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October 7, 1988
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US Nuclear Regulatory Commission
Attn: Document Control Desk
Washington, DC 20555

Dear Sirs:

Three Mile Island Nuclear Station, Unit 2 (TMI-2)
Operating License No. DPR-73
Docket No. 50-320
Processed Water Disposal System
Technical Evaluation Report

Attached for your review and approval is a copy of the Processed Water Disposal System Technical Evaluation Report. The purpose of this report is to provide a description of the processed water disposal system and its interfaces with other plant systems; to provide a technical evaluation of the system's conformance to applicable codes, standards, and regulatory requirements; and to provide a safety evaluation of the system and its operation. This report concludes that the Processed Water Disposal System does not constitute an unreviewed safety question and that the system can be operated as designed without undue risk to the public health and safety. Further, it concludes that the environmental impacts of the system operation and potential accidents involving the system fall within the bounds of activities previously evaluated by the NRC staff in their Programmatic Environmental Impact Statement and its supplements.

Per the requirements of 10 CFR 170, an application fee of $150.00 is enclosed.

Sincerely,

MBRoche

M. B. Roche
Director, TMI-2

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w/check $150
#017555

DHW/mkk

Enclosure: GPU Nuclear Corp. Check No. 01755

cc: R. J. Conte - Senior Resident Inspector, TMI
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GPU NUCLEAR

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DIVISION

TECHNICAL EVALUATION REPORT

FOR

PROCESSED WATER DISPOSAL SYSTEM

Cognizant Engineer [signature] Date 10-7-88

RTR Daniel W. Weimer Date 10-7-88

COG ENG MGR. D R Buchanan Date 10-7-88

Rev.	SUMMARY OF CHANGE	Approval	Date
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1.0 INTRODUCTION

1.1 Background

The TMI-2 accident resulted in the production of large volumes of contaminated water. Direct releases of reactor coolant during the accident filled the reactor building basement to a depth of about 3-1/2 feet. In the two years following the accident, additional water was added to this inventory by primary coolant leakage and inleakage of river water through the reactor building air coolers. In 1980, an agreement was executed between the City of Lancaster, Pennsylvania, GPU Nuclear Corporation, and the Nuclear Regulatory Commission (NRC) which prevented discharge or disposal of this accident generated water, even after treatment to reduce its radionuclide content to within regulatory limits, prior to an environmental evaluation by the NRC. In mid 1981, treatment of this water through the Submerged Demineralizer System (SDS) and EPICOR II System was begun. Since 1981, the total inventory of this accident generated water has increased to the current volume of 2.15 million gallons due to continued additions from defueling and decontamination activities and condensation from the reactor building air coolers. With the projected additions to this volume of water through the end of the defueling and decontamination of the facility, the total volume of water that will require disposal is anticipated to be about 2.3 million gallons. Most of this accident generated water has already been processed to very low levels of radionuclide contamination and is commonly referred to as Processed Water. This water is continuously recycled for use in cleanup activities and is subsequently reprocessed. Some of the water, such as the approximate volume of 66,000 gallons in the reactor coolant system, will require some form of processing prior to disposal. The method of disposal that is proposed is to process the water through a closed cycle evaporator, reheat the purified distillate, and discharge it as a vapor containing essentially all of the tritium and a small fraction of the particulate contamination to the atmosphere in a controlled and monitored manner via a 100 ft. high exhaust stack. The remaining particulate contamination will be concentrated in the evaporator bottoms, collected, and further concentrated to a dry solid that can be shipped off-site for disposal by burial at a commercial low level radioactive waste facility.

1.2 Purpose and Scope

The purpose of this report is to provide a description of the processed water disposal system and its interfaces with other plant systems; to provide a technical evaluation of the system's conformance to applicable codes, standards, and regulatory requirements; and to provide a safety evaluation of the system and its operation. This report concludes that the Processed Water Disposal System does not constitute an unreviewed safety question and that the system can be operated as designed without undue risk to the public health and safety. Further, it concludes that the environmental impacts of the system operation and potential accidents involving the system fall within the bounds of activities previously evaluated by the NRC staff in their Programmatic Environmental Impact Statement and its supplements.

2.0 SYSTEM DESCRIPTION

2.1 General

The processed water disposal system consists of: (1) a vapor recompression distillation unit (main evaporator) that will distill the processed water feed in a closed cycle process and collect the purified distillate for subsequent release by vaporization; (2) an auxiliary evaporator that will further concentrate the bottoms from the main evaporator; (3) a flash vaporizer unit that will heat and vaporize the purified distillate from the other evaporation and drying systems and release the vapor to the atmosphere in a controlled and monitored manner; (4) a waste dryer that will further evaporate water from the concentrated waste and produce a dry solid; and (5) a packaging system that will prepare the dry solid waste in containers acceptable for shipment and for burial in a commercial low level radioactive waste disposal site. A block diagram of the process is shown in Figure 1.

2.2 Main Evaporator

The main, or VC-300, evaporator is a vapor recompression type distiller that can be operated in either a climbing film or spraying film mode. The heating section consists of a horizontal shell and tube type heat exchanger that is 24 inches in diameter and 120 inches long. The heat exchanger is of a patented design known as a Bayonet Augmented Tube (BAT) heat exchanger.

The evaporator feed enters the bottom of the heat exchanger shell where it is heated to boiling by steam condensing in the tubes. The heated vapors along with a significant quantity of entrained liquid exits the shell through two 12 inch diameter vapor risers and enters the separator/vapor dome section. The majority of the entrained liquid is collected in the bottom of the 24 inch diameter separator. The remainder of the entrained liquid is removed from the vapor as it rises into the vapor dome through two stages of woven wire demister screens. The liquid collected in the bottom of the vapor dome is drawn off by a pump along with a portion of the liquid from the heat exchanger section and returned to the main (VC-300) concentrate tank. The dried vapors exit the vapor dome through a 14 inch steam line and enter the suction side of a motor driven mechanical vapor recompressor. The compressor will increase the temperature and pressure of the steam and discharge it to the tube side of the heat exchanger in the evaporator heating section. The vapor condenses in the tubes, giving up its superheat and latent heat to the boiling liquid in the shell. The condensate, or distillate, is removed from the tubes by a vacuum eductor and discharged to the VC-300 distillate tank.

The system is designed to operate under a vacuum and will boil the feed liquid at a temperature of about 150° F. The mechanical vapor recompressor will raise the temperature of the vapor to about 170° F. The compressor will supply all the heat needed for steady state operation, operating on the principal of continuous reclamation and reuse of the latent heat of vaporization of the steam produced by evaporation. The cycle is basically a refrigeration cycle as employed in conventional heat pumps, but it uses water as the heat transfer fluid. The heat necessary for system start-up is supplied in the form of steam from the auxiliary evaporator which is described in Section 2.3.

Processed water will be fed to the VC-300 concentrate tank at a rate of no more than 5 gpm. The liquid is moved by vacuum from the concentrate tank to the evaporator heat exchanger shell at a rate of about double the evaporation rate. The excess feed is carried over with the vapor, removed in the vapor separator section, and returned along with a portion of the concentrated liquid from the heat exchanger shell to the concentrate tank for recycle. The liquid level in the heat exchanger shell is maintained high enough to cover about one third of the heat exchanger tubes. The vigorous foaming action during boiling, which is typical of waste water streams, will ensure continuous wetting of the rest of the tubes to provide good heat transfer characteristics, while the low liquid level in the shell provides a low hydrostatic head. If the foaming action is insufficient to adequately wet the tubes, the system can be operated in a spraying film mode. In the spraying film mode, a portion of the feed enters the top of the heat exchanger shell and is sprayed over the tubes to provide a constantly wetted film on the heat transfer surfaces.

A small flow, on the order 0.5 gpm for a 5 gpm evaporator feed rate, of the concentrated liquid gravity drains from the VC-300 concentrate tank to the auxiliary (C-30) evaporator concentrate tank for further concentration and processing. When the VC-300 evaporator is supplied with processed water containing about 3,000 ppm boron, it will produce a concentrated solution of about 30,000 ppm boron. The concentration of other soluble and particulate contaminants, including radionuclides, will be increased by the same proportion. The final concentration ratios can be varied to suit the processing needs or to optimize the process as experience dictates. The purified distillate will contain nearly all of the tritiated water but will be essentially free of other contaminants since less than 0.1% of the soluble and particulate contaminants in the processed water will be carried over in the VC-300 distillate. The distillate will be collected in the distillate tank for further staging in an on-site storage tank or for direct feed to the flash vaporizer.

2.3 Auxiliary Evaporator

The auxiliary (C-30) evaporator is similar in design to the VC-300 evaporator, but it is smaller and does not use a vapor recompressor. The heating section is a 6 inch diameter horizontal shell and tube heat exchanger and the separator section is 8 inches in diameter. The auxiliary evaporator is fed by recirculation from its concentrate tank (C-30 concentrate tank) and will further concentrate the 30,000 ppm discharge from the main evaporator to a concentration of between 30 and 50 percent total solids, depending on operational needs. The C-30 evaporator heat exchanger operates on the submerged tube principle with liquid level being maintained by an overflow weir in the discharge end of the shell. The heat source to the auxiliary evaporator is waste heat from the hot distillate in the VC-300 distillate tank supplemented by two thermostatically controlled 30 KW electric heaters. Distillate is pumped from the VC-300 distillate tank through the electric heaters which heat it to about 170°F. It flows to the tube side of the shell and tube heat exchanger portion of the auxiliary evaporator where it heats the boiling liquid on the shell side. The distillate then exits the tubes and returns to the VC-300 distillate tank. During system start-up, vapor from the auxiliary evaporator is used to provide a heat source to the main evaporator. Once the main evaporator is heated up and in operation, a valve in the vapor line to the main evaporator is closed and the vapors are routed to the auxiliary condenser. The condensate is removed from the condenser by an eductor and discharged to the C-30 distillate tank. It is then transferred by pump to the VC-300 concentrate tank for reprocessing. A portion of the concentrated liquid is pumped from the C-30 concentrate tank to the blender/dryer transfer tank for subsequent drying and packaging.

2.4 Flash Vaporizer

The flash vaporizer will perform the final evaporation of the purified distillate and will release the resultant vapor to atmosphere through a 100 foot high exhaust stack. Distillate will be pumped to the system at a rate of no more than 5 gpm. It will enter the system flow stream at the suction of a 500 gpm recirculation pump. The recirculation pump forces water through three 300 KW electric heaters where the temperature and pressure are raised to about 240° F and 10 psig respectively. The heated water discharges through a bleed/orifice valve into the 24 inch diameter by 60 inch high cylindrical flash tank where the reduced pressure results in immediate vaporization of a portion of the heated water. The vapors exit the top of the tank through a 10 inch thick demister screen into a 3 inch diameter by 100 foot high exhaust stack and are released to the atmosphere. A small amount of liquid will be drained from the flash tank as a continuous blowdown and returned to the VC-300 concentrate tank. Any condensate that forms in the exhaust stack will be drained through a steam trap to the VC-300 distillate tank.

2.5 Blender/Dryer

The blender/dryer will receive the liquid or slurry product from the auxiliary evaporator at a concentration of 30 to 50 percent total solids, evaporate the remaining water, and produce a dry solid waste. The water removed by the dryer in the form of vapor will be condensed in a heat exchanger and returned to the VC-300 concentrate tank for reprocessing. The body of the dryer consists of a cylindrical horizontal vessel that is about 10 feet long by 3 feet in diameter with a holding capacity of 50 cubic feet. It is equipped with three sets of electrical strip heaters (100 KW per set) in direct contact with the outside surface of the shell. The outside of this heated surface is covered with a layer of insulating material. The inside surface of the dryer is continuously scraped by a rotating helical ribbon agitator that removes and mixes the material that dries on the inside surface of the shell. The liquid or slurry is pumped into the dryer in batches through two (2) 2 inch feed connections located on the dryer side near each end of the unit. As the material comes in contact with the heated shell surface, the remaining water is evaporated. The rotating helical ribbon agitator scrapes the dried material from the surface, continually blends the material, and conveys it toward the center of the dryer body. When a batch has been dried, it will be discharged through a four inch pneumatically operated ball valve into the blender/dryer discharge hopper.

2.6 Packaging System

The dry solid waste from the blender/dryer discharge hopper is transferred by a fully enclosed screw conveyor to the pelletizer feed hopper. The pelletizer is a standard Model 200 Blount/Ferrel-Ross laboratory pellet mill. The dry product flows by gravity from the feed hopper into the center of a cylinderical extrusion die. The product which enters as a powder is pressed or extruded through radial holes in the die, forming a compacted solid material. As it exits the die, the material will be cut off to pellets about 3/8 inch in diameter and about 1/2 inch long. The pellets then drop through a shroud into a DOT Specification 17-C shipping container. The pelletizer is integrally mounted on top of an enclosure around the DOT Specification 17-C container. A ventilation blower, which discharges to the building atmosphere, draws a constant suction through a HEPA filter on the enclosure to ensure that the enclosure and the pellet mill are maintained under a negative pressure while in use. This will prevent leakage of material that could cause an airborne radioactivity problem in the building. All handling of the open solid waste containers such as installation of lids and wiping of the exterior surfaces will be performed with the drum in the ventilated drum enclosure.

2.7 Ancillary Equipment

2.7.1 Enclosure Building

The entire processed water disposal system will be enclosed in a modular building 26'X30'X14' high located as shown on Figure 2. The primary purpose of the building is to shield the equipment and operators from the environment and to contain the process liquid in the extremely unlikely event of catastrophic failure of the system tanks or piping. The building is constructed of pre-fabricated interlocking panels that lock together with hook devices. The panels are laminated construction consisting of an insulating foam material sandwiched between sheet metal. The panels are painted on their interior and exterior surfaces for easy cleaning. Attached to the building is 10'X12' office area that will serve as an operating control point. In addition, it will provide a controlled point of entry into the equipment building which will be a radiologically controlled area. The building will be placed on a poured, reinforced foundation and slab which will be curbed to contain any liquid spilled, and sloped to channel spilled liquid to a sump. The curbing is of sufficient size to contain the entire volume of liquid that could be contained in the system. The foundation and slab will be coated with an epoxy base sealant to facilitate decontamination, as needed.

The building will be provided with the necessary lighting and telephone communication to facilitate efficient operation. In addition, portable heaters can be installed if needed during periods of shutdown if cold weather presents a possibility of freezing.

The building will be ventilated by an exhaust fan that will provide 2,500 CFM air flow out through the building exhaust. This will provide about 15 air exchanges per hour.

An ambient air sampler will be operated within the evaporator building to evaluate airborne radiological conditions. Airborne radiological concentrations will be controlled to less than or equal to 25 percent of Maximum Permissible Concentration (MPC) to personnel.

If airborne concentrations exceed 25 percent of MPC to personnel, decontamination or other radiological condition improvements will be made within 1 hour, during which time period the airborne radiological concentration will not exceed 25 percent to 50 percent MPC. If after 1 hour, mitigation of the release is not achieved, the evaporator building exhaust will be shut down, and evaporator operations will be terminated until acceptable radiological conditions can be restored.

If operating experience shows that airborne concentrations of less than 25 percent of MPC to personnel cannot be achieved through radiological controls, then engineered controls including a building exhaust monitor, will be instituted.

2.7.2 Cooling Water System

Cooling water for the processed water disposal system will be supplied from and returned to a closed cycle chilled water system. The self contained chiller and chilled water system will be located adjacent to the evaporator building and will provide about 20 gpm of cooling water at a temperature of about 50° F to the C-30 condenser and the main evaporator compressor oil cooler.

2.7.3 Electrical System

The evaporator system requires a 480V, 3 phase, 60 Hz main power feeder capable of supplying 1600 KVA to the evaporator building switchgear. This is provided by a single 13.2 KV primary from an existing MET-ED junction pedestal at the NE end of the 230 KV substation. This is routed through existing underground duct banks to a 2500 KVA step-down transformer (13.2 KV - 480V/277V). The step-down transformer is installed on a concrete pad adjacent to the evaporator building and is surrounded by a block wall to prevent the spread of possible fire due to a transformer oil leak. The switchgear is supplied by the evaporator vendor as part of the system.

2.7.4 Plant System Tie-ins

Operation of the evaporator system requires connection to existing plant systems for various service needs. These plant tie-ins are shown schematically in Figure 3. The figure shows the connections to the contractor supplied evaporator system as well as the modifications to the existing systems necessary to facilitate the tie-ins.

The existing Processed Water Storage Tanks (PWSTs) will be the primary feed source to the evaporator. The tie-in to the PW System allows pumping from either of the 500,000 gallon PWSTs to the evaporator. Evaporator distillate can also be returned to either tank. The Auxiliary Building Emergency Liquid Cleanup System (ALC) will be modified to allow using the existing 85,000 gallon CC-T-1 in the EPICOR II system as a distillate staging tank. This tank can receive distillate from the evaporator or it can transfer liquid as either feed to the vaporizer or feed to the evaporator. Cross connect valves between the source tanks and the evaporator and vaporizer feed connections are capable of being locked closed to prevent inadvertently feeding raw water to the vaporizer. They will be locked and controlled per GPUN procedures. In addition, the tie-ins are designed so that any tank being used to feed the system will be isolated from all sources that may add any water to that tank while in service as a feed source. Similarly, any tank used as a staging tank to receive distillate will be isolated from any other sources of water.

Domestic water is supplied to the evaporator system for equipment flushing and cleaning. It is supplied from the plant Domestic Water (DO) System.

Service air is supplied to the evaporator building from the existing plant Instrument Air (IA) System. It supplies the air driven building sump pump, the blender/dryer transfer pump, and the air operated blender/dryer discharge valve.

All piping containing liquids that is outside the building is heat traced to prevent freezing in cold weather. Process connections to the vendor supplied system from plant liquid systems will be bolted flanged connections.

2.7.5 Fire Protection

Fire protection will be provided by portable fire extinguishers installed in the building in accordance with National Fire Protection Association Codes and Standards and the Plant Fire Protection Plan.

3.0 SYSTEM OPERATION AND CONTROL

3.1 General Operation

The processed water disposal system is designed to operate at a steady state feed rate of no more than 5 gpm. The currently projected disposal program will process the entire 2.3 million gallons of water over a period of two years with about half of the total inventory being processed in each of the two years. The projection of 1.15 million gallons per year is based on current estimates of water availability and estimated system down time. If operational availability of the evaporator system permits, and progress of defueling, decontamination, and preprocessing of water improves the availability of water, it is feasible to dispose of the entire 2.3 million gallons of accident generated water in as little as 16 months. This estimate is based on operating the evaporator 7 days per week with 25 percent down time. Regardless of the overall length of the operating program, the system will be operated and controlled in such a manner that the environmental impacts of the project will be no more than the minimal impacts projected and evaluated in the NRC Staff's Programmatic Environmental Impact Statement, Supplement 2. This section of the report describes the modes of operation of the system, the instrumentation and controls used in the system, and describes the basis for the operating limits imposed on the system to assure that the resulting environmental impacts are within those analyzed.

3.2 Operational Modes

The processed water disposal system is designed with the flexibility to operate the evaporator and vaporizer as a coupled unit or to separate the two units and operate them independently. In the coupled mode, the evaporator and vaporizer are operated in series in a continuous flow operation. The distillate from the evaporator is fed directly to the vaporizer for atmospheric discharge. When decoupled, the evaporator and vaporizer are operated separately with the vaporizer influent independent of the evaporator effluent. The distillate from the evaporator is pumped to a separate staging tank and the feed to the vaporizer is supplied from an independent staging tank. These modes are described in detail in Sections 3.2.1 and 3.2.2.

Operation of the processed water disposal system will be under direct control and supervision of GPUN operations staff. The personnel performing the operation will be contractor personnel provided by Pacific Nuclear Incorporated, the vendor and owner of the system. These personnel will receive the training required by plant procedures for access to the facility's protected area and radiation work permit areas and will perform all operations under the control of GPUN approved operating procedures. Radiological controls, chemistry, and effluent sampling and analysis needed to support system operation will be provided by GPUN staff.

3.2.1 Coupled Operation

In this configuration the evaporator and vaporizer will be coupled and operated as a continuous cycle system. The primary control over environmental effluents will be established by strict control over the process influents. The body of water to be processed will be isolated from all other possible sources of contamination, the source tank will be recirculated to assure homogeniety, and then sampled. A chemical and radiochemical analysis for the principal radionuclides will be performed as presently done on-site and the analytical results compared to the influent criteria discussed in Section 3.3. Once conformance to the influent criteria is confirmed, water may be processed. Water will be supplied at a rate of no more than 5 gpm to the VC-300 concentrate tank from where it is fed and recirculated through the main evaporator. The main evaporator will increase the concentration of dissolved solids, including the particulate radionuclides, by a factor of about 10. The concentrated liquid is continuously drawn from the VC-300 concentrate tank and sent to the C-30 evaporator. The C-30 evaporator will produce a further concentrated liquid that is about 30 to 50 percent dissolved solids. The purified distillate from the VC-300 evaporator is continuously discharged to the VC-300 distillate tank. The C-30 distillate is first collected in the C-30 distillate tank and then pumped back to the VC-300 concentrate tank for reprocessing. VC-300 distillate is continuously recirculated by the main distillate pump, P-5, and the C-30 evaporator heating loop pump, P-4. Heating loop pump, P-4, circulates distillate from the VC-300 distillate tank as cooling water through the blender/dryer vapor condenser, then through the two 30 KW electric heaters to the C-30 evaporator as its heat source. From the C-30 evaporator heating section it returns to the VC-300 distillate tank. Distillate pump, P-5, pumps from the VC-300 distillate tank through a recirculation loop that supplies clean water to the desuperheater nozzles in the vapor recompressor suction, hot water as a heat source to the feed preheater, seal water to the VC-300 vacuum pump, P-6, and motive force to the VC-300 eductors, E-1 and E-2. The water to the desuperheater, vacuum pump, and eductors is subsequently returned to the distillate tank. A side stream is discharged from this loop through letdown valves that operate automatically to provide level control for the distillate tank. When operating in the coupled mode, which is expected to be the normal mode of operation, the letdown flow from the distillate loop will be discharged directly to the vaporizer. The distillate will pass through a radiation monitor and enter the vaporizer recirculation loop as described in Section 2.4. During operation, samples will be obtained periodically from the raw feed to the evaporator and from the distillate feed to the vaporizer. Later analyses of these samples in the site laboratory will confirm that the evaporator influent quality had been within the required specifications during the previous operating period and that the evaporator produced a decontamination factor of at least 1000. If these two criteria are met, the environmental release from the system will have been within the limits discussed in Section 3.3. If either of these criteria have not been met, the system will be shutdown and corrective action will be taken. When tankage is available, an alternative to full system shutdown will be to terminate the release from the vaporizer and return the evaporator distillate to an interim staging tank. This will allow adjustments to the process to restore its operation to within the specifications without a full system shutdown. System instrumentation will provide a continuous indication that the environmental releases are within the limits required by the TMI-2 Technical Specifications. If sample analyses show that the environmental release rates have been higher than those stated in Section 3.3, influent limits will be adjusted for subsequent operating periods to ensure conformance to the average quarterly limits discussed is Section 3.3.

Operation in the coupled mode will not occur until sufficient data has been obtained from system testing to verify that the design decontamination factor are achieved.

3.2.2 Decoupled Operation

In the decoupled mode of operation, the evaporator and vaporizer are operated as separate units with the vaporizer feed independent of the evaporator distillate discharge. The source tank to be processed is isolated, recirculated, sampled, and analyzed for conformance to the criteria in Section 3.3. In decoupled operation, the evaporator influent criteria are based on assuring that the solid waste form produced meets the requirements for an LSA, Class A waste. In coupled mode operation, the evaporator influent criteria are based on assuring that the environmental releases from the system are within the established specifications and the solid waste produced meets the requirements for LSA, Class A waste. Slightly different influent criteria are imposed because in the decoupled mode, the evaporator does not discharge its distillate directly to the vaporizer for release to the environment. This is discussed further in Section 3.3. Water from the source tank is fed to the system as in coupled operation. The evaporator operation is identical except that the distillate letdown is pumped to a holding tank rather than being fed directly to the vaporizer. The water will be held until analysis shows it is acceptable for release. If the water meets the established effluent criteria, it may be later pumped directly to the vaporizer for vaporization and release to the atmosphere. If it does not meet the release limits it will be held and later reprocessed through the evaporator. This option allows using the evaporator as a preprocessing system for water sources that do not meet the criteria for discharge by direct coupled operation. Higher activity waters may be processed in batches through the evaporator until it is suitable for final vaporization. When processing higher activity water, care will be taken to avoid cross contamination of later lower activity batches. Sample analysis will confirm that cross contamination has not occurred.

3.3 Influent Limits

As previously stated, the primary method for control of the effluent from the evaporator or vaporizer is by establishing strict controls on the process influent characteristics. The effluent liquid quality from the evaporator is dependent upon the decontamination factor, or DF, achieved by the process. The DF is defined as the concentration of contaminants in the system influent divided by the concentration of contaminants in the effluent. The LICON evaporator has been designed to provide a decontamination factor of at least 1000 for particulates. In other words, less than one one-thousandth or 0.1 percent of the particulate radionuclides present in the evaporator influent will be carried over with the purified distillate. Further, 99.9 percent of the particulate radionuclides will be collected in the dry solid waste that will be packaged for disposal. This DF of 1000 for particulates will be verified by a series of tests performed by the vendor prior to delivery of the system to the TMI site. These tests will involve full flow operation of the system using liquid solutions that are very close in composition to the TMI-2 processed water but contain no radioactive material. After demonstration of satisfactory evaporator performance, the system will be assembled at the TMI site. It will again undergo a test run using a non-radioactive surrogate solution. The evaporator DF will be verified by chemical analysis of the feed solutions and purified distillates. Once the system is placed in service, the DF will be periodically verified by laboratory analyses of the influent and effluent. The system is also provided with instrumentation that will detect upset conditions that may affect the effluent quality. This instrumentation is discussed in Section 3.4.

The influent quality must be controlled to assure achieving two effluent results. First, the purified distillate will be released to the environment via the vaporizer. Essentially all of the contaminants contained in the distillate will be vented into the atmosphere. The level of contaminants released must be kept low enough to assure minimal environmental impacts. Second, at least 99.9 percent of the contaminants contained in the evaporator influent will be collected as dry solid waste. This waste will be packaged on-site and transported for burial in a commercially operated radioactive waste disposal facility. The waste form produced must be suitable for transportation and burial in accordance with the regulations of the U.S. Department of Transportation and the U. S. Nuclear Regulatory Commission. GPUN has chosen to process the waste to a form that meets the transportation requirements for Low Specific Activity (LSA) radioactive material. In addition it will conform to the burial requirements for Class A waste. In general, the criteria for LSA and Class A waste constitute the lowest level radioactive waste material originating from commercial nuclear power plants that are regulated for purposes of transportation and disposal.

The water to be disposed is in storage in various tanks around the site, some of which is still in use for clean-up activities. Some of this water has already received final processing through the Submerged Demineralizer System (SDS) and EPICOR II. About 40 percent of the 2.3 million gallon inventory will require some form of preprocessing before being processed for disposal by the evaporator system in a coupled mode. Table 1, Columns 1 and 2 show the projected average activity levels for the total 2.3 million gallons of accident generated water assuming preprocessing of about forty percent of the total inventory. This data appears in the NRC staff's Programmatic Environmental Impact Statement (PEIS) Supplement 2 (NUREG-0683, Supp 2) in Table 2.2 and is identified as "Base Case" water. These activity levels formed the basis for the NRC staff's analysis of the environmental impacts of evaporator discharges. The activity releases occurring from evaporator discharges of "Base Case" water result in releases that are a small fraction of the releases permissible by existing regulatory requirements. Even though higher releases are legally acceptable and of very minor environmental consequence, the processed water disposal system will be operated in such a manner that the PEIS projections of environmental impact are not exceeded. Since the PEIS analysis assumed processing "Base Case" water with a vaporizer discharge to the atmosphere containing 0.1 percent of the radioactive particulates from the influent, that value will be used as the system operating limit. Therefore, when operating the processed water disposal system in the coupled mode, the volume of water being processed will be isolated from all sources of contamination. The concentrations of the principal radionuclides will be verified by on-site analysis to be within limits so that quarterly average concentrations of all water processed in this mode will be no greater than the concentrations listed in Table 1, Column 2. When processing water through the vaporizer in the decoupled mode, the quarterly average vaporizer influent concentrations will be no greater than 0.1 percent of the values in Table 1, Column 2. These limits equate to an atmospheric release rate for particulate radionuclides of 8.2E-5 μCi per second if processing water containing the maximum limits at a rate of 5 gpm. These limits are shown in Table 2.

The evaporator influent limit for coupled mode operations assumes a DF of 1000 for particulates. If system testing and operational experience demonstrate with reasonable confidence that the system achieves a higher DF, the evaporator influent limit for coupled mode operation will be increased accordingly.

When processing water in the decoupled mode, the evaporator will not discharge the distillate directly to the environment since the distillate is collected and stored in an on-site staging tank. It will be held for future discharge directly through the vaporizer, final processing through the evaporator and vaporizer in coupled mode, or further preprocessing through the evaporator in decoupled mode, depending upon its radionuclide content. Therefore, the evaporator influent limits in the decoupled mode are based on assuring an acceptable final waste form.

The major constituent of the processed water that contributes to the final solid waste is ortho-boric acid (H_3BO_3) which has been used throughout the cleanup program for criticality control. The current processed water inventory of 2.15 million gallons contains an average concentration of boron from boric acid additions of about 3500 parts per million (ppm) but can range as high as 6000 ppm in some of the sources. Sodium hydroxide (NaOH) has been added to the water for control of pH and has an average concentration of about 700 ppm sodium ions in the 2.15 million gallons. As the water is evaporated, the NaOH and H_3BO_3 will combine to yield sodium borate salts in the form of $Na_2O \cdot 2B_2O_3$ (Sodium Tetra-Borate) and $Na_2O \cdot B_2O_3$ (Sodium Meta-Borate). The remainder of the H_3BO_3 will crystallize as ortho-boric acid. At the current averages of 3500 ppm Boron and 700 ppm Sodium, the 2.15 million gallons of processed water contain about 179 tons of boric acid and about 11 tons of sodium hydroxide. This material is non-radioactive. In contrast to this, Table 1, Columns 3 and 5 show the specific activity of the radionuclides present in the processed water and the resultant total quantity of each in 2.3 million gallons of "Base Case" water. It shows that the total weight of radioactive material present with the 190 tons of boric acid and sodium hydroxide is less than one pound. Therefore, the predominant material present in the solid waste is boric acid and its sodium salts. The projected weight of boric acid and sodium hydroxide shown here are based, as previously stated, on the current inventory of 2.15 million gallons and average boron and sodium concentations of 3500 ppm and 700 ppm respectively. The increase in the inventory to 2.3 million gallons projected between now and the end of the project is not expected to require any further boron additions. Therefore, the total projected weight of boric acid is not expected to change. Likewise, the weight of sodium hydroxide in the processed water is based on current inventories. The final amount in the projected 2.3 million gallons will depend upon processing requirements for pH adjustment and the amount of sodium removal that occurs in ion exchange preprocessing. These weights differ from the values given in the PEIS. The values used by the NRC in preparing the PEIS were based on data provided by GPU Nuclear in July 1986. (i.e., 2.1 million gallons, 3000 ppm Boron, and 700 ppm Sodium.) Since submission of that data, additions of boric acid and inventory changes have increased the values to the current 2.15 million gallons, 3500 ppm Boron, and 700 ppm Sodium.

To determine the transportation category, each radionuclide present in the waste is assigned an A-2 value which is the number of curies of that nuclide that may be shipped in a Type A container. The A-2 values are obtained from the applicable DOT and NRC regulations and are shown in Table 1, Column 4. From the A-2 values, a permissible LSA concentration is determined. The LSA concentrations are the maximum concentrations in millicuries per gram that may be packaged in a strong tight container and shipped in an "exclusive use" vehicle as Low Specific Activity (LSA) material. Calculations show that processed water containing 3000 ppm Boron and the radionuclide concentrations of Table 1, Column 2, will yield an LSA waste when evaporated. The waste will be shipped in DOT Specification 17-C containers. These containers exceed the minimum requirements for "strong tight containers".

To determine the burial category of the waste, similar calculations are done to compare the waste to criteria in 10 CFR 61. Calculations show that processing of water with Table 1, Column 2 concentrations of radionuclides and 3000 ppm Boron will result in a Class A waste form.

Boron concentrations higher than 3000 ppm will yield larger quantities of solids and resultant lower activity concentrations in the final waste form. Similarly, higher activity concentrations in the source water produce higher concentrations in the final waste form. Therefore, when processing water with activity levels higher than those shown in Table 1, Column 2, or Boron concentrations of less than 3000 ppm calculations will be performed and documented in accordance with a GPU Nuclear approved process control plan to determine the transportation and disposal categories of the final waste form. Only water that will yield an LSA, Class A waste form will be processed through the evaporator.

3.4 System Instrumentation and Control

As previously discussed, the primary control on effluent quality from the evaporator is an operating program that places strict controls on the influent or raw feed quality. The system is designed to operate with minimal manual control by the operator even though an operator will be present during system operation. The automatic controls and instrumentation incorporated in the processed water disposal system are discussed in this section.

3.4.1 Liquid Level Controls

Raw feed from the plant source tank is either pumped or gravity flowed to the evaporator depending upon level in the source tank. The feed enters the VC-300 concentrate tank through a solenoid operated valve with a manual bypass valve. The manual bypass valve will be adjusted to maintain a nearly constant level in the VC-300 concentrate tank with the solenoid valve open. The tank is provided with three sonic level switches. If the level in the tank varies, the top sonic switch closes the solenoid operated feed valve, the middle switch opens the valve, and the lower switch actuates a low level alarm and deenergizes the evaporator causing a system shutdown. In addition, a High-High level switch will actuate an alarm and shut the main feed valve to the system and the C-30 distillate tank discharge valve to prevent overflow of the tank. Similarly the feed rate to the VC-300 evaporator shell is set manually and the recycle rate back to the concentrate tank is controlled by an electric motor operated recycle valve in parallel with a manual valve. The solenoid valve is cycled open and closed by a sonic level detector on the evaporator shell. The C-30 concentrate tank is supplied by the concentrate drain from the VC-300 concentrate tank. The gravity flow line is provided with a similar arrangement of a manual valve and a solenoid valve in parallel, with the solenoid valve being controlled by level switches in the C-30 concentrate tank. The low level alarm switch causes an alarm, deenergizes the evaporator system and trips the pump to the blender/dryer transfer tank. Discharge from the two distillate tanks is controlled in a similar manner. The level in the vaporizer flash tank is controlled by three sonic level switches. The top switch opens a solenoid valve in the blowdown line, the middle switch closes the valve, and the bottom switch actuates an alarm and trips the vaporizer circulation pump and electric heaters causing an automatic shutdown of the vaporizer.

The VC-300 and C-30 evaporator vapor domes and the vaporizer flash tank have liquid level gauge glasses for visual indication of liquid level. The level gauges on the vapor domes are equipped with sonic level switches that actuate alarms to warn of excessive foaming or over feeding of the evaporator. They also deenergize the evaporator causing a system shutdown. The sonic level controls chosen for this system are widely used throughout the industry to control liquid levels in hostile environments. They have no moving parts, are unaffected by changes in dielectric constants, perform well in high density slurries, and work well throughout a large range of viscosities.

3.4.2 Flow Measurement

A water flow meter is installed on the evaporator feed line to keep track of total volume of raw processed water sent to the evaporator. It is a turbine type flow meter with a totalizer. Similar flow meters are installed in the system distillate discharge line and in the distillate line from the C-30 distillate tank. These will provide data for performance of the system mass flow balances. Flowrate meters are installed in the desuperheat line, both evaporator recycle lines and the vaporizer blowdown line. These meters provide on-line indication of process conditions and provide no automatic control functions.

3.4.3 Conductivity Monitors

An effective measure of the amount of dissolved material in water is its conductivity. Four conductivity monitors are installed in the system to detect trends or upset conditions during processing. There is a monitor in the distillate lines from both the VC-300 evaporator and C-30 distillate tank discharge. These monitors will give indication of excessive carryover from the evaporators or of unexpected tube leakage in the evaporator heat exchangers. Monitors are installed in both the vaporizer and evaporator feed lines. These will provide an indication of any unplanned upset that may degrade the influent water quality. Each of these monitoring points is also equipped with a sample station for extraction of process fluids for chemical and radiochemical analysis. Operational experience and an accumulated data base accrued during actual evaporator operations will provide a sound basis for comparing these two methods of analysis, i.e., laboratory analysis and steady state conductivity monitoring. After adequate demonstration of comparable analytical results and conductivity data, operational procedures may be modified to rely more extensively on the steady state conductivity instrumentation. However, until a data base can be compiled based on actual system operations, the control method utilized in procedures and operating programs will be the physical sampling and laboratory analysis of process liquids in conjunction with conductivity monitoring.

3.4.4 Radiation Monitor

A gamma radiation detector is installed in the vaporizer feed line and is intended to detect gross upsets in the system operation. The primary means of monitoring and controlling the environmental releases of particulate radioactive material will be limiting the radionuclide concentrations in the system influents and by periodic sampling and radiochemical analyses. The radiation monitor will detect major deviations in the process and will cause a termination of the releases to the environment if upsets occur. It will alarm and cause an automatic shutdown before the environmental release rate exceeds the particulate release limit of the TMI-2 Technical Specifications. The detector is calibrated to the .661 MEV gamma ray emitted by the Cesium-137/Barium 137m decay chain. The alarm is set to a concentration in the liquid which corresponds to a particulate release rate of 7.5E-2 μCi/sec. This represents 25 percent of the instantaneous particulate release rate limit of the TMI-2 Technical Specifications. The alarm set point corresponds to a Cesium-137 release rate of 1.1E-2 μCi/sec assuming the isotopic distribution of Table 1, Column 2. This correlates to a Cesium-137 concentation in the vaporizer feed of 3.5E-5 μCi/ml which is very nearly equal to the coupled mode evaporator influent limit. Thus, the detector alarm would also provide a warning that the evaporator had been inadvertently bypassed.

The high level alarm signal on the radiation monitor will cause an audible alarm, trip the vaporizer recirculation pump, and deenergize the vaporizer heaters. This will effectively terminate the release of radioactive material at a level below the Technical Specification instantaneous release limit. The monitor chosen for this system is a Nuclear Research Corporation Model 4PI-3 sampler. It uses a Sodium Iodide crystal as a gamma scintillation detector. It has a monitoring sensitivity of 1E-7 μCi/ml of Cesium-137 at a 99 percent confidence level.

3.4.5 Other Instrumentation

In addition to the instrumentation and controls discussed above, additional features support the system and enhance the ease of operation and system reliability.

Full view sight windows on the evaporator shells and viewing windows on the vapor domes allow the operator to see the process as concentration progresses. They provide easy assessment of too much or too little foaming in the evaporator and provide a means of immediate confirmation of any carry-over from the separators if indicated by the conductivity monitors.

The distillate pumps, P-3 and P-5, are equipped with discharge pressure switches that provide assurance of sufficient pressure for operation of the condensate eductors. Low pressure would cause the eductors to back-fire and the system would operate erratically. If pressure falls below 35 psig, the pressure switches actuate a system shutdown by deenergizing the electrical system.

Pressure switches are provided in the vaporizer heating loop and in the C-30 evaporator heating loop to deenergize the heaters in the event of insufficient water flow through the heaters. These loops are also equipped with high temperature shut-off switches.

The transfer skid holding tank which receives concentrated liquid from the C-30 concentrate tank for feed to the blender/dryer is equipped with a conductance type level control. A high level will shut-off the transfer pump and a low level will deenergize the tank heater.

The blender/dryer discharge hopper has an RF capacitance level control which will automatically close the blender/dryer discharge valve on high level. The pellet mill feed hopper has an ultrasonic type level control to prevent overfilling of the hopper. It will automatically trip the transfer conveyor.

The drum filling enclosure is equipped with a thru-scan LED photocell that will monitor the drum filling operation. If the drum overflows, the photocell circuit will shutdown the pellet mill.

4.0 TECHNICAL EVALUATION

The purpose of this section is to describe the engineering specifications to which the processed water disposal system has been built, and to discuss the applicable codes, standards, and regulatory requirements imposed on its design, fabrication, and assembly. This section will further discuss the technical features of the system that make failures unlikely and that mitigate the safety impacts of postulated system failures.

4.1 Codes, Standards, and Engineering Specifications

The vendor supplied evaporator components are classified as Important To Safety (ITS) per the GPU Nuclear Recovery Quality Assurance Plan for TMI-2. Equipment and hardware procured and installed on-site which is required to maintain the pressure boundary for radioactive fluids are also classified as ITS. Process instrumentation, including the power and signal cabling, which is required to ensure that releases from the system are maintained within the design specification are ITS. All remaining components are classified as Not Important To Safety (NITS).

The system design and its intended operations have been classified under the standards of Quality Group D per the recommendations of NRC Regulatory Guide 1.26, "Quality Group Classifications and Standards for Water, Steam, and Radioactive Waste Containing Components of Nuclear Power Plants". Conformance to these standards is shown in the discussions that follow.

The system was reviewed for conformance to the guidance of NRC Regulatory Guide 1.143, "Design Guidance for Radioactive Waste Management Systems, Structure, and Components Installed in Light-Water-Cooled Nuclear Power Plants". Although this guide is applicable to permanently installed radwaste treatment systems rather than temporary removable systems, we have determined that the evaporator system does in general conform to Regulatory Guide 1.143 with the following exceptions: 1) The piping system and the building foundation and walls are not designed to the specified seismic response criteria. The seismic design criteria, however, were specifically exempted for recovery systems in the NRC approved Recovery Quality Assurance Plan; 2) The requirement to have a dike or retention pond around outside tanks as stated by regulatory position 1.2.5 is not met. The only outside tanks associated with the system are the Processed Water Storage Tanks. These tanks are atmospheric storage tanks built to the standards of API-650. They are fabricated of ASME SA 285 grade C carbon steel with an epoxy-phenolic type interior lining. The tanks were built and are operated under the provisions of an NRC approved plan for storage of processed water.

The VC-300 and C-30 evaporators are engineered in conformance with the ASME Code, Section VIII, for unfired pressure vessels and to TEMA (Tubular Exchanger Manufacturers Association) standards where applicable. The shells are made of 316 stainless steel. The VC-300 heat exchanger is a Bayonet Augumented Tube (BAT) type with both the tubes and bayonets built of titanium. The C-30 is also a BAT type heat exchanger with titanium tubes and chlorinated polyvinyl chloride bayonets. The C-30 condenser is similar in construction with a 316 stainless steel shell, titanium tubes, and polyvinyl chloride bayonets.

The support building foundation and floor slab are built to ACI Standard 318-83, "Building Code Requirements for Reinforced Concrete". The floor is sealed with an epoxy based coating and the structure is curbed to provide sufficient retention volume to contain the entire liquid contents of the system in the event of catastrophic system failure.

The support building is a prefabricated structure that conforms to the Uniform Building Code of the International Council of Building Officials.

All four atmospheric tanks in the system are fabricated of stainless steel and conform to ASME Code Section IX and V. The tanks have the following capacities: VC-300 Concentrate Tank, 75 gallons; C-30 Concentrate Tank, 60 gallons; VC-300 Distillate Tank, 90 gallons; and C-30 Distillate Tank, 34 gallons. The tanks are provided with sealed lids equipped with an atmospheric vent that discharges to the building atmosphere through a HEPA filter.

The electrical system is protected by suitably sized wiring, hardware, and circuit breakers per NEC 1987. All electrical junction boxes and enclosures are NEMA 4 or equivalent and all motors are TEFC. All equipment is grounded through the switchgear ground bus which is connected to the GPUN grounding system.

All process piping in the system is 304 stainless steel and conforms to the requirements of the ASME Code for Pressure Piping, ANSI 831.1, "Power Piping". Tank overflow lines and system drains are routed to the building sump using flexible hose. These are non-pressure retaining components and conform to ANSI 831.1, Section 105.3(C).

The following is a list of the engineering specifications on major system components not previously discussed.

- Vapor Compressor:	Roots rotary lobe model 1039 compressor, 4100 CFM at 1400 RPM, driven by a 125 HP TEFC motor.
- Vaporizer Recirculation Pump, P-7:	Goulds Model 3196 MT, Size 4X6-10, 500GPM at 40ft TDH, driven by a 7-1/2 HP TEFC motor, 1150 RPM.

- VC-300 Concentrate Pump, P-1:	Corcoran Series 2000 DH, with double mechanical seals, 10 GPM at 50 ft TDH, driven by a 3.4 HP TEFC motor, 3500 RPM.
- C-30 Concentrate Pump, P-2:	Same as P-1 except with a cut down impeller to give 3 GPM at 60 ft TDH.
- VC-300 Distillate Pump, P-5:	Grundfos Model CR4-50N, multi stage, 35 GPM at 110 ft TDH, driven by a 2 HP TEFC motor at 3500 RPM.
- C-30 Distillate Pump, P-3:	Grundfos Model CR2-30N, multi stage, 10 GPM at 110 ft TDH, driven by a 3/4 HP TEFC motor at 3500 RPM.
- Vacuum Pump, P-6:	Atlantic Fluidic Model A-10, rotary liquid ring pump/compressor, driven by a 1.5 HP TEFC motor at 3500 RPM. The pump will evacuate 14 CFM at 25 inches Hg Vacuum.
- Conductivity Monitors:	Series 800, MK 817, Wet Tap assemblies. Stainless steel housing, 2.0 cell constant, range 0 to 25,000 µS/Cm.
- Sonic Level Sensors:	SONARSWITCH Model 700, 316 Stainless steel, NEMA 7 enclosure, .03 inch repeatability.
- Blender Dryer Transfer Skid Level Control:	B/W control, Series 1, Model 1E1C4.
- Blender Dryer Discharge Hopper Level:	Penberthy Model 801132-1, RF capacitance level control.
- Pellet Mill Feed Hopper Level:	Bindicator Breakdata 2200, ultrasonic level control.
- Drum Enclosure Filling Monitor:	Microswitch Model FE-LP, thru scan LED photocell.

4.2 System Response to Upset Conditions

As shown in the previous section, the processed water disposal system is designed and built to sufficient industrial codes and standards to assure a high standard of quality. The system is designed and built to such quality standards to minimize system failures. However unlikely, the system design has been evaluated to assure safe and environmentally sound response to a number of abnormal conditions.

4.2.1 Loss of Electrical Power

All electrically operated valves in the system are energized to open and are spring loaded to close when deenergized. Upon loss of electrical power, feed water to the evaporator building will be automatically secured by closure of the feed valves. All heaters will shutdown securing the heat source to the vaporizer and the C-30 evaporator. The vapor compressor will shut down securing the heat source to the main evaporator. The blender/dryer will shutdown and all electrically driven pumps will trip. Thus, all evaporator and drying processes terminate and the system becomes stagnant. The only adverse consequence of this event is possible precipitation of dissolved solids from the concentrate as the system cools. If plugging of piping or heat exchanger tubes occurs, the precipitate can be redissolved by dilution of the liquid with clean water. If necessary, the system is designed for relatively easy removal of the tube bundles for cleaning.

4.2.2 Loss of Service Air

Service air is supplied to the processed water disposal system from the plant instrument air system. It is used to power the air driven pump in the building sump, the air driven diaphragm pump on the blender/dryer transfer tank, and the air operated discharge valve on the blender/dryer. Loss of service air pressure will result in the blender/dryer discharge valve failing closed and shutdown of the transfer pump. Thus, material will not be able to be transferred into or out of the blender/dryer. The heaters can be secured if necessary and the material allowed to remain in the vessel until service air can be restored. Thus, loss of service air supply will not result in a major upset condition for the overall process and will not hinder an orderly system shutdown if necessary.

4.2.3 Tank or Pipe Rupture

Tank or pipe ruptures are considered to be of extremely small probability because of the system design and fabrication and pressure conditions to which the system will be exposed. But in the very unlikely event of such an occurrence, low level sensors on the tanks will cause a system shutdown by deenergizing the electrical system. The building is designed to contain the entire volume of liquid that could be present in the system if completely flooded, so spillage of radioactive liquids to the environment will not occur. Minor spills occurring during system sampling or as a result of small leaks are similarly of little consequence. Standard radiological control practices will assure minimal spread of contamination. In addition, the building floor is sloped to channel water to the building sump and it is sealed with an epoxy coating for easy cleanup and decontamination. If a spill of dry solid waste occurs outside of the ventilated drum enclosure, the area will be controlled to prevent the spread of contamination until cleanup is complete. This will prevent unplanned environmental release of airborne radioactive material.

4.2.4 Severe Weather Conditions

The evaporator building is designed to the Uniform Building Code and will provide a secure protective enclosure around the system under all normally expected conditions. If severe weather or environmental conditions exist that would result in declaration of an Unusual Event as specified in the GPU Nuclear Emergency Plan, the processed water disposal system will be shutdown. Therefore, severe natural phenomenon that may result in damage or destruction of the building will not cause uncontrolled release of radioactive material from evaporator operation.

5.0 Environmental and Radiological Assessment

The purpose of this section is to present an evaluation of the environmental and radiological effects of processing 2.3 million gallons of water meeting the influent and effluent criteria discussed in Section 3.3, and discharging the effluent directly to the atmosphere.

5.1 Environmental Assessment

The processed water disposal system will produce environmental releases of tritium, particulate radionuclides, and boric acid and sodium borate salts.

The 2.3 million gallons of processed water contains about 1020 curies of tritium as reported in the PEIS. All of this tritium will be released to the environment through the vaporizer since the evaporator system will not remove it. Tritium has a specific activity of 9.7E+3 curies per gram which corresponds to a total quantity 0.105 grams of tritium in the 2.3 million gallons of water. If all of the tritium in the processed water is in the form of tritiated water (H-T-O), this equates to 0.7 milliliters of H-T-O in the 2.3 million gallons. This tritium will be released at an average rate of 37 μCi per second during evaporator operation. Since no conventional waste treatment processes will affect the tritium content of the water, the release rate of tritium to the environment will vary depending upon the water source being processed and the vaporizer processing rate. Tritium concentrations in the source tanks range from as low as 1.4E-5 μCi/ml to as high as 0.31 μCi/ml. This corresponds to environmental release rates ranging from 4E-3 to 98 μCi per second at a 5 GPM processing rate. The continuous tritium release rate is limited by the current Environmental Technical Specifications, Section 2.1.2 C. The release rate limit for a ground level release that is derived from that specification is 570 μCi/sec. Thus, the average and maximum releases that will result from evaporator operation are a small fraction of the releases permitted by the facility license.

The processed water disposal system will cause small environmental releases of particulate radionuclides. The release rate is dependent upon the particulate concentrations in the influent and upon the DF achieved by the evaporator. The minimum DF that the evaporator will achieve is 1000. The maximum influent concentrations that will be fed to the evaporator in coupled mode are as shown in Table 1, Column 2. Included in the table is Iodine-129. It is expected that Iodine is present in the chemical form of Cesium Iodide or other alkali-metal iodide. In this form, the iodine will be removed by the evaporator in the same proportions as the other particulates. However, in the very unlikely event that it is present in the elemental form, it will volatilize and be carried over with the distillate. For conservatism in projection of environmental releases, it will be assumed that all of the I-129 is released to the atmosphere. (Note that in calculating the nuclide content of the solid waste, it is assumed that all of the I-129 is present also in the evaporator bottoms.) This yields a concentration of particulates and I-129 in the distillate of 8.6E-7 μCi/ml and an atmospheric release rate of 2.7E-4 μCi/sec. This is comprised of 8.2E-5 μCi/sec of particulates, predominantly Cs-137, Sr-90, and C-14; plus 1.89E-4 μCi/sec of I-129. This is a small fraction of the continuous particulate release rate of 2.4E-2 μCi/sec permitted by the current Technical Specifications.

The radiation exposure to the public from releases of this magnitude were analyzed and evaluated by the NRC Staff in NUREG-0683, Supplement No. 2, and found to have no significant affect on the human environment.

In addition to the radionuclides released, the processed water disposal system will also release small quantities of boric acid and sodium borate salts to the atmosphere. Based on a DF of 1000, no more than 0.1 percent of the chemical constituents of the processed water will be released. For conservatism, a total released quantity of 0.2 tons was used in the following environmental analysis.

If the release is averaged over the 2-year projected time span for the evaporator project, it gives an average release rate of 0.0028 g/sec of particulates. Applying the annual average dispersion factor of 2×10^{-6} sec/m^3 cited in the TMI Off-site Dose Calculation Manual (ODCM), the average concentration of the chemical constituents off-site will be approximately 6×10^{-3} µg/m^3. Applying the worst case dispersion factor of 6×10^{-4} sec/m^3 (based on the TMI-2 FSAR accident dispersion factor), the worst case off-site concentration of particulates will be approximately 2 µg/m^3. Neither of these concentrations is a threat to the public, plant nor animal communities as shown in the following comparisons.

- o The threshold limit value, or TLV, (i.e., eight-hour time weighted average concentration) for nuisance particulates, including boron oxide, recommended for the human environment is 1×10^4 µg/m^3. The calculated average particulate concentration of 6×10^{-3} µg/m^3 and the calculated worst case particulate concentration of 2 µg/m^3 resulting from the proposed evaporation process are more than 1.5 million and 5000 times smaller, respectively, than the recommended TLV.

- o According to studies documented by the NRC in NUREG/CR-3585, the typical nuisance dust concentration in the Central Atlantic States is 258 µg/m^3. This is over 40,000 times greater than the projected average concentration resulting from the evaporator. It is also more than 125 time greater than the concentration which would result from the evaporator during the worst case atmospheric conditions which are not common and of only very short duration.

- o The NRC advises, in Regulatory Guide 4.11, Revision 1, 1977, that chemical studies of cooling tower drift are usually not needed when all of the following apply: 1) the dominant salts are harmless mixtures of biological nutrients, 2) the expected peak deposition beyond the site boundary is less than 20 kg/hectare - year of mixed salts, and 3) the drift does not contain toxic elements or compounds in amounts that could be hazardous to plants or animals either by direct or indirect exposure over the expected lifetime of the facility.

  Comparing the first guideline, the evaporator emissions will deposit sodium borate. Sodium and calcium borate salts are typically found in nature. The element boron is a micro nutrient which is essential to the nutrition of higher plants. It is common practice to add boron to agricultural fields as a supplemental nutrient. The highest annual deposition factor of 6.5×10^{-8}/m^2, cited in the TMI ODCM, can be applied to compare the second NRC guideline to the evaporator emissions. The resultant total solids deposition would be less than 6×10^{-2} kg/hectare - year. This concentration is approximately 300 times lower than the NRC guideline. The third guideline regards toxic elements or compounds. The evaporator emission would not contain toxic substance. Boron compounds are typically found in soils at an average concentration of 50 ppm and ranging up to 150 ppm. The total solids from the evaporator are conservatively estimated to be 0.25 ppm if they accumulated in the first inch of soil over the two year period. Boron exists in river and lake waters at concentrations averaging 0.1 mg/L but ranging as high as 5 mg/L. A conservative estimate of the concentration of total solids from the evaporator would be below 0.5 mg/L if they accumulated in shallow depths of water. The EPA limits boron concentrations to 0.75 mg/L for long-term irrigation on sensitive crops (Quality Criteria for Water, 1986 EPA 440/5-86-001). The example of sensitive crops given by the EPA is citrus plants and those plants are not produced in the TMI vicinity. Regarding animal life, in the dairy cow, 16 to 20 g/day of boric acid for 40 days produce no ill effects (EPA 440/5-86-001). Also, the minimum lethal dose for minnows exposed to boric acid was reported to be 18,000 mg/L (EPA 440/5-86-001). Thus, the emissions from the evaporator process fall well below the guideline advised by the NRC requiring a chemical study.

- With regard to impact on plant species, the Air Pollution Control Association (1970) documents the following: "Particulate emissions are not generally considered harmful to vegetation unless they are highly caustic or heavy deposits occur". As shown in the previous comparisons, the depositions resulting from the proposed evaporation process are neither "highly caustic" nor will they result in "heavy" deposition. Further, the element boron, as discussed in NUREG/CR-3332, is relatively immobile in plants.

5.2 Radiological Assessment

5.2.1 Off-site

Doses were calculated using the Meteorological Information and Dose Assessment System (MIDAS) which is used by TMI Environmental Controls for quarterly and semi-annual dose assessments which are submitted to the NRC with TMI-1 and TMI-2 effluent reports. MIDAS uses hourly averages of on-site meteorological data to calculate an integrated dispersion for the period of interest. It integrates the dispersion over each hour into each of sixteen sectors at ten distances. The location of the five nearest vegetable gardens larger than 500 square feet, and the location of the nearest milk cow, milk goat, meat animal, and residence in each of the sixteen sectors, is used to evaluate seven airborne pathways: plume exposure, direct dose from ground deposition, inhalation, and the consumption of meat, cow milk, goat milk, and vegetables. The maximally exposed hypothetical individual is conservatively taken to be that person in the maximum inhalation location and is assumed to consume meat, vegetables, and milk from each of the other maximum locations. These calculations are performed in accordance with Regulatory Guide 1.109 and are identical to those used for semi-annual and quarterly effluent/dose reports. The meteorological data from 1985 was used to calculate annual dispersion into the atmosphere. There is good confidence that the dispersion resulting from the 1985 data is similar to annual dispersion in recent years.

Using the releases projected in Section 5.1, the dose estimate for the maximally exposed individual for the duration of the project is 2.0 mrem total body and 3.6 mrem to the bone. Since the expected duration of the project is two years, the annual exposure to the maximally exposed individual is one-half of this.

To estimate the population dose MIDAS was again utilized. The affected population is considered to be the population surrounding TMI-2 out to a distance of 50 miles. The population affected by the atmospheric release associated with the evaporation of the processed water is estimated to be 2.2 million people. The dose pathways include inhalation; milk, meat, and vegetable consumption; plume exposure; and direct dose from ground deposition. This yields a total population dose of 18 person-rem total body and 25 person-rem to the bone and an average exposure to a member of the population of 0.008 mrem total body and 0.011 mrem to the bone.

5.2.2 On-site Occupational Exposure

Personnel exposure resulting from evaporator operation will be primarily due to ambient radiation in the vicinity of the evaporator and from packaging of the dry solids. Since the proposed influent criteria are such that only water that will produce an LSA, Class A waste will be processed, the radionuclide concentrations even in the concentrated evaporator bottoms, will be relatively low. The maximum dose is conservatively estimated to be 23 person-rem. This is based on 16,000 person-hours for the evaporation process in a radiation field of 0.6 mrem/hr, about 3500 person hours for packaging of the dry solids in a radiation field of 2.5 mrem/hr, and preprocessing operations for about 40 percent of the total inventory.

In the unlikely event of an on-site accident involving the rupture and spill of a drum full of dry solid waste, the dose to the on-site worker would be from a spilled quantity of LSA material. The dose from such an accident is bounded by previous analysis of on-site spills of radioactive materials. The dose to the on-site worker would be no more than the permissable dose to a member of the public from a transportation accident involving LSA material as used in IAEA Safety Series 37 in the development of A-2 quantities for radioactive waste shipments.

6.0 SAFETY EVALUATION

10 CFR, Paragraph 50.59, permits the holder of an operating license to make changes to the facility or perform a test or experiment, without prior Commission approval, provided the change, test, or experiment does not involve a change in the Technical Specifications incorporated in the license, and it does not involve an unreviewed safety question.

Disposal of processed water does not require a Technical Specification change. NRC approval of the disposal option selected by GPU Nuclear is required by Technical Specification 3.9.13; accordingly, this evaluation is submitted to obtain that approval. In addition, at the request of the NRC staff and to clarify the current license conditions, Technical Specification Change Request number 56 has been submitted to delete the prohibitions on disposal of the AGW as presently stated in Specification 3.9.13. Further, the effluent release analyses performed in support of this evaluation demonstrate that the effluents from the proposed process water disposal system are well within the limits imposed by Appendix B to the TMI-2 Technical Specifications. Therefore, no changes to the TMI-2 Technical Specifications are required.

10 CFR 50, Paragraph 50.59, states a proposed change involves an unreviewed safety question if:

a. The probability of occurrence or the consequence of an accident or malfunction of equipment Important To Safety previously evaluated in the safety analysis report may be increased; or

b. The possibility for an accident or malfunction of a different type than any evaluated previously in the safety analysis report may be created; or

c. The margin of safety, as defined in the basis for any technical specification, is reduced.

Although the disposal system outlined in this report is different from the disposal options for liquid waste outlined in the FSAR, the consequences of these activities are bounded by analyses provided in the FSAR.

The disposal system proposed does not increase the probability of an accident or malfunction of equipment important to safety. The operation and control of the system will be governed by procedures prepared and approved pursuant to Section 6.8.1, 6.8.2 and 3.9.13 of the TMI-2 Technical specifications and will be designed to minimize the potential for an inadvertent release and, therefore, reduce the probability of an accident. Additionally, the consequences of any accident associated with the disposal system would be bounded by the evaluations given in the TMI-2 FSAR for a postulated failure of the Borated Water Storage Tank (BWST).

Supplement 2 of the TMI-2 FSAR evaluated the postulated failure of the BWST. The evaluation assumed that the BWST contained "design basis" radioisotopic concentration. The mix of radioisotopes, in the FSAR evaluation, is vastly different from the mix of radioisotopes in the processed water. However, the resulting doses from the release of the BWST contents into the Susquehanna River can be compared to the expected doses resulting from a hypothetical release to the river of all of the processed water. The doses calculated below are for illustrative purposes only and show that the hypothetcal release of all of the processed water is bounded by a previously reviewed accident evaluation. Table 1 in Supplement 2 (page S2-13C) of the FSAR, presents the resulting concentrations in the river from the postulated failure of the BWST. For this mix of radioisotopes, the radiologically significant radioisotopes are Cs-134, Cs-136, and Cs-137. Using the concentrations given in Table 1 of Supplement 2 for the east side of the island and the dose methodology given in Regulatory Guide 1.109, an adult is estimated to receive a dose of 7.8 rem to the liver from the consumption of one kilogram of fish residing in the east side of the island. The liver is the limiting organ for exposure to cesium.

For comparative purposes, Section 7.2.4 of the NRC's PEIS (NUREG-0683 of March 1981) presents analyses of various accidents involving rupture of a processed water storage tank (PWST). The resulting doses evaluated in the PEIS for these accidents are significantly less and bounded by the dose consequences for the postulated failure of the BWST presented in the FSAR.

The disposal system being proposed would not create an accident or malfunction of a different type. Postulated accidents associated with processed water disposal would consist of line breaks or tank ruptures for which the bounding accident has been evaluated above. The disposal of the processed water does not reduce any margin of safety as defined in the basis for any technical specification. The disposal system has been evaluated to determine the controls necessary to ensure, by compliance with governing procedures, that the operation of the system will comply with applicable technical specifications. Compliance with the applicable technical specifications ensures that public exposure from the planned gaseous or liquid discharges is well within the objectives of 10 CFR 50, Appendix I.

In conclusion, the disposal of the processed water does not involve an unreviewed safety question.

TABLE 1

IDENTIFICATION OF RADIONUCLIDES IN PROCESSED WATER

	Column 1	Column 2	Column 3	Column 4	Column 5
Nuclides	Curies Present in 2.3 MGAL	Concentration in µCi/ml in 2.3 MGAL	Specific Activity in Ci/gram	A-2 Value	Total Grams Present in 2.3 MGAL
Cesium-137	3.2E-1	3.7E-5	9.8E+1	10	3.7E-3
Cesium-134	7.66E-3	8.8E-7	1.2E+3	10	6.38E-6
Strontium-90	9.6E-1	1.1E-4	1.5E+2	0.4	6.4E-3
Antimony-125/	2.0E-2	2.3E-6	1.4E+3	25	1.43E-5
Tellurium-125m			1.8E+4	100	
Carbon-14	8.7E-1	1.0E-4	4.6	60	1.89E-2
Technetium-99	8.7E-3	1.0E-6	1.7E-2	25	5.12E-1
Iron-55	4.2E-3	4.8E-7	2.2E+3	1000	1.91E-6
Cobalt-60	4.2E-3	4.8E-7	1.1E+3	7	3.82E-6
Iodine-129	<5.2E-3	<6.0E-7	1.6E-4	2	<3.25E+1
Cerium-144	<1.4E-2	<1.8E-6	3.2E+3	7	<4.38E-6
Manganese-54	<3.5E-4	<4.0E-8	8.3E+3	20	<4.2E-8
Cobalt-58	<3.5E-4	<4.0E-8	3.1E+4	20	<1.13E-8
Nickel-63	<5.2E-3	<6.0E-7	4.6E+1	100	<1.1E-4
Zinc-65	<8.5E-4	<9.8E-8	8.0E+3	30	<1.06E-7
Ruthenium-106/ Rhodium-106	<2.9E-3	<3.3E-7	3.4E+3	7	<8.53E-7
Silver-110m	<4.9E-4	<5.6E-8	4.7E+3	7	<1.04E-7
Promethium-147	<4.2E-2	<4.8E-6	9.4E+2	25	<4.47E-5
Europium-152	<3.3E-6	<3.8E-10	1.9E+2	10	<1.74E-8
Europium-154	<3.8E-4	<4.4E-8	1.5E+2	5	<2.53E-6
Europium-155	<9.6E-4	<1.1E-7	1.4E+3	60	<6.86E-7
Uranium-234	<8.7E-5	<1.0E-8	6.2E-3	0.1	<1.40E-2
Uranium-235	<1.0E-4	<1.2E-8	2.1E-6	0.2	<4.76E+1
Uranium-238	<1.0E-4	<1.2E-8	3.3E-7	Unlimited	<3.03E+2
Plutonium-238	<1.0E-4	<1.2E-8	1.7E+1	.003	<5.88E-6
Plutonium-239	<1.2E-4	<1.4E-8	6.2E-2	.002	<1.94E-3
Plutonium-240	<1.2E-4	<1.4E-8	2.3E-1	.002	<5.22E-4
Plutonium-241	<5.7E-3	<6.5E-7	1.1E+2	0.1	<5.18E-5
Americium-241	<1.0E-4	<1.2E-8	3.2	.008	<3.13E-5
Curium-242	<8.7E-4	<1.0E-7	3.3E+3	0.2	<2.64E-7
Total	<2.27 Ci	<2.6E-4 µCi/ml			<384.66 grams

TABLE 2

PROCESSED WATER DISPOSAL SYSTEM INFLUENT LIMITS IN μCi/ml

AND THE RESULTING ENVIRONMENTAL RELEASE RATES IN μCi/ml

	Coupled Mode		Decoupled Mode	
Constituent	Evaporator Influent Limit	Resulting Vaporizer Limit	Vaporizer Influent Limit	Environmental Release Rate Limit
Cesium-137	3.7E-5	3.7E-8	3.7E-8	3.7E-8
Cesium-134	8.8E-7	8.8E-10	8.8E-10	8.8E-10
Strontium-90	1.1E-4	1.1E-7	1.1E-7	1.1E-7
Antimony-125/ Tellurium-125m	2.3E-6	2.3E-9	2.3E-9	2.3E-9
Carbon-14	1.0E-4	1.0E-7	1.0E-7	1.0E-7
Technetium-99	1.0E-6	1.0E-9	1.0E-9	1.0E-9
Iron-55	4.8E-7	4.8E-10	4.8E-10	4.8E-10
Cobalt-60	4.8E-7	4.8E-10	4.8E-10	4.8E-10
Iodine-129	<6.0E-7	<6.0E-10	<6.0E-10	<6.0E-10
Cerium-144	<1.8E-6	<1.8E-9	<1.8E-9	<1.8E-9
Manganese-54	<4.0E-8	<4.0E-11	<4.0E-11	<4.0E-11
Cobalt-58	<4.0E-8	<4.0E-11	<4.0E-11	<4.0E-11
Nickel-63	<6.0E-7	<6.0E-10	<6.0E-10	<6.0E-10
Zinc-65	<9.8E-8	<9.8E-11	<9.8E-11	<9.8E-11
Ruthenium-106/ Rhodium-106	<3.3E-7	<3.3E-10	<3.3E-10	<3.3E-10
Silver-110m	<5.6E-8	<5.6E-11	<5.6E-11	<5.6E-11
Promethium-147	<4.8E-6	<4.8E-9	<4.8E-9	<4.8E-9
Europium-152	<3.8E-10	<3.8E-13	<3.8E-13	<3.8E-13
Europium-154	<4.4E-8	<4.4E-11	<4.4E-11	<4.4E-11
Europium-155	<1.1E-7	<1.1E-10	<1.1E-10	<1.1E-10
Uranium-234	<1.0E-8	<1.0E-11	<1.0E-11	<1.0E-11
Uranium-235	<1.2E-8	<1.2E-11	<1.2E-11	<1.2E-11
Uranium-238	<1.2E-8	<1.2E-11	<1.2E-11	<1.2E-11
Plutonium-238	<1.2E-8	<1.2E-11	<1.2E-11	<1.2E-11
Plutonium-239	<1.4E-8	<1.4E-11	<1.4E-11	<1.4E-11
Plutonium-240	<1.4E-8	<1.4E-11	<1.4E-11	<1.4E-11
Plutonium-241	<6.5E-7	<6.5E-10	<6.5E-10	<6.5E-10
Americium-241	<1.2E-8	<1.2E-11	<1.2E-11	<1.2E-11
Curium-242	<1.0E-7	<1.0E-10	<1.0E-10	<1.0E-10

Limits as specified are averaged over a calendar quarter.

PROCESSED WATER DISPOSAL SYSTEM

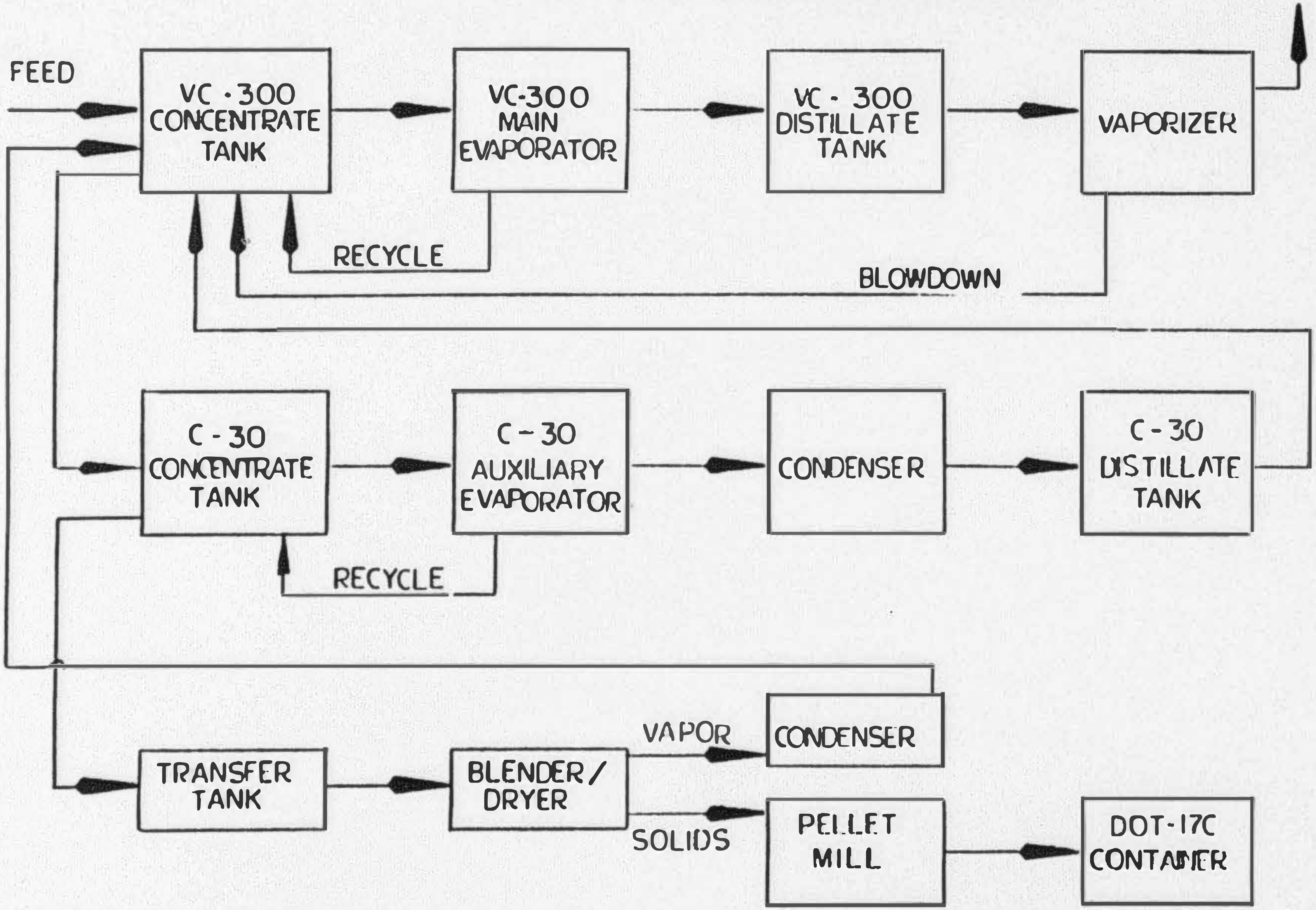


Figure 1: PROCESS FLOW BLOCK DIAGRAM

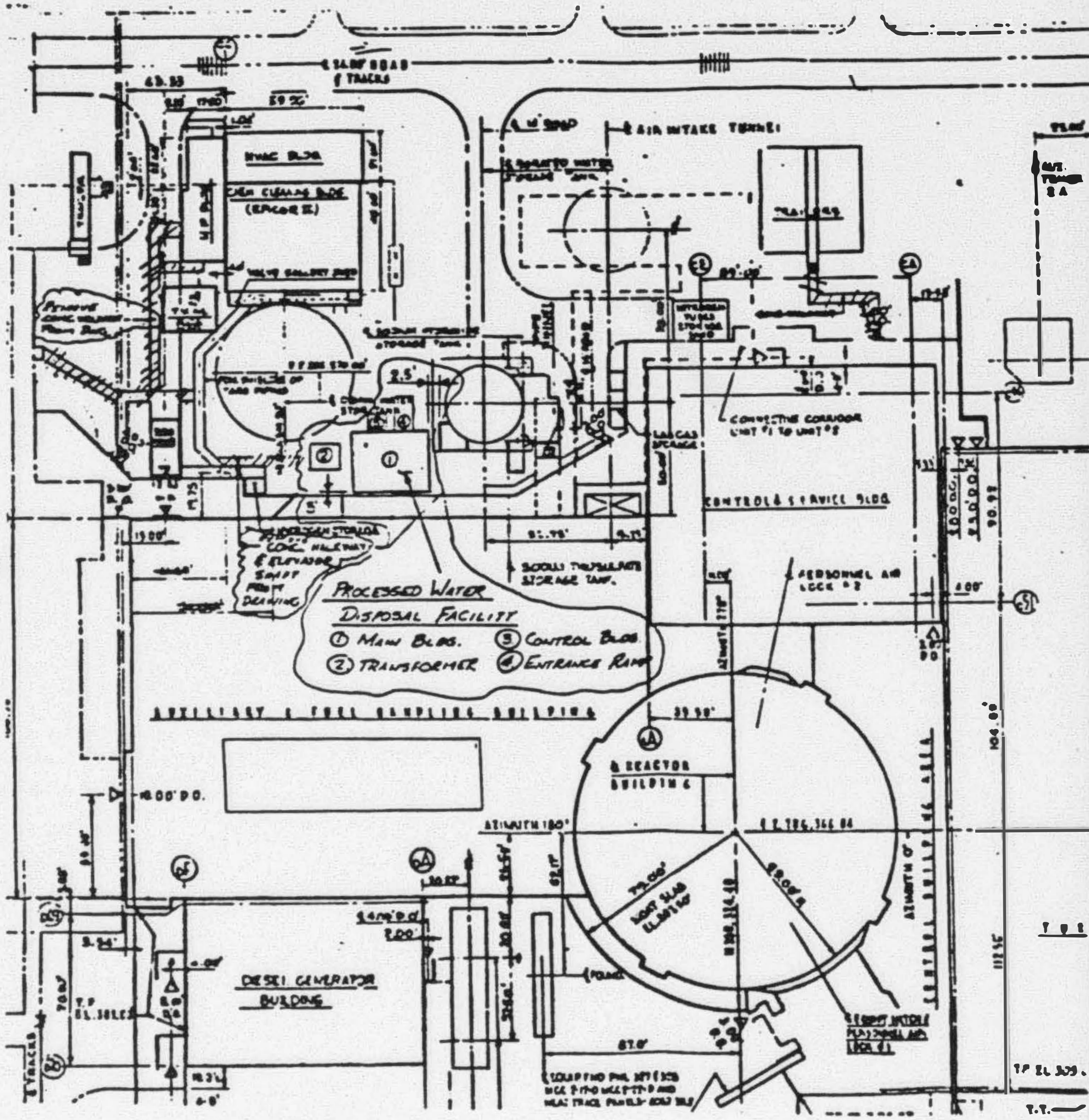
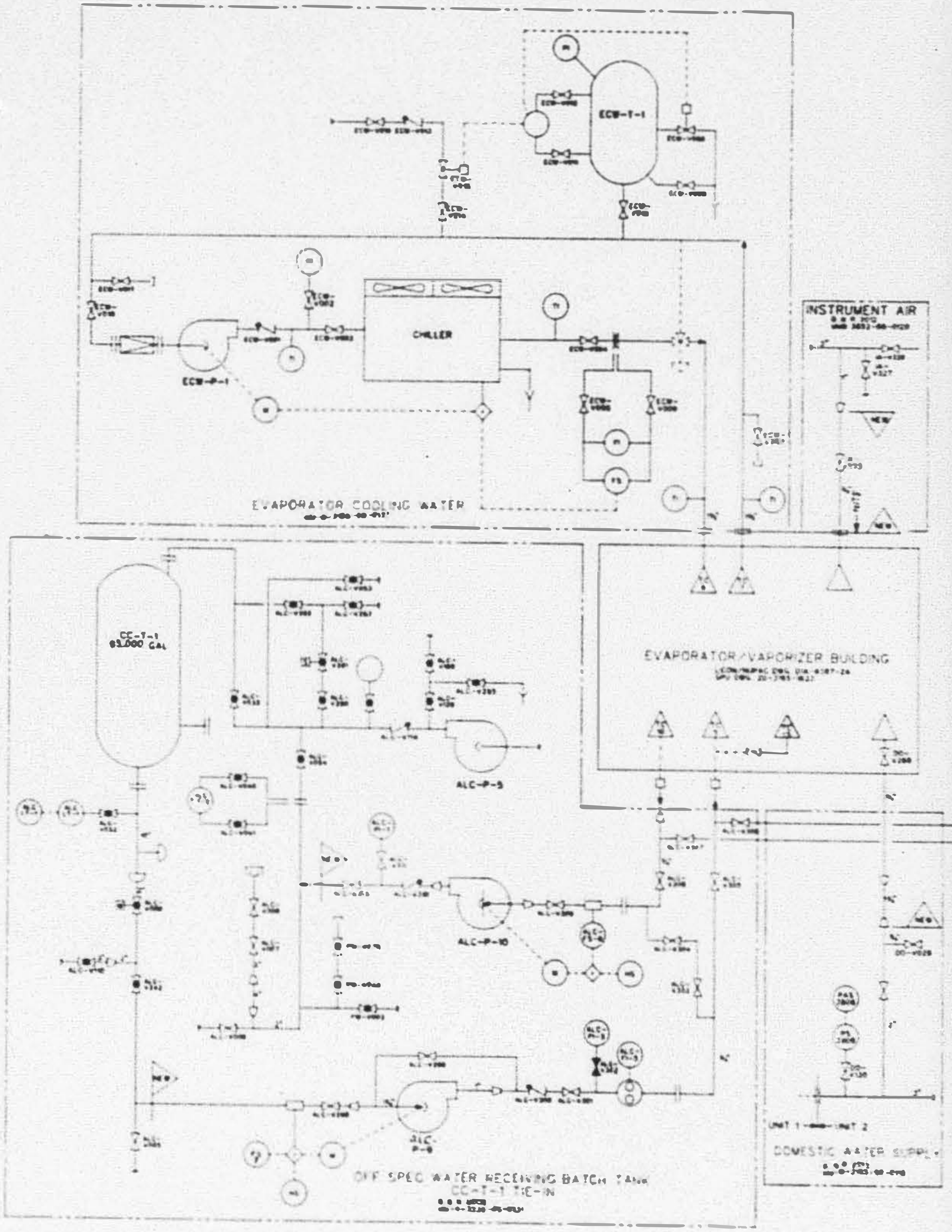
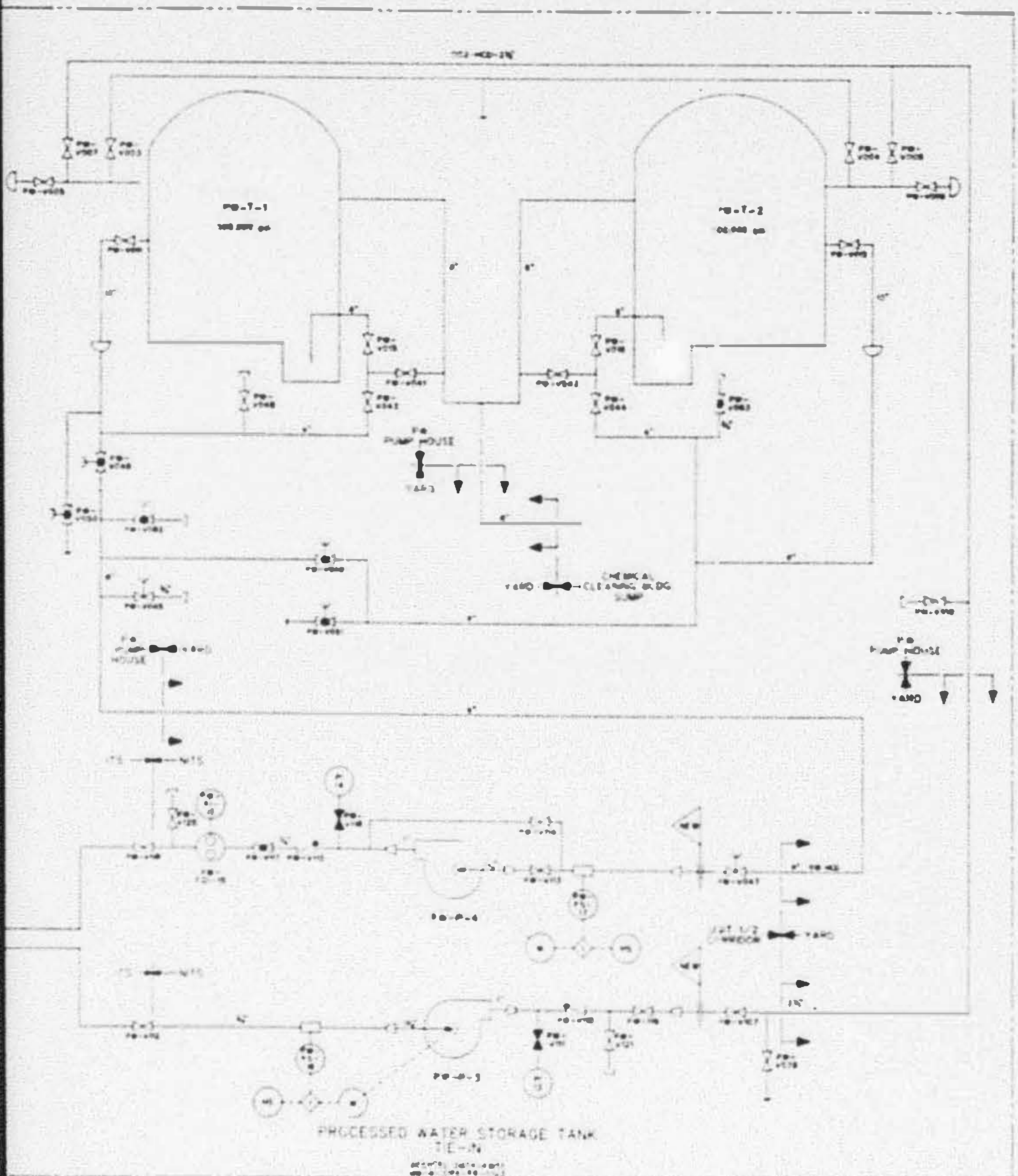


Figure 2: Site plan showing location of the Processed Water Disposal System


ECW-T-1
CHILLER
ECW-P-1
EVAPORATOR COOLING WATER
INSTRUMENT AIR
NEW
EVAPORATOR/VAPORIZER BUILDING
CC-T-1
83,000 GAL
ALC-P-9
ALC-P-10
ALC-P-8
OFF SPEC WATER RECEIVING BATCH TANK
CC-T-1 TIE-IN
UNIT 1
UNIT 2
DOMESTIC WATER SUPPLY



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CARD

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8810170192-01

REV	DESCRIPTION	DATE	BY	CHKD	APPR

GPU Nuclear TMI-2

TMI UNIT II EVAPORATOR PLANT SYSTEM TIE IN P&ID.

DRAWN	DATE
	DATE
DESIGN LEADER	DATE
PROJECTS	DATE
MANAGER APPROVAL	DATE

DWG NO. 2D-3185-1630 REV. 0

SCALE: NONE

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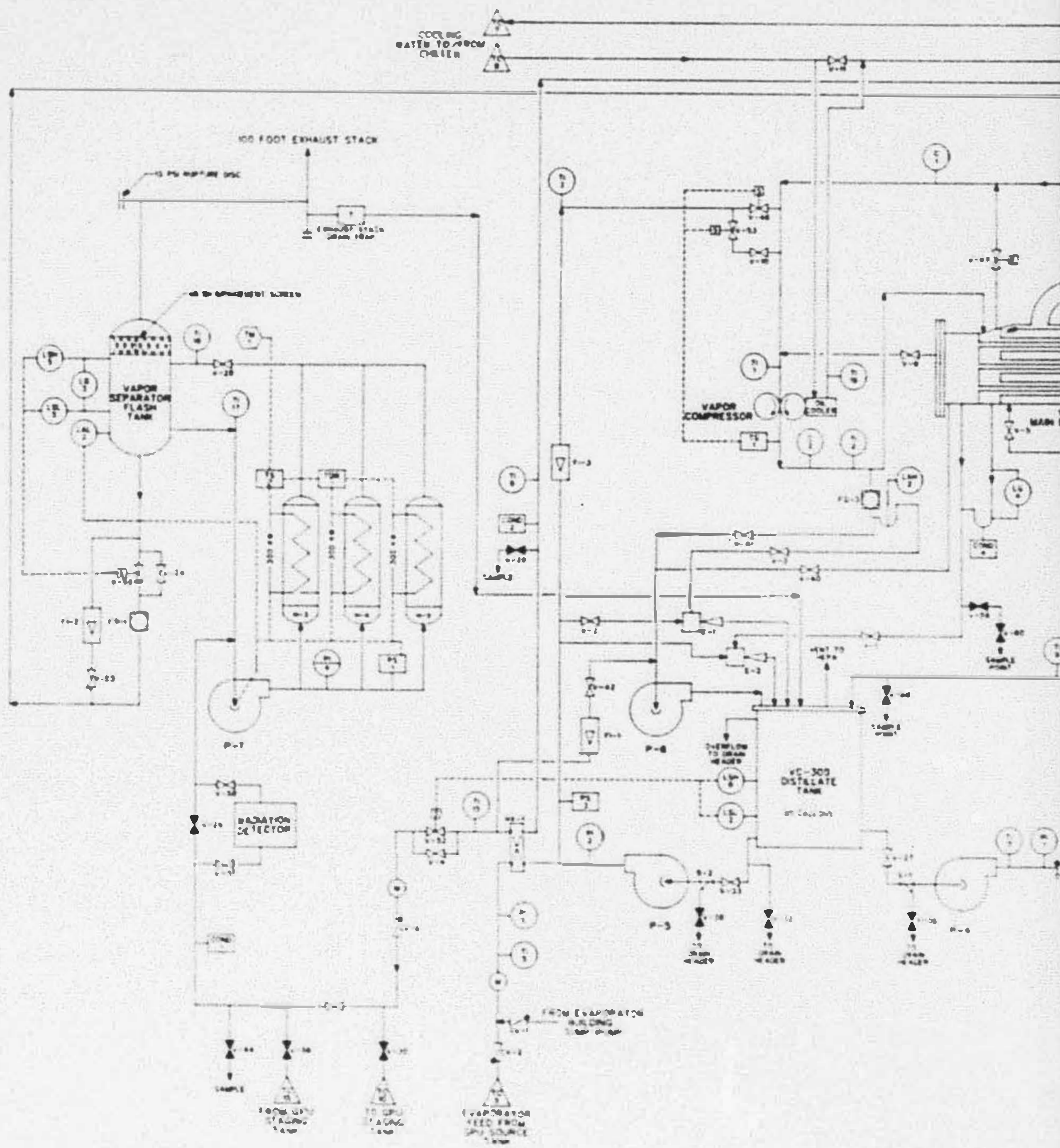

SI APERTURE CARD

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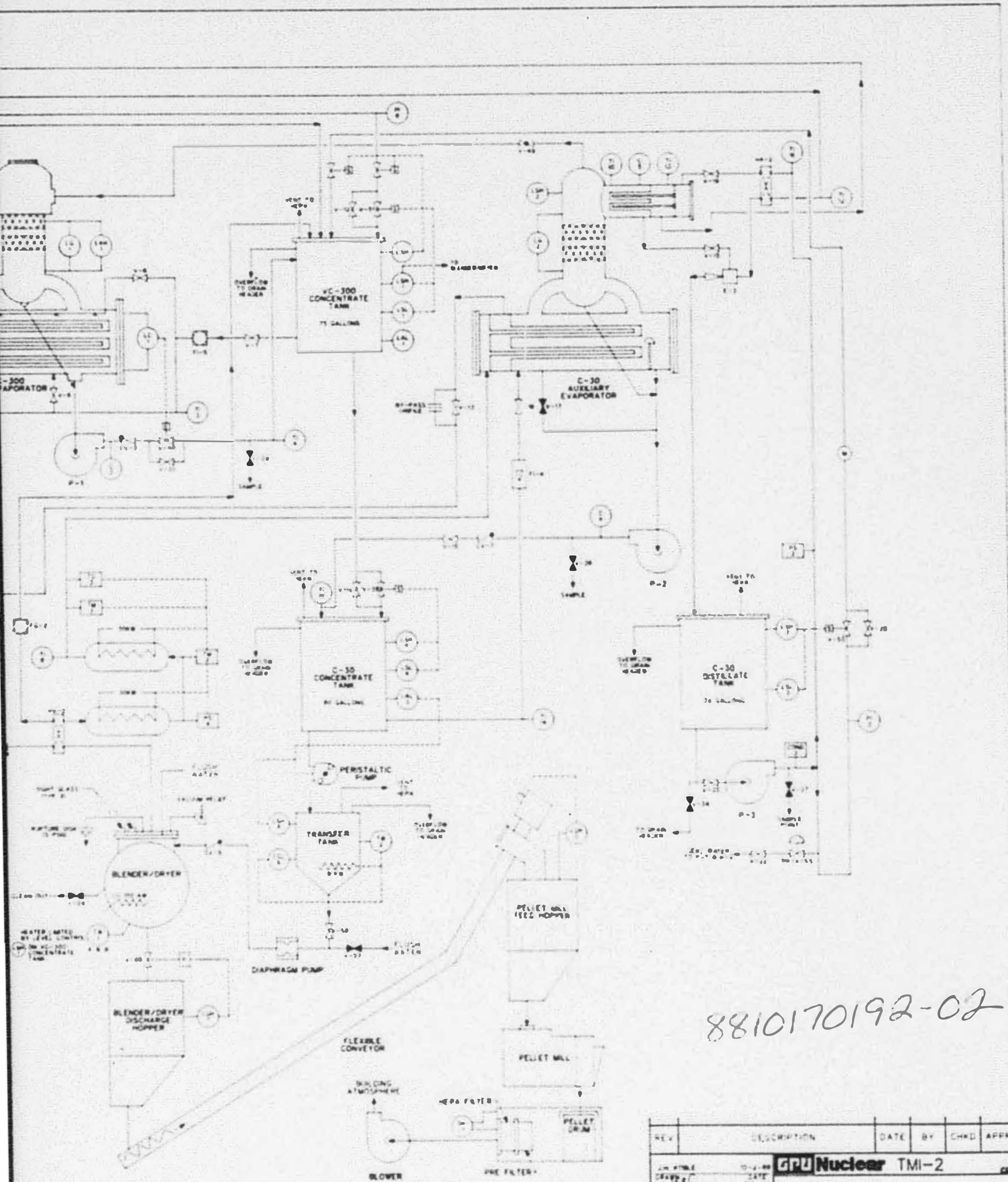

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REV	DESCRIPTION	DATE	BY	CHKD	APPR

GPU Nuclear TMI-2

PROCESSED WATER DISPOSAL
SYSTEM P&ID.

DWG NO. 20-3185-1033 REV. 0

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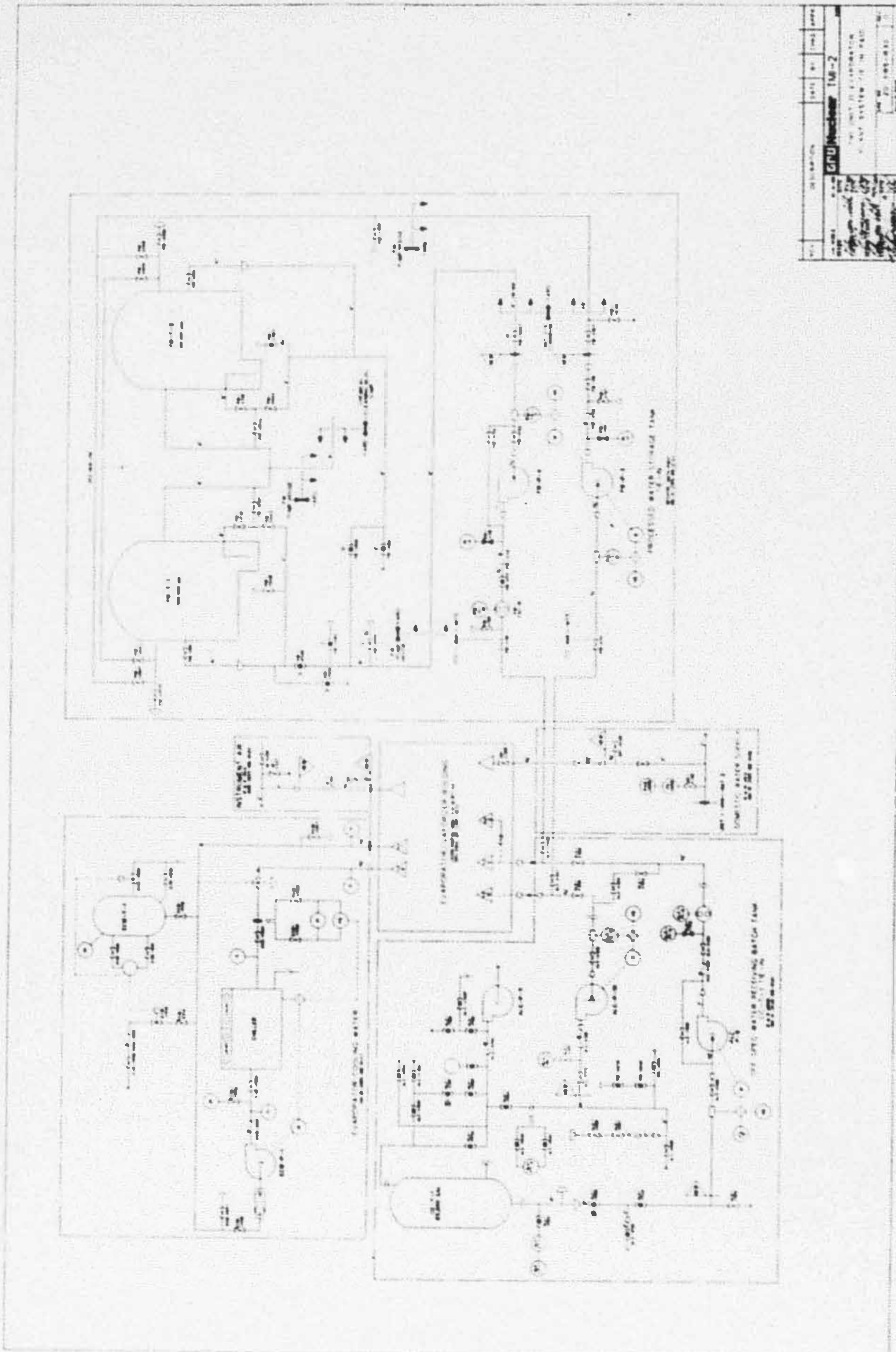
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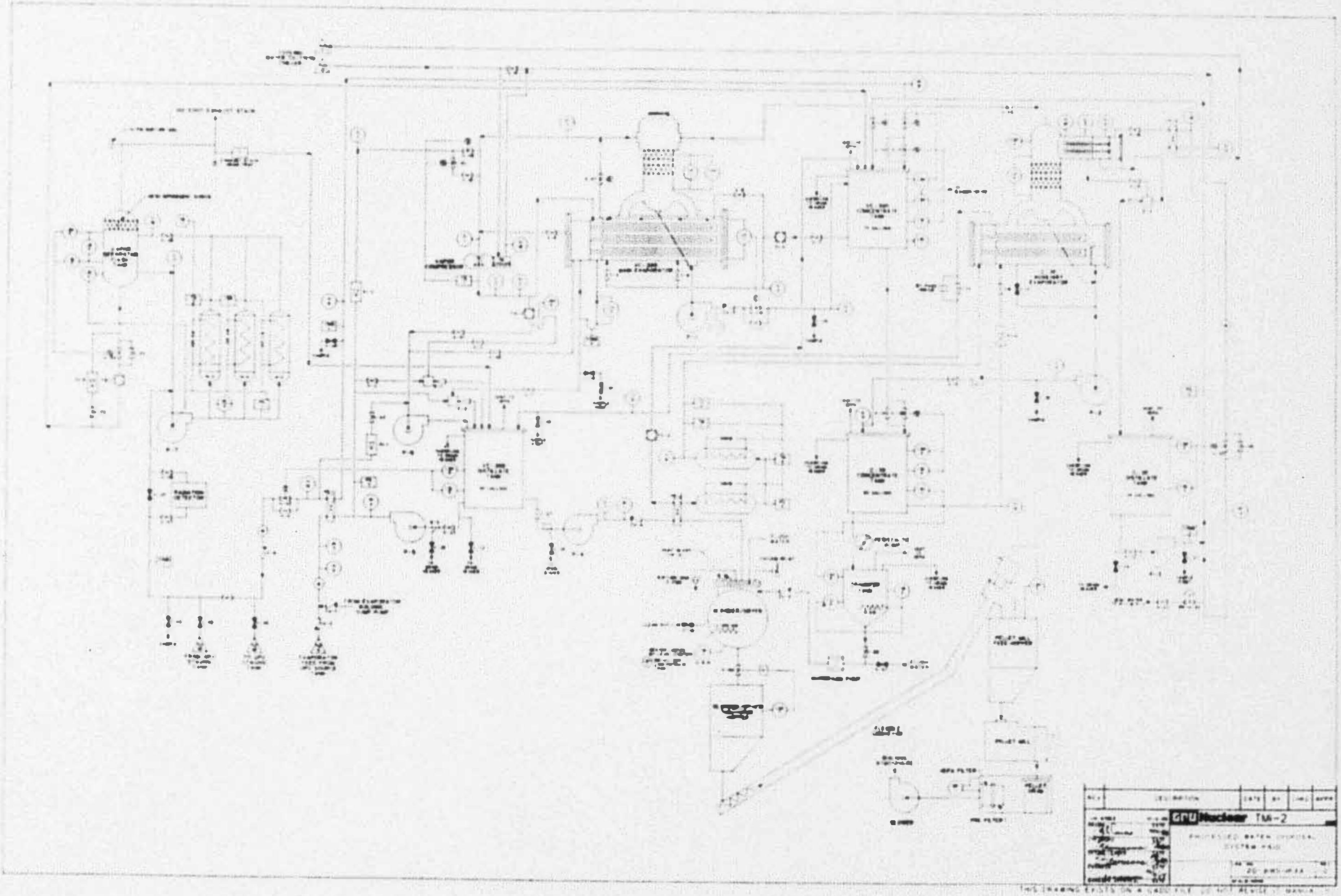
GPU Nuclear TMI-2
PROCESSED WATER DISPOSAL
SYSTEM P&ID

LIST OF SPECIALITY SYMBOLS

Figure 4a

LAH	Level Alarm High
LAL	Level Alarm Low
LC	Level Control
TI	Temperature Indicator
TW	Thermal Well
M	Flow Meter
PS	Pressure Switch
TS	Temperature Switch
	Sight Flow Gauge
TC	Terminal Connection
S	Flow Strainer
HX	Heat Exchanger
LSH	Level Switch High
LSL	Level Switch Low
LG	Level Gauge
PI	Pressure Indicator
DP	Differential Pressure Gauge
C	Compound Gauge
COND	Conductivity Meter
TM or TM	Thermostat
	Flow Indicator
	Eductor