would be set up to invest in, own and operate the MOX facility. We estimate that over 75% of the materials and labor required to convert and operate the MOX facility would involve U.S. jobs.

To support this process, facility concept design would begin immediately upon identification of the DOE site and establishment of the Consortium owners. This preliminary work would include finalizing the fuel specifications and cost estimates, including site acquisition and financing arrangements. We have assumed this phase would take about 1 year, although it could take more, or less, depending on the urgency, and the ability of Government agencies to provide decisions and approvals quickly. We have allowed $3.45 million to accomplish the Phase I activities. (this was derived in our 1994 study on FMEF) We expect that DOE funding will be provided for this preliminary work. However, it is possible that some of the funding will be shared by the Consortium partners with the understanding that the investment will be recovered after the program is underway. For purposes of this study, the $3.45 million cost is capitalized, and included in the financing analysis. As shown in the Project Schedule in Figure 10-1, Phase I also includes some work on design of facility modifications and process equipment and layout, as needed to provide confidence in the cost estimates.

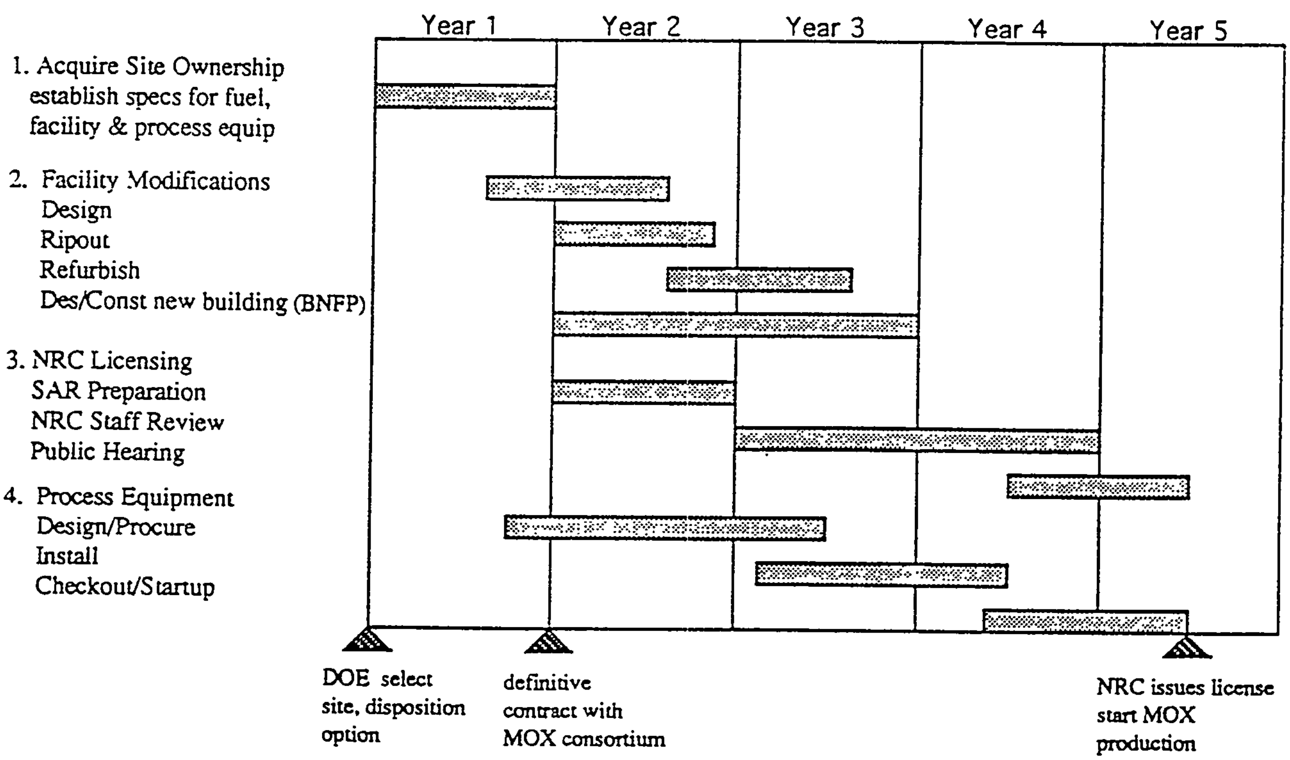

Figure 10-1 - Construction and Startup Schedule

10.3 Phase II - BNFP Facility Conversion and Startup

Financing of the project would be arranged by the Consortium in two steps. First, a construction loan would be secured to cover the cost of facility acquisition, conversion, and startup. The major cost items for establishing a MOX fuel fabrication facility at BNFP are developed in the previous chapters and are summarized below.

	Cost (1994 $ in thousands)
(1) Establish consortium, finalize DOE contract, complete site conceptual design	$3,450
(2) Facility design, modification, ripout, and refurbishment	71,780
(3) Licensing and permitting	11,349
(4) Process equipment including design, installation, and startup costs	74,675
(5) Program management	11,213
Total	$172,467

Financing these construction costs will be secured partly from the equity investment of the partners and partly through loans from private banks. Assumptions for the construction loan are as follows:

Based on a preliminary analysis performed for AECLT by BCM Capital Corporation, cash flow for the first 4 years (1997 through 2001) would involve about $48 million in shareholders equity and $194 million in long term debt. The construction loan is based on a 20% equity - 80 % loan ratio, with the entire loan to be refinanced using long term debt upon completion of facility construction and startup. These represent the sum of current year dollars, assuming the inflation base year is 1993, with annual inflation rate of 4.10%. Additional details of the financial analysis are presented in an internal AECLT report.

10.4 - PHASE III - MOX Facility Production Phase - Standard Fuel

The case of the Standard fuel utilizes 2 metric tons per year of plutonium in two Bruce A reactors, and therefore requires 25 years to dispose of 50 metric tons of plutonium. Cost of operating the MOX facility is estimated in Chapter 9 at $64.6 Million per year in 1994 dollars.

We calculate that the price for this production necessary to cover interest on loans, pay off the capital investment, and provide a reasonable rate of return, is $93.5 million per year in 1994 US dollars. Thus about $29 million/year is required for financing of the construction and operation, and return on investment to the owners. This estimate is based on a detailed analysis performed by BCM Capital Corporation and presented in an internal AECLT report.

For the 25 year disposition program (2001 - 2026) using 2 Bruce reactors on standard fuel, the total MOX fuel supply cost is thus 25 x $ 93.5M = **$2,338 million.**

10.5 Alternative (Preferred) Scenario - Hybrid Operation (5 years standard fuel; 10 years CANFLEX fuel)

In this case, the financing costs are estimated by assuming 5 years of production for the standard CANDU fuel, followed by a 6 month Facility and Bruce Site transition to CANFLEX fuel, which then has a ten year production run. The facility will supply, in two phases respectively, the two different fuels to consume a total of 50 tonnes of plutonium over 15 years. In the first phase, two Bruce reactors will be producing electrical power on MOX fuel, and in the second phase four Bruce reactors will be producing electrical power on MOX fuel.

We have performed a separate financing analysis for this hybrid case. Annual costs for the site average $103.75 million per year averaged over the fifteen years. In practice, costs of $93.5 million per year would be incurred during the first five years on Standard Fuel, and $108.9 million per year would be incurred during the next ten years on CANFLEX fuel. The $23 million of facility transition costs are included in the financing costs.

The net costs then amount to:	Five years on Standard fuel	=	$ 467.5	M
	Ten years on CANFLEX fuel	=	1,088.8	M
	Total Hybrid Case	=	**$1,556.3**	**million**

Cost and schedule for plutonium disposition with the Hybrid case as compared to the standard fuel case is shown in Figure 10-2

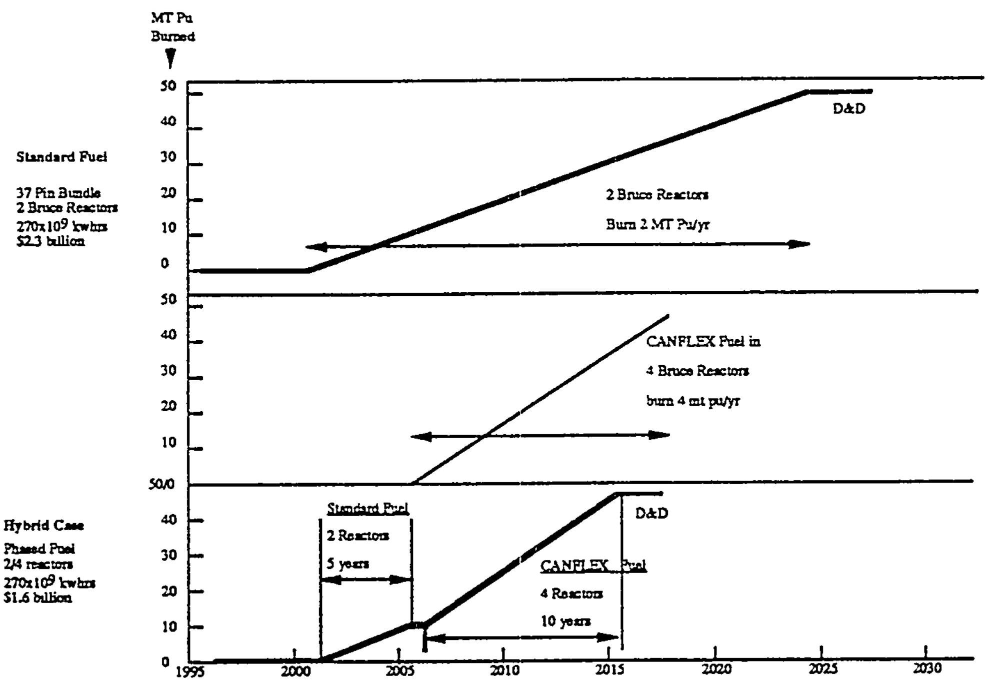

Figure 10-2 CANDU MOX Fuel Utilization Scenarios

10.6 Summary of Financing Assumptions

In analyzing the project, the following assumptions were made:

(1) Two facilities are being considered, the Hanford facility (FMEF) and the Barnwell facility (BNFP). The cost of conversion is estimated at $112 million U.S. for the Hanford facility and $172 million U.S. for the Barnwell facility.

(2) The annual operating cost of each facility is estimated at $67 million U.S. and $65 million U.S. for FMEF and BNFP respectively, exclusive of financing charges and depreciation.

(3) Facility conversion and regulatory approval will take 4 1/2 years for either facility; the agreement between the parties will provide that in the event that the regulatory process is

delayed beyond the stipulated period or if the hearing process is terminated or the project abandoned by the Government, the investors will be compensated.

(4) The plutonium oxide and depleted uranium feed stock will be supplied by the U.S. Government at no cost to the Consortium.

(5) Site acquisition charges are not known and not included in the financial analysis.

(6) The output of the facility will be purchased under a contract that requires purchase of all fuel produced by the facility.

(7) The agreement will also provide that a designated sum be set aside annually in a decontamination and decommissioning fund that in 20 to 30 years (depending on the fuel design option) from the start of the project would be sufficient to decontaminate and decommission the facility.

(8) The private investors in the facility will receive a return based upon the risk assumed. The U.S. Government would assumes all non-technology risk in bringing the facility on stream. The U.S. Government would also guarantee specified quantities of feed materials to the facility, and assures a guaranteed market for consumption of the fuel. Thus much of the conventional credit risk is removed from the project. The risk assumed by the operator of the project is that of technology, i.e. that the facility will be capable of operating correctly so as to produce fuel in sufficient quality and quantities to meet the utility needs and the long term debt obligations used to fund the facility.

11. BNFP and FMEF Facilities Relative Costs

The directive of the DOE is to compare the cost estimates for development of a MOX fabrication plant at two sites, FMEF and BNFP. Preceding chapters have described the modifications required at the BNFP and the costs associated with these modifications. Equipment purchases, licensing, security etc. have also been described, both in the absolute sense and relative one plant to the other. The private financing plan for the two sites is described in Chapter 10.

11.1 Comparison of Initial Capital Costs

The differences in the initial capital costs between the two MOX fabrication facilities and the changes of costs for FMEF from the original report are explained below.

(1) Site Conceptual Design

In the initial submission Plutonium Consumption Program CANDU Reactor Project Final Report, July 31, 1994, a cost of $3 million with a contingency of 15% was estimated for site confirmation and conceptual design of facility modifications and process. It is assumed that similar costs would be required for the Barnwell site.

(2) Process Equipment and Design Cost

The estimate for FMEF is $42.0 million, and for BNFP is $52.8 million. Details can be found in summary form for FMEF in Table 9.2 MOX Fuel Supply Construction and Modification Costs in the original report. Additional detail for FMEF is in Section 4.10 of the original report.

The detail for BNFP is found in section 4 of this report.

In order to ensure an apples to apples comparison the data has been prepared in as comparable a fashion as possible. The difference of $10.8 million is illustrated in the following table (numbers in $millions):

	FMEF	BNFP	Difference
Equipment	19.5	24.4	4.9
Glove Boxes	4.1	4.7	0.6
Installation	4.0	4.9	0.9
Recycle and Pu Finishing Station	5.1	5.1*	0.0
Design Costs	3.9**	4.9**	1.0
PuO_2 Storage and Retrieval	0	2.0	2.0
Contingency @15%	5.5	6.9	1.4
Total	42.0	52.8	10.8

* It was assumed that the cost of this facility would be the same in both locations and it was not specifically costed for BNFP.

** Estimates for the final design of the equipment and facility modifications at FMEF are assumed to be 20% percent of the total equipment costs, as per the original report (page 4-84,85). The design cost for process equipment at BNFP is $4.9 million.

(3) Facility Modifications

The facility modifications for FMEF were estimated to be $20.3 million, and for BNFP $47.3 million, excluding the $24.5 million for a new hardened building. Details can be found in summary form for FMEF in Table 9.2 MOX Fuel Supply Construction and Modification Costs in the original report. Additional detail for FMEF is in Section 4.6.2.6 of the original report.

The detail for BNFP is found in section 5 of this report.

The difference of $27.0 million is illustrated in the following table (numbers in $million):

	FMEF	BNFP	Difference
Security	3.2	4.2*	1.0
Modifications & Refurbishment	8.4	24.4*	16.0
Engineering/Design	2.3	5.7	3.4
Project Management	3.8**	3.4	-0.4
Contingency	2.6*** @15%	9.5 @25%	6.9
Total	20.3	47.3	27.0

* The BNFP data given in Table 5-2 is different from the information provided above. In order to compare the BNFP costs with the comparable costs prepared for FMEF, the engineering 20%), project management (10%) and contingency (25%) calculations that were made in producing the BNFP estimates have been removed from the individual line items of Table 5-2 and summed under engineering, project management and contingency as was done in the FMEF report. The total for BNFP equals the sub-total shown in Table 5-2 of this report.

** The project management number for FMEF was $7.5 million. To permit direct comparison, this was split between Facility Modifications and Overall Program Management.

***The contingency factor for the BNFP modification is 25% reflecting the increased uncertainty inherent in the larger task required to ready BNFP for MOX fuel production.

(4) New Building

The new building requirement does not exist at FMEF but only at BNFP as explained in 5.3.3.4.

(5) Licensing/Permitting

The difference is $2.0 million which is attributable to differences in the estimated costs of the State regulatory process. The original study calculated Washington State costs at $2.5 million. The estimated costs for South Carolina are $0.7 million. The reasons for these differences are presented in Chapter 6. Contingency at 30% for both locations makes up the balance of the difference in cost. Note that the contingency allowance has been increased from 15% used in the original report.

Note that the estimated costs for Federal (NRC) licensing has been reduced compared to our 1994 report. The total Federal costs moved from $10 million to $8 million. The original study allocated costs among the Safety Analysis Report (SAR), NRC licensing fees and Licensing support as $2, 5 and 3 million respectively. Further study as described in Chapter 6 has led us to modify these estimates according to the table shown below (numbers in $million).

	FMEF	BNFP	Difference
State Permitting	2.5	0.7	1.7
SAR Prep and Support	3.9	3.9	0.0
NRC Review	2.5	2.5	0.0
Public Review	1.6	1.6	0.0
Contingency	3.2	2.6	0.6
Total	13.7	11.3	2.3

(6) Safeguards and Accountabilty

The assumptions on safeguards are the same for both facilities and no changes to the original report were needed as a result of further study.

(7) Overall Program Management

As noted above, engineering and project management costs were assigned to this area. These costs would be comparable between the two sites and no changes to the original report are needed.

(8) Checkout, Training and Startup

Assumptions as to these various costs of startup were reviewed and differences noted as in the report. Briefly we determined that wage rates in South Carolina are lower than Washington, but these savings are offset by the increased manpower required to operate the BNFP MOX facility. The BNFP MOX facility requires additional personnel as a result of a more complex plant layout. Financing charges involved in the startup at FMEF ($4.1 million) were erroneously included in the 1994 report) have been removed from the FMEF estimate, and made a part of the private financing described in Chapter 10. The result is that costs at the two sites are estimated to be comparable.

(9) Summary of Comparison of Initial Capital Costs

The total capital cost shown for the FMEF facility in the original report was $117.9 million. Table 11.1 indicates the total cost has dropped to $112.5 million. The difference is attributable to the decreased licensing costs (less $0.7 million even with the higher contingency), and the removal of financing costs for facility checkout, which costs are now included in the overall financing costs.

	FMEF	BNFP
1. Establish Consortium; finalize DOE contract; complete conceptual design	$3,450	$3,450
2. Modify and Refurbish the Facility (includes new building for BNFP)	20,256	71,780
3. Licensing and permitting	13,650	11,349
4. Process Equipment, including safeguards & Security (11.5M) and startup/training (10.35M)	63,896	74,675
5. Program Management	11,213	11,213
TOTAL	**112, 465**	**172,467**

Table 11.1 Comparison of Initial Capital Costs ($ in thousands)

11.2 Comparison of Annual Operating Costs

The differences between the two sites and the changes for FMEF from the original report are explained below.

(1) Materials and Supplies

There is no difference in the estimate of materials and supplies costs between the two sites.

(2) Labor, Fees and Management

Again, the cost of operating the two facilities is virtually identical. The lower labor rates in South Carolina do not entirely offset the increased manpower required to operate the more complex product flow. As a result the annual labor cost at BNFP is $0.15 million higher than the expected cost at FMEF.

The allowance for annual NRC licensing fees has been increased from $2.0 million in the original report to $3.3 million for each site in this report.

(3) Facility Support Services

Facility support services includes the costs of security, landlord functions, maintenance and an annual capital replacement allowance. Security costs are comparable, landlord costs at BNFP are $7.0 vs $10.0 million at FMEF, as the BNFP facility will be maintained by private contractors with lower overheads than the government contractors that must be utilized at FMEF. The annual capital replacement allowance was set at $1.5 million for both sites. Note that this is an addition to the original costs established for FMEF.

(4) Annual Decontamination Fund

In the original study an allowance of $40 million was made for decontamination and removal of all contaminated equipment including glove-boxes and ducting. The same figure is used for BNFP with an allowance for an increase in area from 41,000 square feet to 44,000 square feet. Assuming a real cost of money of 5%, and accrual of the funds over 25 years, gives an annual set aside requirement of $2.8 million for FMEF and $3.0 for BNFP.

(5) Nuclear Liability Insurance

In the original report, no allowance was made for insurance as the option of private ownership was not costed. The assumption is that the cost of insurance will be the same for both facilities and that cost is estimated to be $0.4 million for nuclear liability insurance (maximum currently available commercial insurance of $200 million) and $0.2 million for property damage insurance.

(6) Summary of Comparison of Annual Operating Costs

Table 11.2 below shows a summary of the comparison of annual operating costs at the two sites and by using the two different fuel designs. The costs shown do not include financing costs for the two facilities. The differences that are foreseen in operating the MOX facility at FMEF and BNFP amount to $2.6 million per annum, with BNFP being the less expensive facility to operate.

Table 11.2 Comparison of Annual Operating Costs ($ in thousand)

Fuel Design > Cost Item v	FMEF- Standard fuel	BNFP- Standard fuel	FMEF- CANFLEX	BNFP- CANFLEX
Materials & Supplies	14,422	14,422	17,291	18,325
Labor, Fees & Mgment	27,860	28,010	33,432	33,612
Facility Support Services/Capital Replacement	21,500	18,500	21,600	18,600
Annual Decontam'n Fund	2,838	3,046	3,854	4,136
Nuclear Liability & Damage Insurance	600	600	600	600
Total Costs	67,220	64,578	76,777	75,273

11.3 Comparison of Total Costs Including Financing

The financing model for the two MOX fuel supply facilities are described in Chapter 10. A comparison of total fuel costs for both Standard Fuel and the Hybrid case is provided below.

(1) Standard Fuel: In this case, the financing costs are estimated by assuming MOX fuel production for the standard 37 pin CANDU fuel. The facility will supply MOX fuel bundles to consume 50 tonnes of plutonium in two Bruce reactors over 25 years. Reactor plant consumption of the weapons grade plutonium material would start in the year 2001. The costs shown below are the annualized operational costs over the 25 year life of the MOX facility.

	Ave. Financing cost/year	Operating cost/year	Total cost/year	Total cost over 25 years
BNFP	$28,900,000	$64,600,000	$93,500,000	$2,337,500,000
FMEF	19,000,000	67,200,000	86,200,000	$2,155,000,000

(2) Hybrid Case: In this case, the financing costs are estimated by assuming operating a MOX fuel supply facility for the standard CANDU fuel for the first five years, then the facility will be refurbished to produce the CANFLEX fuel for the next 10 years. The facility will supply, in two phases respectively, the two different fuels to consume a total of 50 tonnes of plutonium over 15 years. In the first phase, two Bruce reactors will be producing electrical power, and in the second phase, four reactors at Bruce Station will be producing electrical power. Reactor plant consumption of the weapons grade plutonium material would start in the year 2001.

	Ave. Financing cost/year	Operating cost/year	Average cost/year	Total cost over 15 years
BNFP	$28,450,000	$75,300,000	$103,750,000	$1,556,250,000
FMEF	19,000,000	76,800,000	95,500,000	$1,432,500,000

APPENDIX A

Excerpts From 1994 AECL Technologies Report on

CANDU Plutonium Consumption Study

1. Executive Summary

2. FEMF Fuel Study Conclusions (Chapter 4)

3. CANDU MOX Fuel Packaging and Transportation (Chapter 5)

appendix A removed for separate processing. na

APPENDIX B

SUMMARY CHRONOLOGY -- MAJOR INFLUENCES, AGNS ACTIVITIES, AND LICENSING ACTIONS RELATED TO THE BNFP

November 6, 1968:	Application for construction permit (Separations Facility and Fuel Receiving and Storage Station, Docket 50-332) made by Allied Chemical. Safety Analysis Report submitted
July 7, 1970:	Environmental Report submitted
October 20-21, 1970:	Public hearings on construction permit application held in Barnwell, SC
December 18, 1970:	Construction permit issued
Early 1971:	Began construction
February 26, 1971:	Official ground breaking
August 26, 1971:	Letter dated August 23, 1971, received from Director of Regulations, USAEC, advising that AEC is developing appropriate regulations to implement July 23 Court of Appeals decision in Calvert Cliffs case, concerning implementation of National Environmental Policy Act (NEPA)
December 8, 1971:	Determination not to suspend AGNS construction permit pending completion of NEPA environmental review announced in Federal Register
June 30, 1972:	Application made for materials license for conversion of uranyl nitrate to uranium hexafluoride (Docket 70-1327), including Environmental Report and Facility Safety Evaluation
January 3, 1973:	Notice of availability of (Separations) Environmental Report and Draft Detailed Statement on Environmental Considerations published in Federal Register, Volume 38, No. 1
July 2, 1973:	Amendment 6 to Application submitted, requesting construction permit amendment to include conversion of plutonium to plutonium oxide. Preliminary SAR Addendum 7 issued, describing the planned plutonium conversion process (Docket 70-1821)
October 10, 1973:	Amendment 7 to Application submitted, requesting conversion of (Separations-FRSS) construction permit to operating license. Final SAR submitted
November 2, 1973:	Construction permit for UF_6 Conversion Facility issued
January 1974:	Final Environmental State (Separations) issued by USAEC
January 1974:	Began construction of UF_6 Conversion Facility
April 29, 1974:	Received (UF_6 Conversion) Draft Environmental Statement on Environmental Considerations

June 17, 1974:	USAEC announced ban on shipment of plutonium nitrate solution, effective June 1978, necessitating conversion of nitrate to solid form prior to shipment
July 1, 1974:	Issued revised PSAR for Plutonium Product Facility (PPF)
July 3, 1974:	Submitted application for authorization for receipt and storage of irradiated fuel in FRSS (early FRSS operation, Docket 70-1729). Filed under Docket 50-332. Submitted AG-L 105, "Technical Description in Support of Application for FRSS Operation"
August 21, 1974:	USAEC issued for comment the draft report, "The Generic Environmental Statement on the Use of Recycle Plutonium in Mixed Oxide Fuels in LWR's" (GESMO), WASH-1327
September 10, 1974:	Public hearings on (Separations) construction permit reopened with formal intervention. Since contentions were identical to those for operating license, hearings were consolidated. Hearing continued at intervals through mid-October
September 1974:	USAEC issued the draft report, "Environment Statement -- Management of Commercial High-Level and Transuranium-Contaminated Radioactive Waste", WASH-1539
December 11, 1974:	Advised USAEC of reasons AGNS finds it necessary to request a policy decision to have the government accept and temporarily store privately owned plutonium nitrate
December 23, 1974:	Advised by USAEC staff than, until GESMO issues were resolved, a delay in the issue of the Final Environmental Statement with respect to PPF would be appropriate
January 1, 1975:	USAEC partitioned into Energy Research and Development Administration (ERDA) and Nuclear Regulatory Commission (NRC)
January 3, 1975:	Submitted Nuclear Materials Safeguards Supplement AG-L 109
January 15, 1975:	Advised NRC that design work on PPF had been suspended indefinitely
May 1975:	(FRSS) Draft Environmental Statement issued by NRC
June 2, 1975:	Submitted report, AG-L 110, Amendment 1, "(FRSS) Summary Preoperational Report"
August 26, 1975:	Public hearings on (Separation) construction permit/operating license resumed in Columbia, SC. Five hearings held between August 26, 1975 and January 23, 1976, at which time hearings were terminated indefinitely
October 1975:	Prehearing conference held on early FRSS operation
November 12, 1975:	NRC issued interim licensing position related to limited plutonium recycle activities. Interim licensing was to be permitted based on the balancing of the following factors: (1) whether the facility can be justified without placing "primary reliance" on the side-scale use of mixed oxide fuel; (2) whether the licensing activity would give rise to such a commitment of

	resources as would unjustifiably foreclose future safeguards alternatives; and (3) the effect on the public interest of a delay in licensing. Resolution of GESMO issues was targeted at early 1977".
December 19, 1975:	Submitted supplement to FSAR, "Analysis of Moisture and Nuclide Transport in an Engineered Interim Waste Storage Berm" (Initial on-site solid waste management licensing activities)
January 30, 1976:	Final Environmental Statement and Safety Evaluation Report issued by NRC for FRSS
May 26, 1976:	Decision by Second Circuit Court of Appeals, interpreted to inhibit NRC's proposed procedures on interim licensing and to prohibit the granting of construction permits and operating licenses for plutonium-related facilities until GESMO resolution
August 1976:	Major construction completed. Preoperational cold checkout activities begun (first initiated in late 1974), including integrated runs with demineralized water, then organic solvent, and then natural uranium
August 1976:	NRC issued the final GESMO report (NUREG-0002), without safeguards supplement
October 16, 1976:	Prehearing conferences held on early FRSS operation
April 7, 1977	President Carter announced a nuclear non-proliferation policy calling for indefinite deferral of domestic commercial reprocessing and the recycle of plutonium and the commencement of domestic and international studies of alternative fuel cycles. GESMO proceedings were suspended within a few days
May 3, 1977:	NRC requested comment on disposition of GESMO from all interested parties, including President Carter, and announced its intention to reassess the November 1975 interim licensing policy
October 1, 1977:	DOE formed
October 4, 1977:	In responding to May 3 request, Stuart Eizenstat replied for the Administration that it was believed non-proliferation initiatives would be assisted if GESMO proceedings were terminated
October 18, 1977:	DOE announced that U.S. would receive spent nuclear fuel for a one-time fee from U.S. utilities and some foreign countries
December 12, 1977:	Began contract period for $13-million FY 1978 research, development, and demonstration program with DOE, Contract No. ET-78-C-09-1040
December 23, 1977:	Order issued by NRC on GESMO which terminated the GESMO proceedings and AGNS's proceedings covering Separations, UF_6, and PPF. The NRC statement left open the possibility of licensing the plant for experimental purposes on a non-commercial basis

APPENDIX C

TABLES CONTAINING MORE DETAILED DATA for SECTION 5.0 - FACILITY MODIFICATIONS

TABLE C-1
SAVANNAH RIVER SITE LOCAL LABOR RATE
($/Hour)

Craft Designation	Base	M&W	Pen.	App.	Total Fringe[a]	Total Package	Total [b]
Boilermaker	17.90	3.25	2.005	.19	5.445	23.345	28.79
Cement Masons	13.15	1.10	1.00	0.1	2.20	15.35	17.55
Elevator Constructors	16.22	---	6.125		6.125	22.345	28.47
Electricians	17.46	1.73	2.493	.43	4.653	21.813	26.47
Laborers	10.26	1.00	.53	.25	1.78	12.04	13.82
Painters	15.16	1.55	1.30	.14	2.99	18.15	21.14
Pipefitters	17.64	2.00	1.47	.08	3.55	21.19	24.74
Sheetmetal Workers	16.63	2.00	1.57	.99	4.56	21.19	25.75
Teamsters (2.5T/over)	13.53	2.025	0.675	0.	2.7[c]	16.23	18.93

a Total Fringe include also FICA, FUI, SUI, Workman's Compensation

b Other labor rates rounded at 22.18 $/hr.

c Fringe paid weekly, does not increase and not paid on overtime.

TABLE C-2
REMOVAL OF CLEAN PUMPS
<300 lbs

Pumps weighing <300 lb will be removed with motors attached. The pump/motor combination will then be sent to a laydown area.

Act ID	Activity Description	Act. Dur	Crit Dur
a	Disconnect power lines to pump motor	20	20
b	Remove insulation/disconnect suction & discharge connections	25	25
c	Unbolt frame from foundation	10	10
d	Remove and transfer to laydown area	10	10
	Totals (Activity/Critical)	65	65

Duration adjustment factor(s):	
Height factor (15% of critical duration)	10
Actual work duration	75
Productive work duration	75
+ Work break factor (8.33% of productive duration)	6
Total work duration	81 min.

Total Duration = 1.350 hr.

Crew	Number	Duration (hr)	Rate ($/hr)	Cost
Laborers	2.0	1.350	$13.82	$37.31
Total labor cost				$37.31
Equipment Costs				--
Consumables/Materials Costs				
-Gas torch consumables 1 @ $5.10/hr x .417 hr				2.13
TOTAL COST Removal of clean pumps, <300 lb				$39.44

TABLE C-3
REMOVAL OF CLEAN PIPING
>8" Diameter

Pipe with a diameter of >8 inches will be cut with a track mounted torch. The pipe will be cut into nominal 10 foot sections. The pipe will be loaded into transfer containers and sent to a laydown area.

Act ID	Activity Description	Act. Dur	Crit Dur
a	Remove insulation	15	15
b	Set up torch and equipment	10	10
c	Rig to pipe	10	10
d	Cut pipe	15	15
e	Remove track mounted torch	10	10
f	Remove pipe to transfer containers and send to laydown area	15	15
	Totals (Activity/Critical)	75	75

Duration adjustment factor(s):	
Height factor (15% of critical duration)	11
Actual work duration	86
Productive work duration	86
+ Work break factor (8.33% of productive duration)	7
Total work duration	93 min.

Total Duration = 1.550 hr.

Crew	Number	Duration (hr)	Rate ($/hr)	Cost
Laborers	3.0	1.550	$13.82	$64.26
Total labor cost				$64.26
Equipment Costs				--
Consumables/Materials Costs				
-Gas torch consumables 1 @ $5.10/hr x .25 hr				1.27
Total				$65.53
TOTAL COST Removal of clean pipe >8" dia., $/lr ft				$6.55

TABLE C-4
REMOVAL OF CLEAN PIPING
<2.5" Diameter

Pipe with a diameter of <2.5 inches will be cut with a manual torch. The pipe will be cut into nominal 10 foot sections. The pipe will be loaded into transfer containers and sent to a laydown area.

Act ID	Activity Description	Act. Dur	Crit Dur
a	Remove insulation	5	5
b	Set up torch and equipment	10	10
c	Cut pipe	5	5
d	Remove torch and equipment	5	5
f	Place pipe in transfer container for removal to laydown area	5	5
Totals (Activity/Critical)		30	30

Duration adjustment factor(s):	
Height factor (15% of critical duration)	5
Actual work duration	35
Productive work duration	35
+ Work break factor (8.33% of productive duration)	3
Total work duration	38 min.

Total Duration = .633 hr.

Crew	Number	Duration (hr)	Rate ($/hr)	Cost
Laborers	3.0	0.633	$13.82	$26.24
Total labor cost				$26.24
Equipment Costs				--
Consumables/Materials Costs				
-Gas torch consumables 1 @ $5.10/hr x .25 hr				0.42
Total				$26.66

To convert from: $/pipe at 10 linear ft/pipe to: $/lr/ft; therefore divide total by 10

TOTAL COST Removal of clean pipe <2.5 dia., $/lr ft	$2.66

TABLE C-5
REMOVAL OF CLEAN TANKS
300-3,000 gal.

Tanks with a volume of 300 to 3,000 gallons will be removed in one piece. The tanks will then be transferred to a laydown area.

Act ID	Activity Description	Act. Dur	Crit Dur
a	Remove insulation	30	30
b	Disconnect intake and discharge piping	60	60
c	Unbolt from floor	60	0
d	Rig for removal	30	30
e	Remove and transfer to laydown area	120	120
	Totals (Activity/Critical)	300	240

Duration adjustment factor(s):		
Height factor (15% of critical duration)	36	
Actual work duration	276	
Productive work duration	276	
+ Work break factor (8.33% of productive duration)	23	
Total work duration	299	min.

Total Duration = 4.983 hr.

Crew	Number	Duration (hr)	Rate ($/hr)	Cost
Laborers	2.0	4.983	$13.82	$206.59
Total labor cost				$206.59
Equipment Costs				--
Consumables/Materials Costs				
-Gas torch consumables 1 @ $5.10/hr x .25 hr				5.10
TOTAL COST Removal of clean tanks, 300-3,000 gallons				$211.59

TABLE C-6
REMOVAL OF CLEAN MISCELLANEOUS EQUIPMENT
<300 lbs.

Small equipment will be disconnected and sent in batches to a laydown area.

Act ID	Activity Description	Act. Dur	Crit Dur
a	De-energize and disconnect power lines to equipment	45	45
b	Unbolt component from mount(s)	20	0
c	Remove component; accumulate & send batches to laydown area	20	20
Totals (Activity/Critical)		85	65

Duration adjustment factor(s):		
Height factor (15% of critical duration)	10	
Actual work duration	75	
Productive work duration	75	
+ Work break factor (8.33% of productive duration)	6	
Total work duration	81	min.

Total Duration = 1.350 hr.

Crew	Number	Duration (hr)	Rate ($/hr)	Cost
Laborers	3.0	1.350	$13.82	$55.97
Total labor cost				$55.97
Equipment Costs				--
Consumables/Materials Costs				--
TOTAL COST Removal of miscellaneous clean equipment, <300 lb				$55.97

TABLE C-7
REMOVAL OF CLEAN MISCELLANEOUS EQUIPMENT
300-1,000 lbs.

Components weighing 300 to 1,000 lb.s. will be de-energized, disconnected, and removed to the laydown area.

Act ID	Activity Description	Act. Dur	Crit Dur
a	De-energize and disconnect power lines to equipment	60	60
b	Unbolt component from mount(s)	30	0
c	Rig component for removal	15	15
d	Remove component and transfer to laydown area	60	60
	Totals (Activity/Critical)	165	135

Duration adjustment factor(s):		
Height factor (15% of critical duration)	20	
Actual work duration	155	
Productive work duration	155	
+ Work break factor (8.33% of productive duration)	13	
Total work duration	168	min.

Total Duration = 2.800 hr.

Crew	Number	Duration (hr)	Rate ($/hr)	Cost
Laborers	4.0	2.800	$13.82	$154.78
Total labor cost				$154.78
Equipment Costs				--
Consumables/Materials Costs				--
TOTAL COST Removal of miscellaneous clean equipment, 300-1,000 lb				$154.78

TABLE C-8
REMOVAL OF CLEAN HVAC DUCTWORK

Removal of clean HVAC ductwork will occur at an average removal rate of approximately 1,000 lb/day; based on 18 gauge galvanized steel @ 125 linear ft/day. Ductwork is assumed 8 lb/linear ft of 10 in x 12 in ductwork. As the basis for this rate was actual performance rates, no adjustment factors are applied against it. The ductwork will be sent to the laydown area.

Act ID	Activity Description	Act. Dur	Crit Dur
a	Remove ductwork and transport to laydown area	480	480
Totals (Activity/Critical)		480	480

Duration adjustment factor(s):

Actual work duration	480
Productive work duration	480
Total work duration	480 min.

Total Duration = 8.000 hr.

Crew	Number	Duration (hr)	Rate ($/hr)	Cost
Laborers	2.0	8.000	$13.82	$221.12
Total labor cost				$221.12
Equipment Costs				--
Consumables/Materials Costs				--

To convert from: $/day @ 1000 lb/day to $/lb; therefore divide total by 1000

TOTAL COST Removal of clean HVAC ductwork, $/lb — $0.22

TABLE C-9
REMOVAL OF MASONRY BLOCK WALL

Removal of standard concrete block will be performed with air powered tools. The listed performance rate is 880 cu ft/day for 12-in. thick walls, or 32.6 cu yd/day. As this is an actual rate; no adjustment factors are applied against this rate.

Act ID	Activity Description	Act. Dur	Crit Dur
a	Remove concrete block with air tools	480	480
Totals (Activity/Critical)		480	480

Duration adjustment factor(s):

Actual work duration	480
Productive work duration	480
Total work duration	480 min.

Total Duration = 8.000 hr.

Crew	Number	Duration (hr)	Rate ($/hr)	Cost
Laborers	5.0	8.000	$13.82	$532.80

Equipment Costs	
--Air compressor/250 CFM 1 @ $4.43/hr x 8.000 hr	35.44
--Air tools & accessories 1 @ $1.01/hr x 8.000 hr	8.08
--Air Hoses/50 ft long 2 @ $0.65/hr x 8.000 hr	10.40
Consumables/Materials Costs	
--Consum. for 250 CFM air comp. 1 @ $6.90/hr x 8.000 hr	55.20
--Consum. for air tools 1 @ $0.57/hr x 8.000 hr	4.56
	113.68
Total	$666.48

To convert from: $/day @ 32.6 cu yd/day, to $cu yd; therefore divide total by 32.6

TOTAL COST Removal of masonry block wall, $/cu yd	$20.44
TOTAL Craft labor required required per cu yd	$1.23

TABLE C-10
REMOVAL OF GRADE SLAB CONCRETE

Removal of grade slab concrete will be performed with air powered tools. The listed performance rate is 25 cu yd/day. As this is an actual rate, no adjustment factors are applied against this rate.

Act ID	Activity Description	Act. Dur	Crit Dur
a	Remove slab concrete with air tools	480	480
Totals (Activity/Critical)		480	480

Duration adjustment factor(s):

Actual work duration	480
Productive work duration	480
Total work duration	480 min.

Total Duration = 8.000 hr.

Crew	Number	Duration (hr)	Rate ($/hr)	Cost
Laborers	7.0	8.000	$13.82	$773.92

Equipment Costs	
--Air compressor/250 CFM 1 @ $4.43/hr x 8.000 hr	35.44
--Hyd. exvtr w/2.5 cu yd bucket 1 @ $68.45/hr x 8.000 hr	547.60
--Air tools & accessories 1 @ $1.01/hr x 8.000 hr	8.08
--Air Hoses/50 ft long 2 @ $0.65/hr x 8.000 hr	10.40
Consumables/Materials Costs	
--Consum. for 250 CFM air comp. 1 @ $6.90/hr x 8.000 hr	55.20
--Consum. for 2.5 cu yd hrd. exvtr 1 @ $41.00/hr x 8.000 hr	328.00
--Consum. for air tools 1 @ $0.57/hr x 8.000 hr	4.56
	989.28
Total	$1,763.20

To convert from: $/day @ 25 cu yd/day, to $cu yd; therefore divide total by 25

TOTAL COST Removal of grade slab concrete, $/cu yd $70.52

TOTAL Craft labor hours required per cu yd $2.24

TABLE C-11
ESTIMATE OF STAINLESS STEEL LINER
RPC CELL (100' X 22')

Description	Quantity	Unit	Material		Manhours		Labor		Subcontract		
			Unit Cost	Material Cost	Unit Manhours	Total Manhours	Labor Rate	Labor Cost	Unit Rate	Total Cost	Total Cost
Bar Joist	2.1	TN	600	1,260	18	38	25.75	978	0	0	2,238
1/4" SS Liner Plate (5'x11' Sheets)	58.6	TN	5,000	293,000	60	3,516	25.75	90,537	0	0	383,537
2"x2"x1/4" SS Angle	10.6	TN	5,000	53,000	9	95	25.75	2,446	0	0	55,446
Welds, Angle, Framework	290	LF	0	0	0.19	55	25.75	1,416	0	0	1,416
Welds, Plate, Full Penetration	4,018	LF	0	0	0.33	1,326	25.75	34,144	0	0	34,144
Total				347,260		5,030		129,521			476,781

A frame of stainless steel angle (2" x 2" x 1/4") is constructed and bolted to the floor and walls of the cell. Also, a bar joist is installed at the top of the cell which allows a simil stainless steel angle frame to be installed in the ceiling. The stainless steel plates are welded to the angle. All edges of the plate are bevelled, thus allowing full penetration welds.

Total square footage: 11,600 ft^2

Stainless steel plate weight: 58.6 tons

TABLE C-12

HVAC UNITS COST BREAKDOWN

Description	Quantity	Unit	Material Unit Cost	Material Material Cost	Manhours Unit Manhours	Manhours Total Manhours	Labor Labor Rate	Labor Labor Cost	Subcontract Unit Rate	Subcontract Total Cost	Total Cost
HVAC Units											
Area Air Handling Unit, 7500 CFM	6	EA	15,090	90,540	70	420	24.76	10,390			$100,930
Supply Air Fan/Motor	6	EA	2,900	17,400	20	120	24.74	2,968			20,368
Exhaust Fan/Motor	6	EA	5,300	31,800	20	120	24.74	2,968	0	0	34,768
HEPA Filter Plenum, 9000 CFM	2	EA	135,000	270,000	36	72	24.74	1,781	0	0	136,781
Grills, Registers, Diffusers		ALL	12,000	12,000	1,000	1,000	20.56	20,560	0	0	32,560
HVAC Dampers		ALL	26,000	26,000	2,000	2,000	20.56	41,120	0	0	67,120
Steel Ductwork (Seismic I)	100,000	LB	0.92	9.200	1,000	1,000	20.56	20,560	0	0	29,760
Fiberglass Insulation Jacket	1,700	LF	9.18	15,606	0.39	663	20.56	13,631	0	0	29,237
											$451,524