GPU NUCLEAR

TER 3232-019 REV. 1

ISSUE DATE September 25, 1989

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DIVISION
TECHNICAL EVALUATION REPORT
FOR
THE PROCESSED WATER DISPOSAL SYSTEM

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Rev.	SUMMARY OF CHANGE	Approval	Date
0	Initial Issue for Use	YR	10/88
1	General Revision to Reflect System Modification	YR	9/89

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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 using 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 2.25 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 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. Water that requires processing to reduce its radionuclide concentrations prior to disposal may be processed by ion exchange, filtration, or distillation. Systems presently available to perform such processing include the Defueling Water Cleanup System, EPICOR, and the proposed evaporator operated in closed cycle.

1.2 Purpose and Scope

The purpose of this report is to provide a description of the Processed Water Disposal System (PWDS) 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 (NUREG-0683) 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 in a closed cycle 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 main evaporator 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 mode, a spraying film mode, or a combination of these two modes. 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 vapor exits the shell, along with a significant quantity of entrained liquid, 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 shell 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 compressor. The compressor increases the temperature and pressure of the steam and discharges 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 160°F. The mechanical vapor recompressor will raise the temperature of the vapor to about 180°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 heat necessary for system start-up is supplied in the form of steam from the auxiliary evaporator which is described in Section 2.3.

In order to prevent overheating of the vapor compressor discharge due to excessive superheating of the vapors, a water spray is injected into the compressor suction duct. This water spray is supplied from the VC Distillate tank and provides desuperheat and a liquid seal around the compressor lobes. Excess water is removed from the low point of the compressor discharge duct by a vacuum eductor and/or a liquid ring mechanical vacuum pump. Since this liquid may be contaminated by volatilized boric acid quenched from the vapor stream by the desuperheat spray nozzles, it is discharged into the contaminated distillate tank. The water in the contaminated distillate tank, which is supplemented by the overflow from the C-30 distillate tank (discussed later), is sprayed through two reflux spray nozzles into the main evaporator vapor dome. The spray is introduced between the two stages of demister screens. Since boric acid is volatile in steam, a portion of it will be mixed with the steam in a vapor phase. The reflux sprays, having a very low boric acid concentration, will quench most of the boric acid vapor and return it to the boiling liquid.

Processed water will be fed to the VC-300 concentrate tank at a nominal rate of 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 pumped along with a portion of the concentrated liquid from the heat exchanger shell to the concentrate tank by the VC Concentrate pump. The liquid level in the heat exchanger shell is maintained high enough to cover about one third to two thirds of the heat exchanger tubes. The 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. If necessary, small amounts of detergent can be added to the feed stream to enhance the foaming action to ensure adequate wetting of the heat exchanger tubes.

Both ends of the evaporator heat exchanger are equipped with clear plexiglass viewing windows which allow the operator to see the boiling liquid level and degree of foaming so that level adjustments can be made as needed. In addition, the drain from the vapor dome to the recycle pump suction is provided with a sight flow indicator allowing the operator to visually assess the amount of entrained liquid entering the vapor dome with the stream.

About 1 gallon per minute of the main evaporator concentrate recycle is discharged through a side stream from the VC Concentrate pump to the auxiliary (C-30) evaporator concentrate tank for further concentration and processing. When the VC-300 system is supplied with processed water containing a total solids concentration of 1.8 to 2.0%, it will produce a concentrated solution of about 10% total dissolved solids. 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 a very small percentage 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 discharge from the main evaporator to a concentration of between 20 and 25 percent total solids, depending on operational needs. 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 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 which then overflows to the contaminated distillate tank. Water in the C-30 distillate tank is pumped through a recirculation loop by the C-30 distillate pump, P-3. This loop supplies the motive force for the distillate eductor, E-3. A sidestream from this loop supplies the seal water to the VC-300 and C-30 concentrate pumps and an additional sidestream can supply an alternate source to the VC-300 desuperheating sprays. Concentrated solution from the C-30 evaporator is discharged at a rate of 0.3 to 0.5 gpm 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 an exhaust stack. Distillate will be pumped to the vaporizer flash tank at a rate of about 5 gpm. A 500 gpm recirculation pump forces water from the flash tank 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 contaminated distillate tank.

2.5 Blender/Dryer

The blender/dryer will receive the liquid or slurry product from the auxiliary evaporator at a concentration of 20 to 25 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 pass through a condenser and be 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 which 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 a 1/2 inch feed connection located on the dryer side. 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. As the solids exit the blender dryer, they pass through a roller mill, or "de-lumper", that assures any large chunks are reduced in size to preclude plugging of the down stream handling equipment.

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 cylindrical 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 are discharged into a DOT Specification 17-C shipping container. A small electrically powered steam generator supplies moisture into the pellet mill to serve as a binder and assure stable pellets. The steam generator is fed from the C-30 distillate tank at a rate of about 0.1 gpm.

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 will be performed with the drum inside the ventilated drum enclosure.

2.7 Tank Vent System

All of the tanks on the evaporator skid and transfer skid are closed at the top with gasketed plexiglass covers equipped with two inch vent connections. The vents are routed via flexible hose to a manifold mounted in the building ceiling. The manifold discharges through a condenser to a HEPA filter that exhausts to the building atmosphere. The condenser removes any moisture or steam vented from the tanks and drains the condensate to the blender/dryer transfer tank. This protects the HEPA filters from excessive moisture. The HEPA removes any particulate matter from the vent stream before it discharges to the building atmosphere.

2.8 Ancillary Equipment

2.8.1 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. The panels are laminated construction consisting of an insulating foam material sandwiched between sheet metal and are painted on their interior and exterior surfaces for easy cleaning. Attached to the building is a 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 (about 2200 gallons) 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 a variable speed exhaust fan that will provide 625 to 2,500 CFM air flow out through the building exhaust. This will provide up to 15 air exchanges per hour.

An ambient air sampler will be operated continuously within the evaporator building to evaluate airborne radiological conditions. The monitor will be provided with a strip chart recorder and will be set to alarm at 25 percent of Maximum Permissible Concentration (MPC) to personnel. The monitor with its strip chart recorder will be used to monitor for trends in the building airborne radioactivity levels. Reaching levels of 25 percent of MPC is extremely unlikely due to the low specific activity of the radioactive material being handled.

In the event the sampler becomes inoperable, continued operation of the PWDS will be permitted for up to one week provided high volume air samples are obtained in the building every four hours.

Because of the nature of the contaminants in the processing stream, primarily boric acid and borate salts, material leakage and spills in the building will result in airborne dust hazards before the airborne radioactivity reaches a level of concern. The building atmosphere will be periodically monitored for respirable dust and workers will be required to use respiratory protection if airborne concentrations of boric acid and borates exceed 1 mg/m^3.

In the unlikely event that acceptable radiological or nonradiological working conditions cannot be achieved in the evaporator building, action will be initiated to protect the operators, the system will be placed in a safe shutdown condition, and all processing activities will be terminated until the problem is corrected. In addition, the building ventilation will be shutdown when necessary to terminate any unplanned airborne radioactivity releases to the environment.

In addition to monitoring the airborne radiological working conditions inside the building, the continuous air monitor will be located so that its sampling point provides a sample that is generally representative of the air being discharged from the building ventilation exhaust. This will provide a means of quantifying the material released from the building in the event of a spill of liquid or solid waste. Initially, the monitor will be placed in the area that in the judgement of the engineering staff is most likely to be representative of the building atmosphere. After system startup, high volume air samples will be obtained to confirm that the monitor location has been chosen properly. A program will be established to confirm quarterly that the continuous air monitor is placed in a location such that it provides an adequate indication of the radiological releases from the building exhaust.

2.8.2 Cooling Water System

Cooling water for the processed water disposal system will be supplied from and returned to two closed cycle chilled water systems. The self contained chillers and chilled water system will be located adjacent to the evaporator building and each will provide about 20 gpm of cooling water at a temperature of about 50° F to the evaporator building. One chiller, supplied by GPUN, provides cooling water to the C-30 condenser and the main evaporator compressor oil cooler. The other unit, provided by the vendor, supplies cooling water to the blender/dryer exhaust condenser and to the tank vent condenser.

2.8.3 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.

In the unlikely event of failure of the 13.2KV power feeder or the 2500KVA step-down transformer, a 200 amp, 480 volt emergency power feeder has been provided from the existing plant electrical distribution system. The power can be brought in from USS 2-48 through the normal power supply to the high pressure spray pump, TDW-P-1 (the NLB pump) via a normally locked open disconnect switch that has been added to the line side of the NLB pump disconnect. This should provide power to sufficient loads in the evaporator system to permit dilution and flushing of the evaporator to prevent solids precipitation and to keep the blender/dryer operating without its heaters until normal power can be restored.

2.8.4 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 on GPUN Drawing 2D-3185-1630. The drawing 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 EPICOR II System will be modified to allow using the existing 85,000 gallon CC-T-1 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 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 blender/dryer transfer pump, the air operated blender/dryer discharge valve, a vibrator on the blender/dryer discharge hopper, and an air sparger on the transfer tank.

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.

2.8.5 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 about 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 14 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 held for later feed to the vaporizer or reprocessing through the evaporator. 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 Nuclear Packaging Services 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 about 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 5. The concentrated solution is continuously drawn from the VC-300 recycle line and pumped to the C-30 auxiliary evaporator. The C-30 evaporator will produce a further concentrated solution that is about 20 to 25 percent dissolved solids. The purified distillate is continuously removed from the VC-300 tube bundle by eductor, E-2, and is discharged to the VC Distillate Tank. The water in the distillate tank is continuously recirculated by the main distillate pump, P-2, and the heating loop pump, P-1. The heating loop pump, P-1, circulates water from the VC distillate tank through two 30 KW thermostatically controlled electric heaters, through heat exchanger HX-3, and then to the tube bundle of the C-30 evaporator. The residual heat, supplemented by the electric heaters, provides the heat source to the C-30 evaporator. The water discharges from the C-30 tube bundle back to the VC distillate tank. The distillate pump, P-2, supplies water to a recirculation loop that feeds clean water to the desuperheater spray nozzles in the vapor recompressor suction, motive force water to the VC-300 distillate eductor, E-2, and the evaporator distillate discharge. The discharge sidestream passes through the raw feed preheater, HX-2, and out through automatic letdown valves operated by level controls on the VC 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, from the distillate feed to the vaporizer, and from the vaporizer discharge. 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 Processed Water Disposal System 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. The boron analysis will be used to calculate a 96-hour rolling average of the system DF. If the system average performance drops below a DF of 1000 over a 96 hour period (except for periods of startup, shutdown, or short duration malfunctions) or if conditions should exist which, in the judgement of GPU Nuclear, is such that a 96-hour average DF of 1000 cannot be re-established, releases to the environment through the vaporizer will be terminated, 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 or recirculate it back to the VC-300 Concentrate 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 is achieved.

3.2.2 Decoupled Operation

In the decoupled mode of operation, the evaporator and vaporizer are operated as separate units. The source tank to be processed is isolated, recirculated, sampled, and analyzed for conformance to the criteria in Section 3.3. The water is fed from the source tank to the evaporator. The evaporator operates as described in section 3.2.1 with the exception that the distillate is discharged to a holding tank rather than being fed directly to the vaporizer. When the holding tank is filled, the evaporator is shutdown and the holding tank is sampled and analyzed. If the water is suitable for direct vaporization, it is fed to the vaporizer and discharged to the atmosphere. If it is not suitable for direct vaporization, it can be processed again through the evaporator in either coupled or decoupled mode depending upon its contaminant concentration. 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.

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.

3.2.3 Final Waste Processing Operations

The final processing of the evaporator bottoms is the same whether operating in the coupled or decoupled mode. Concentrate is discharged at a rate of about .4 to .5 gpm from the C-30 evaporator and pumped to the 275 gallon transfer tank. The concentrate is then fed in 90 gallon batches to the blender/dryer. The first batch may be 90 to 100 gallons depending upon the volume available in the transfer tank. After the transfer of the first 180 gallons, the blender/dryer is heated to about 375°F and its pressure allowed to build to about 8 psig. A vacuum pump then draws the pressure down to about 10 inches of water and allows the pressure to cycle between these two points. The vapor is discharged by the vacuum pump through a condenser to the VC concentrate tank. Successive 90 gallon batches are charged to the blender/dryer until a total of about 450 gallons of concentrate has been added. After the final batch has been added, the material is dried to the desired moisture content and then discharged to the discharge hopper. The dried material is then fed to the pelletizer as described in section 2.6.

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 System DF is defined as the concentration of contaminants in the system influent divided by the concentration of contaminants in the system effluent. The Processed Water Disposal System is intended 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 vapors discharged to atmosphere. 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 both prior to delivery of the system to the TMI site and after installation of the system at the 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. The evaporator DF will be verified by chemical analysis of the feed solutions, the purified distillates, and the vapor discharged to atmosphere. 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. The level of contaminants released in the vapor 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. Some of the 2.3 million gallon inventory will require some form of additional 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 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 evaporation and vaporizer 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 permissible by 10 CFR 20 and plant Technical Specifications 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. Further, if the DF achieved for a particular nuclide can be shown to vary significantly from DF's achieved for other constituents, the influent limit for that nuclide will be adjusted 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 2.25 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 2.25 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 tetra-borate form will predominate as very little if any meta-borate is expected with a feed solution pH of less than 10. 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 2.25 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 2.25 million gallons and average boron and sodium concentrations 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 any 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 2.25 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 (V-51 and V-12). 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 four sonic level switches. As the level in the tank varies, the high level sonic switch closes the solenoid operated feed valve, the low level switch opens the valve, and the low-low level switch actuates a low level alarm and deenergizes the evaporator causing a system shutdown. The High-High level switch will actuate an alarm light and shut the main feed valve (V-62) to the system to prevent overflow of the tank. 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 a side stream discharge from the VC-300 recycle line. The concentrate flow from the VC-300 evaporator to the C-30 concentrate tank is controlled by a similar arrangement of a manual valve and a solenoid valve in parallel. The solenoid valve is controlled by two level switches in the C-30 concentrate tank. A third level switch in the C-30 concentrate tank causes a low level alarm, deenergizes the evaporator system and trips the pump to the blender/dryer transfer tank. Discharge from the VC distillate tank is controlled in a similar manner. The level in the vaporizer flash tank is controlled by three sonic level switches. The top switch closes a solenoid valve (V-54) in the feed line, the middle switch opens the valve, and the bottom switch actuates a low level 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. 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

Water meters with flow totalizers are installed on the evaporator feed line and vaporizer feed line to keep track of total volume of water processed. These will provide data for the determination of the system mass flow balances. Flowrate meters are installed in the desuperheat line, reflux spray line, both evaporator recycle feed 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

Measurements of conductivity provide a relative indication of the amount of dissolved material in water. 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 have degraded 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 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 concentration 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 if 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-4A sampler. It uses a Model MD-51 (V-7) high temperature, thermally insulated sodium iodide crystal as a gamma scintillation detector. It has a monitoring sensitivity of 3.7E-7 µCi/ml of Cesium-137 at a 95 percent confidence level. The system includes continuous digital readout and a strip chart recorder for continuous monitoring.

3.4.5 Overpressure Protection

The vaporizer flash tank is protected from overpressurization by a rupture disk located on the vapor discharge line. The 2 inch rupture disk is designed to relieve at a 15 psi differential pressure and discharge to atmosphere through a duct out through the evaporator building roof.

The blender/dryer shell is protected from overpressurization by a rupture disk and from an over vacuum condition by a vacuum relief valve. The 15 psi rupture disk relieves into a header that discharges into the building sump. The 13 psid vacuum relief valve allows air from the building atmosphere to relieve into the blender/dryer shell.

3.4.6 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-2 and P-3, and the contaminated distillate pump, P-8, 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 tripping their respective pumps which subsequently deenergizes 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.

Two float switches provide level control for the transfer skid holding tank which receives concentrated liquid from the C-30 concentrate tank for feed to the blender/dryer. 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.

3.5 Sampling and Analysis Program

To assure that influents and effluents from the PWDS are within the specifications discussed, a rigorous sampling and analysis program will be procedurally implemented as described in this section.

Prior to feeding water to the PWDS for disposal, the source tank must be sampled to verify that the water conforms to the appropriate influent limits for the intended operating mode. Whatever the source tank, it will be recirculated for a minimum of three tank volumes prior to obtaining a sample. A sample will be obtained and analyzed for pH, conductivity, boron concentration, and sodium concentration. Its radionuclide concentration will be determined by a gamma scan, gross alpha count, and determination of the concentration of strontium-90, carbon-14, and tritium. These analyses will be performed on site and are a prerequisite for processing a source tank. Once processing has begun on a source tank, the tank will be periodically resampled to confirm the original analyses. The resampling will be performed after each 100,000 gallons has been processed when a PWST is the source tank. When using a smaller source tank, the resampling will be performed after each 20 percent of the tank's full volume has been processed, but not more frequently than daily. These samples will be analyzed for sodium, boron, pH, conductivity, gross alpha, gamma scan, and strontium-90.

When operating in the coupled mode, the evaporator distillate/vaporizer feed will be sampled every 12 hours and analyzed for boron concentration. This analysis will be used to determine the decontamination factor achieved by the evaporator. In addition, a sample of the vaporizer discharge will be obtained through a sample condenser. This sample, collected every 12 hours, will be analyzed for boron concentration and used to calculate the vaporizer decontamination factor and the total system decontamination factor.

An automatic composite sampler will be operating on the vaporizer feed line. It will collect a six gallon composite sample over a 48 hour period, operating on either a time-based or flow-based automatic controller. The sample obtained will be analyzed for strontium-90, carbon-14, and cesium-137. Further analyses of these composite samples will be performed to obtain the necessary data for quarterly effluent reporting. In the event the automatic sampler becomes inoperable, continued operation of the vaporizer will be permitted for up to seven days while grab samples of the vaporizer feed are obtained every four hours.

If operating the evaporator or vaporizer in the decoupled mode, the source tank will be sampled as described previously. When operating the evaporator in the decoupled mode, the distillate will be sampled and analyzed for boron every 12 hours. When operating the vaporizer in the decoupled mode, the composite samples will be collected every 48 hours as previously described for quarterly effluent monitoring and the boron analysis on the discharge will be done every 12 hours.

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".

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 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, 50 gallons; the contaminated distillate tank, 40 gallons C-30 Distillate Tank, 34 gallons; and the blender/dryer transfer tank, 275 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 B31.1, "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 B31.1, 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 1030 compressor, 4100 CFM at 1400 RPM, driven by a 125 HP TEFC motor.
- Heating Loop Pump, P-1: Grundfos Model CR4-20N, vertical multi-stage centrifugal, 30 gpm at 60 ft TDH, driven by a 3/4 HP TEFC motor, 3500 RPM.
- VC-300 Distillate Pump, P-2: Grundfos Model CR4-50N, vertical multi-stage centrifugal, 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, vertical multi-stage centrifugal, 10 gpm at 110 ft TDH, driven by a 3/4 HP TEFC motor at 3500 RPM.
- C-30 Concentrate Pump, P-4: Same as P-5 except with a cut down impeller to give 3 GPM at 60 ft TDH.

VC-300 Concentrate Pump, P-5:	Corcoran Series 2000 DH, with double mechanical seals, 10 gpm at 50 ft TDH, driven by a 3.4 HP TEFC motor, 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.
Vaporizer Recirculation Pump, P-7:	Goulds Model 3196 MT, Size 4X6-10, 500 gpm at 40 ft TDH, driven by a 7-1/2 HP TEFC motor, 1150 RPM.
Contaminated Distillate Pump, P-8:	Grundfos Model CR2-20N, vertical multi-stage centrifugal, 6 gpm at 80 ft TDH, driven by a 1/2 HP TEFC motor, 3500 RPM.
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 Discharge Hopper Level:	Penberthy Model 801/32-1, 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 and to minimize the potential for 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 solenoid 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 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 diaphragm pump on the blender/dryer transfer tank, the air operated discharge valve on the blender/dryer, a vibrator on the blender/dryer discharge hopper, and an air sparger on the transfer tank. 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. Further, hydrostatic testing, in-service leak testing, and preoperational testing of the equipment with non-radioactive solutions will verify the designed integrity of the system and components. But in the unlikely event of a tank or pipe rupture, low level sensors on the tanks will detect such an occurence and initiate system shutdown by deenergizing the electrical system. The building is designed with a curb of sufficient height to contain the entire volume of liquid that could be present in the system if completely flooded, so spillage of radioactive liquids will be contained within the building. Minor spills occurring during system sampling or as a result of small leaks are of little consequence because of the low specific activity of the material being handled. 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 that will facilitate cleanup and decontamination, if necessary. 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 Overconcentration/Precipitation

Inadvertant crystallization from overconcentration is possible as a result of operator error or equipment malfunction. The consequences of such an event are mitigated by the thermal design of the system. The heating loop on the VC-300 generates excess heat which is rejected to the VC-Distillate tank via the desuperheat spray. This excess heat is the source of energy (supplemented by electric heaters) to the C-30 evaporator. The C-30 evaporator operates at a lower temperature and higher concentration then the VC-300. Thus, plugging of flow path and fouling of heat transfer surfaces will occur first in the C-30. As heat transfer is reduced by fouling in the C-30, the VC-Distillate tank temperatures will increase causing higher temperature water to the desuperheater sprays. This will eventually lead to high temperature shutdown of the VC-300 vapor compressor. In addition, as the VC-Distillate temperature increases, the efficiency of the eductors and vacuum pump will decrease since the distillate is the motive force for the eductors and seal water for the liquid ring vacuum pump. This could lead to reduced vacuum, flooding of the distillate side of the VC-300 and resultant cessation of boiling in the VC-300. If this occurred, the major plugging would be in the small C-30 system and would be on the shell side of the heat exchanger rather than the tube side as in many conventional boric acid evaporators.

In the unlikely event that extreme plugging did occur, the C-30 tube bundle can be easily removed, the exterior surfaces of the tubes cleaned, and the bundle reinstalled. It is unlikely that significant plugging or fouling would occur in the VC-300. Shop testing at the manufacturer's facility showed that precipitation in the VC-300 does not impair its operation to any great extent and the precipitate is easily dissolved by dilution. Although considerably more difficult and time consuming, the VC-300 tube bundle can also be removed for cleaning if necessary.

4.2.5 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 significant quantities 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.

It is conservatively estimated that 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 <u>average</u> 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 system 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 their projection of environmental releases, the NRC Staff assumed in the PEIS 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 plus LLD 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 an LLD derived value of 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.

- 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.

- 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 times 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.

- 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 substances. Boron compounds are typically found in soils at an average concentration of 50 ppm and ranging up to 150 ppm. The total solids concentration in the soil resulting from the evaporator operations 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.

o 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 1.3 mrem total body and 0.4 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 12 person-rem total body and 2.4 person-rem to the bone and an average exposure to a member of the population of 0.005 mrem total body and 0.001 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 hypothetical 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 I

IDENTIFICATION OF RADIONUCLIDES IN PROCESSED WATER*

Nuclides	Column 1 Curies Present in 2.3 MGAL	Column 2 Concentration in μCi/ml in 2.3 MGAL	Column 3 Specific Activity in Ci/gram	Column 4 A-2 Value	Column 5 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/	<2.9E-3	<3.3E-7	3.4E+3	7	<8.53E-7
Rhodium-106					
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

*Total activity and concentration shown are for projected "Base Case" water.

Note: Tritium is not included in this table since the system performs no removal of tritium. Tritium releases from the system are discussed in Section 5.1.

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.

Note: Tritium is not included in this table since the system performs no removal of tritium. Tritium releases from the system are discussed in Section 5.1.

TMI —2 PROCESSED WATER DISPOSAL SYSTEM

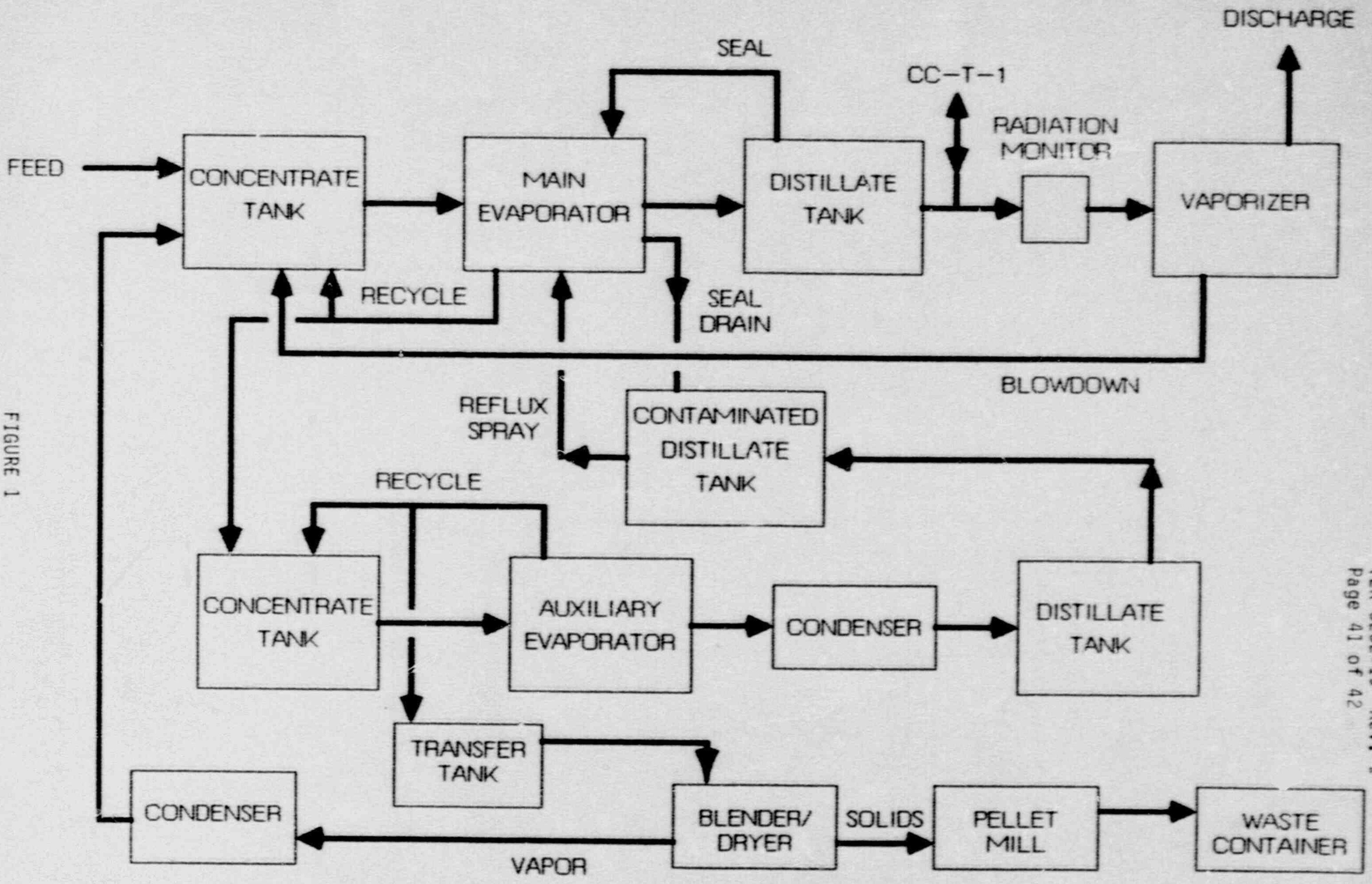

FIGURE 1

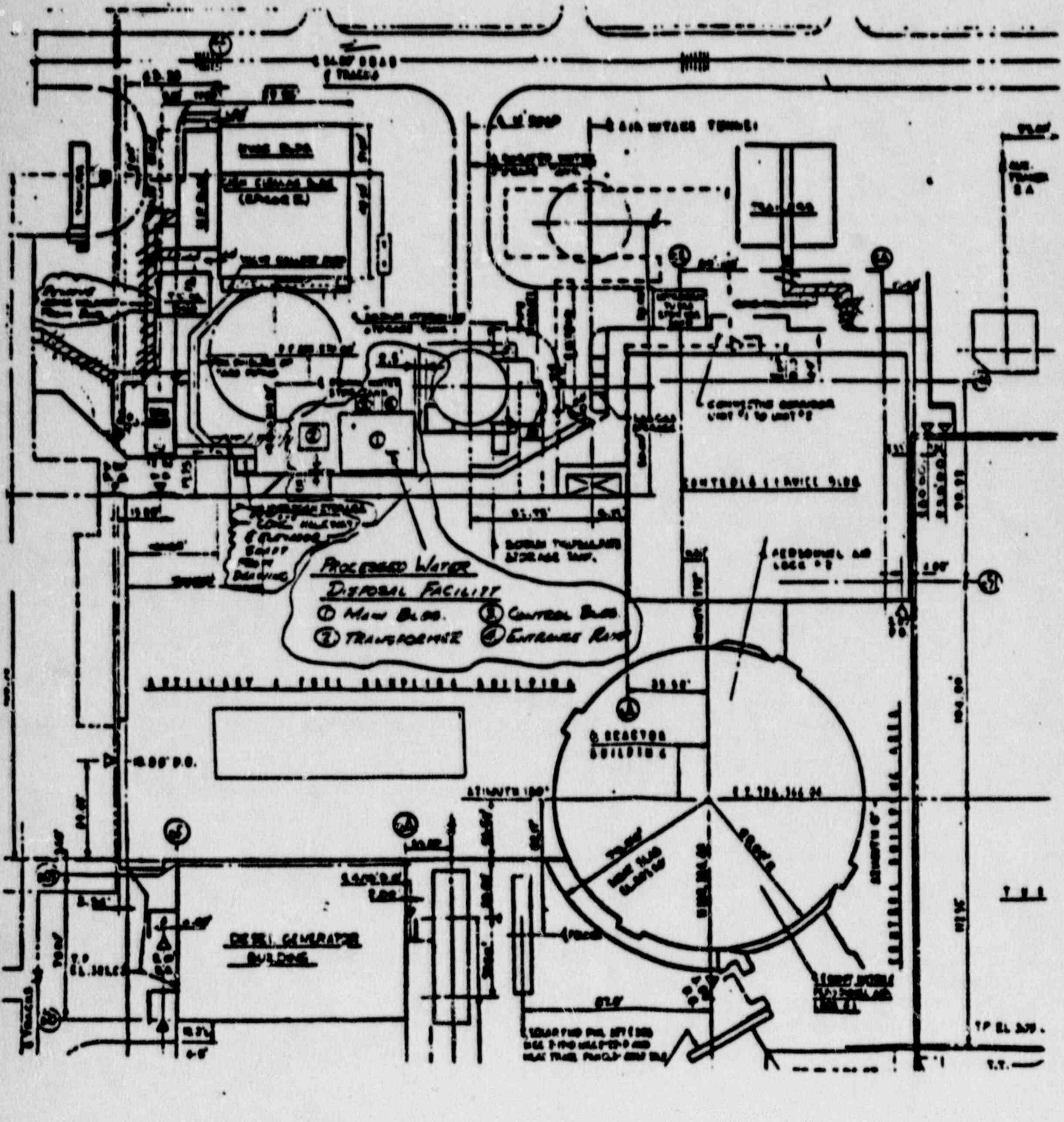

Figure 2: Site plan showing location of the Processed Water Disposal System