Portland General Electric

LCA 237 - Spent Fuel Cask Loading in the Fuel Building

Trojan Nuclear Plant

LICENSE CHANGE APPLICATION (LCA) 237
SPENT FUEL CASK LOADING IN THE FUEL BUILDING

TABLE OF CONTENTS

1. BACKGROUND AND REASON FOR CHANGE

On October 31, 1983, PGE submitted Amendment 1 to License Change Application (LCA) 94, which requested an amendment to Operating License NPF-1 involving the installation of new spent fuel storage racks in the Spent Fuel Pool. The LCA also requested that Operating License NPF-1 be revised to include a prohibition on movement of a spent fuel assembly shipping cask into the Fuel Building.

The reason for requesting this prohibition was that PGE had evaluated the proposed Spent Fuel Pool rerack and concluded that no heavy load drops into the Spent Fuel Pool were credible with the possible exception of a spent fuel assembly shipping cask. This type of drop was an exception because in 1983, the Department of Energy was only beginning to evaluate the types of spent fuel shipping casks that would be approved for use. PGE believed that the design of the casks that would be ultimately approved for use would be significantly different from the generation of casks that were current in 1983. Therefore, PGE was unable to conclusively determine that moving a spent fuel assembly shipping cask into the Fuel Building after the new racks were installed would not involve a significant hazard consideration. Accordingly, PGE requested the license amendment to prohibit bringing a spent fuel shipping cask into the Fuel Building until an evaluation of the consequences of a cask drop could be performed.

Following shutdown of the Trojan Nuclear Plant (TNP) reactor in November 1992, PGE decided to decommission TNP. PGE submitted a Decommissioning Plan dated January 26, 1995, that detailed prompt decontamination and dismantlement of contaminated structures, systems and components. In addition, PGE's Decommissioning Plan stated that relocating the contents of the Spent Fuel Pool to an Independent Spent Fuel Storage Installation (ISFSI) would be the most economical method for storing the TNP spent fuel until a permanent storage facility offsite would be available for offsite shipment of the spent fuel. Relocating the spent fuel and other high-level radioactive waste from the Spent Fuel Pool to the ISFSI also allows decontamination and dismantlement of structures, systems, and components at TNP to occur sooner than if the spent fuel were left in the Spent Fuel Pool until shipment to the offsite facility is possible.

PGE submitted a 10 CFR 72 license application to the NRC for construction and operation of an ISFSI in March 1996 and requested issuance of the 10 CFR 72 license prior to December 1997. As described in the safety evaluation, an evaluation of cask drop events has been completed, as well as an evaluation of a spectrum of postulated off-normal events and accidents. Because the evaluation of cask drops has been completed, the license condition that prohibits bringing casks into the Fuel Building may be removed from the license. This LCA is being submitted to remove the prohibition from the license such that spent fuel casks may be loaded in the Fuel Building for movement of the spent fuel to the ISFSI on the schedule stated in the 10 CFR 72 license application, January 1998.

2. DESCRIPTION OF CHANGE

Facility Operating License No. NPF-1 was superseded in its entirety by Possession Only License No. NPF-1, which was issued as Amendment 190 to License No. NPF-1 on May 5, 1993. Paragraph 2.C(7) of NPF-1 specifically prohibits moving a spent fuel shipping cask into the Fuel Building. Amendments 191, 192, 193, 194 and 195 have been subsequently issued without revising paragraph 2.C.(7). Paragraph 2.C(7) of Possession Only License No. NPF-1 currently reads as follows:

"(7) Spent Fuel Assembly Shipping Cask

The licensee shall not move a spent fuel assembly shipping cask into the Fuel Building."

PGE proposes that paragraph 2.C(7) be deleted in its entirety from License No. NPF-1 to allow movement and handling of spent fuel casks in the Trojan Fuel Building as described in the 10 CFR 72 license application. Limiting Condition for Operation (LCO) 3.1.4, "Spent Fuel Pool Load Restrictions," remains in effect and precludes movement of casks over the Spent Fuel Pool. In addition, the following license condition is proposed to authorize the loading of spent fuel and other materials into casks in the fuel building:

"(7) Loading of Fuel into Casks in the Fuel Building

The licensee is authorized to load spent nuclear fuel and other materials into transfer and storage casks in the Fuel Building in accordance with PGE letter dated January 16, 1997."

A mark-up of the proposed change to Possession Only License No. NPF-1 (as provided by Amendment 190 to License No. NPF-1) is located in Attachment II of this LCA.

3. DESCRIPTION OF THE ISFSI COMPONENTS AND EQUIPMENT

3.1 GENERAL

PGE has selected Sierra Nuclear Corporation's TranStor™ Storage System for the Trojan ISFSI. The TranStor™ Storage System is a vertical dry storage system which utilizes a ventilated concrete cask and a seal-welded steel basket to safely store spent nuclear fuel assemblies, fuel debris, and Greater Than Class C (GTCC) waste material.

The Trojan ISFSI will consist of a reinforced concrete pad, supporting a maximum of 36 Sierra Nuclear Corporation's TranStor™ Storage Systems. It is anticipated that 36 storage baskets and Concrete Casks will be required. Thirty-four of the baskets will be pressurized water reactor (PWR) baskets, designed to safely store intact spent fuel assemblies, suspect/damaged fuel

assemblies, and/or fuel debris. Two of the baskets will be GTCC baskets, designed to safely store GTCC waste.

The system is designed to permit transfer of the basket to a shipping cask once a permanent offsite repository or other offsite facility is available. The TranStor™ Storage System is also designed to accommodate recovery from postulated off-normal events without reliance on the Spent Fuel Pool.

3.2 SYSTEM DESIGN

The TranStor™ Storage System consists of the baskets, concrete casks, a storage pad and associated transfer equipment necessary for safe placement of spent nuclear fuel assemblies, fuel debris, and GTCC waste into dry storage. The Trojan ISFSI storage system utilizes two types of baskets, the PWR basket and the GTCC basket. The baskets are metal containers that are seal welded closed. The baskets serve as the confinement boundary for the materials that are stored within the baskets.

The PWR basket is a fuel storage canister designed to provide safe storage of intact spent fuel, failed fuel, and fuel debris. The PWR basket consists of an internal sleeve assembly, an outer shell assembly, a shield lid, and a structural lid. The internal sleeve assembly is fabricated from high strength steel plates formed into an array of 24 square storage sleeves, each holding one PWR spent fuel assembly. The storage sleeves are sized to accommodate storage of control components within the fuel assembly. The shield lid contains penetrations for drying and filling the basket with helium. The shield lid and structural lid are welded to the basket shell using a semi-automatic electric arc welding system. The outer shell and lids form a confinement boundary for the spent fuel. The PWR basket relies only on geometry for subcriticality during storage.

Assemblies containing damaged fuel are stored in failed fuel cans in the PWR basket. The four peripheral cells in each PWR basket are oversized to accommodate failed fuel cans and will accommodate spent fuel assemblies as well.

The GTCC basket is designed to provide safe storage of GTCC waste. GTCC waste is placed in cans and then placed into the GTCC basket. The GTCC basket does not contain an internal sleeve assembly. The GTCC basket accommodates 28 individual cans designed for GTCC waste.

A skid-mounted vacuum drying system is used to remove the water from the PWR and GTCC baskets (following loading), dry the basket, and backfill the basket with helium. The vacuum drying system is designed to evacuate the basket in a stepwise fashion. During evacuation, the decay heat from the fuel further helps remove residual moisture from the basket.

The transfer cask is used to move the loaded basket from the Spent Fuel Pool to the concrete cask. The transfer cask is constructed with multiple layers of various shielding materials to reduce the radiation exposure to personnel during spent fuel loading and handling. The transfer cask has

retractable doors at the bottom to permit lowering of the loaded basket from the transfer cask into the concrete cask in order to maintain radiation shielding during the transfer. The transfer cask is lifted and moved using a special lifting yoke and the Fuel Building overhead crane.

The concrete cask provides structural support, shielding, and natural circulation cooling for the basket. The basket is stored in the central steel lined cavity of the concrete cask. A steel lid is placed on the concrete cask to protect the basket from the environment. The concrete cask is ventilated by internal air flow paths which allows decay heat to be removed by natural circulation around the metal basket wall. Air flow paths are formed by channels at the bottom (air entrance), the air inlets, the gap between the basket exterior and the concrete cask interior, and the air outlets. The air inlets and outlets are steel lined penetrations that take non-planar paths to minimize radiation streaming. Side surface radiation dose rates are limited by the thick steel and concrete walls of the concrete cask.

An air pad system is used to move a loaded concrete cask from the Fuel Building to the reinforced concrete storage pad. The air pad system consists of four air pads that are about 4' square, a standard air compressor, and associated air hoses. The air pad system lifts the concrete cask a few inches and floats the concrete cask on a cushion of air for movement.

The reinforced concrete storage pad is about 100' by 170' and is about 18" thick. The reinforced concrete pad will be located about 200' north of the Fuel Building at the general site grade elevation of about 45'.

Except for commercially available equipment such as the air pad system, the components and equipment described above will be fabricated/constructed in accordance with specifications and drawings prior to spent fuel loading and handling. The metal components, e.g., basket, transfer cask, and concrete cask liner, will be fabricated offsite and shipped to the site when completed. Final assembly and pouring of the concrete for the concrete cask, as well as construction of the reinforced concrete storage pad, will be accomplished onsite.

4. DESCRIPTION OF THE SPENT FUEL CASK LOADING PROCESS

The basket and transfer cask are brought into the Fuel Building through the crane bay. After examination and any needed cleaning, the transfer cask is moved along a safe load path by the Fuel Building overhead crane and transfer cask lifting yoke to the Cask Wash Pit. There, a protective bottom cover (e.g., plastic sheeting, plexiglas, plywood, etc.) is installed on the transfer cask lower hydraulic door carrier rails, which will prevent potential contamination on the Cask Loading Pit floor from being imbedded in the transfer cask. The basket is then moved by the same crane and placed into the transfer cask. After installation of radiation shielding shims in the gap between the transfer cask and basket, a cask lid assembly is bolted onto the top of the transfer cask. The cask lid assembly, which is a steel ring that has the center section removed to allow loading, ensures that the basket cannot be inadvertently lifted out of the transfer cask while

loaded. The cask lid assembly also has shield lid retainers which are retracted to load the basket and are manually extended after the basket is loaded to prevent the shield lid from coming out of the basket in the unlikely event of a tipover. The basket is then filled with borated water from the Spent Fuel Pool. The water is filtered, if necessary, to reduce the potential for contamination on the exterior of the basket. This filling may be done in the Cask Wash Pit or at the Cask Loading Pit before submergence.

The transfer cask (with empty basket) is then moved along a safe load path by the Fuel Building overhead crane and suspended over the Cask Loading Pit which is filled with borated water. A hose will be connected to a flushing system connection located near the bottom of the transfer cask designed to continuously flush borated water through the basket/transfer cask gap to minimize unnecessary contamination of the basket external surface while the transfer cask is submerged in the Cask Loading Pit. After the transfer cask is lowered onto the impact limiter at the bottom of the Cask Loading Pit, the lifting yoke will be removed.

The Spent Fuel Pool gate, which separates the Spent Fuel Pool from the Cask Loading Pit will be opened and spent fuel assemblies and failed fuel (e.g., non-intact fuel assemblies, non-fuel bearing components, fuel rod storage unit number 1 and spent fuel pool debris in process can capsules) or GTCC waste cans will be loaded into the basket using the Fuel Handling Bridge crane. Handling operations in the Fuel Building that involve spent fuel movement will be directly supervised by Certified Fuel Handlers in accordance with approved procedures. Spent fuel assembly serial numbers will be verified and recorded during the loading process. Failed fuel assemblies will be examined to verify that fuel pellets are structurally contained within the cladding or the failed fuel assembly will be placed in a failed fuel can. When basket loading is completed, the basket shield lid is placed in the basket while in the Cask Loading Pit.

The loaded transfer cask is lifted from the Cask Loading Pit, the basket/transfer cask gap drained, the transfer cask is washed on the exterior to remove potential contamination, the shield lid retainers are extended into position, and the protective bottom cover is removed. The transfer cask is moved along a safe load path by the Fuel Building overhead crane to the Cask Wash Pit.

Decontamination of the transfer cask, if required, and shield lid welding may begin as soon as the transfer cask is in the Cask Wash Pit. Sufficient water is removed from the basket to lower the water level and ensure that the shield lid weld is not affected by water contact. The root and final weld passes on the shield lid are dye penetrant checked. The basket is refilled with borated water and hydrostatically tested to 22 psia (7.3 psig). The test pressure must be held for 10 minutes with zero leakage. The skid mounted vacuum drying system is the preferred equipment for performing gas/liquid filling or evacuation activities. When the hydrostatic test has been satisfactorily completed, the structural lid is installed and welded to the basket shell and the previously installed shield lid (through the valve access ports). The root and final weld passes on the structural lid are dye penetrant checked. The radiation shielding shims are removed individually from the top of the basket area to allow for completion of contamination surveys of the basket external surface. The exterior of the basket will be checked for loose surface

contamination (to the extent possible because of its inaccessibility while in the transfer cask) to determine if decontamination of the basket is required. If loose surface contamination levels exceed 10^{-4} $\mu Ci/cm^2$ β-γ or 10^{-5} $\mu Ci/cm^2$ α, then an evaluation will be performed to determine if decontamination of the basket is required.

Draindown and evacuation of the basket is initiated by pumping the borated water in the basket back into the Spent Fuel Pool or a suitable holding tank. Residual moisture in the basket is removed by blowing dry service air through the basket via the basket drain line (maximum pressure will be controlled to 7.3 psig) and out the vent line for a minimum of 15 minutes and until no water is visible coming from the vent line. The outlet for the vent line will be connected to a suitable filtration system to minimize the possibility of gaseous or particulate airborne contamination.

The vacuum drying system is used to perform multiple evacuations to achieve a stable internal basket vacuum pressure of 3 mm Hg (absolute) for a minimum of 30 minutes. The basket is then flushed with helium and the evacuation process is repeated.

The sealed basket is filled with 99.9% pure helium and pressurized to 7.3 psig. The vacuum drying system gauges are used to regulate internal pressure. Leak tightness is verified by use of a helium sniffer. The pressure is then released back to approximately atmospheric pressure (14.7 psia) while maintaining the helium atmosphere inside the basket.

The vacuum drying system attachment couplings are disconnected and the two valve access port covers are welded in place in the structural lid and the welds are dye penetrant checked. The transfer cask containing the sealed basket is moved along a safe load path in the Fuel Building by the Fuel Building overhead crane to Fuel Building hoistway. The loaded transfer cask is lowered through the hoistway to the Fuel Building bay where a concrete cask has been placed and prepared for acceptance of the basket. Ceramic tiles in the bottom of the concrete cask prevent the stainless steel basket from resting directly upon the carbon steel liner of the concrete cask.

Plastic sheeting is placed on top of the concrete cask walls to prevent contamination from spreading from the bottom of the transfer cask to the concrete cask. The transfer cask is placed on top of the concrete cask and correctly positioned by the use of 1" diameter alignment holes located on each side of the transfer cask. After removing the transfer cask lifting yoke and installing the transfer cask hydraulic door operating system and basket lifting rings and slings, the basket is lifted slightly by the Fuel Building overhead crane to remove the weight from the transfer cask bottom doors. The bottom doors are opened, and the basket is lowered into the concrete cask. When the basket is firmly resting on the ceramic tiles at the bottom of the concrete cask, the basket lifting rings and slings are removed with the aid of an extension device and the transfer cask bottom doors are closed. After removing the hydraulic system from the transfer cask, the lifting yoke is re-attached to the transfer cask and the transfer cask is lifted from the concrete cask and moved back to the Cask Wash Pit where the interior of the transfer cask is checked for loose surface contamination to provide a second check of the surface contamination

levels on the exterior of the basket that was just removed from the transfer cask. If contamination levels exceed the limits previously stated (10^{-4} $\mu Ci/cm^2$ β-γ or 10^{-5} $\mu Ci/cm^2$ α,), then the need to decontaminate the basket previously placed in a concrete cask will be evaluated.

The shield ring is installed on top of the concrete cask and the concrete cask cover plate is bolted into position. A tamper indicating wire is threaded through two of the cover bolts. The concrete cask exterior is surveyed for contamination and radiation levels are measured before moving the loaded concrete cask to the reinforced concrete storage pad.

An air pad system, which floats the concrete cask on a cushion of air, is inserted under the concrete cask in the air inlet openings and inflated by a standard service air compressor. The cask is moved by forklift, tractor, or other vehicle to the reinforced concrete storage pad. Air is released from the pads once the concrete cask is in position on the concrete storage pad surface. The air pad system is removed from air inlets and the air inlet screens are installed.

5. SAFETY EVALUATION

The safety evaluation first discusses normal operational considerations: criticality prevention, spent fuel cladding integrity, and radiation shielding and radiological controls. The second part of the safety evaluation addresses postulated off-normal events and accidents which are grouped into five categories: drops, tipovers, mishandling events, operational errors, and support system malfunctions. The last part of the safety evaluation summarizes operational controls that are implemented to ensure that the assumptions of the safety evaluation and supporting analyses are satisfied during the spent fuel loading and handling process.

This safety evaluation is intended to address the complete spent fuel loading and handling process from the Spent Fuel Pool to the ISFSI storage pad. However, this safety evaluation does not address collection, processing, and loading of the spent fuel debris. The design for this equipment has not been completed. A separate safety evaluation is being prepared for spent fuel debris collection, processing, and loading and will be provided in a separate submittal.

5.1 NORMAL OPERATIONAL CONSIDERATIONS

5.1.1 Criticality Prevention

A criticality analysis was performed that shows that the spent fuel in the basket remains subcritical (k_{eff} less than 0.95) during transportation. The criticality analysis for transportation bounds the spent fuel loading and handling process. The criticality analysis assumed zero fuel burnup, 4.1% U-235 fuel enrichment, 24 fuel assemblies loaded in the most reactive configuration, and the basket filled with pure water. These assumptions are conservative because each Trojan fuel assembly has some burnup, the maximum initial enrichment of Trojan fuel was 3.56%, and the basket will be filled with borated water from the Spent Fuel Pool (2000 ppm boron or greater).

The criticality analysis was performed using the KENO-Va module of the SCALE-PC Modular Code System for Performing Criticality Safety Analysis for Licensing Evaluation, Version 4.1.

5.1.2 Fuel Cladding Integrity

The fuel cladding serves as a fission product barrier, therefore, this barrier must be maintained during the fuel loading process to minimize the potential for radiological releases. When the shield and structural lids have been welded to the basket in the Cask Wash Pit, the basket becomes an additional fission product barrier. The fuel cladding integrity may be breached by physical mishandling or elevated temperatures that cause excessive stress. Physical mishandling (i.e., dropping a fuel assembly) is not likely due to stringent fuel handling procedures, but is discussed under postulated off-normal events and accidents. Effects due to elevated temperatures are discussed in the following paragraphs.

A thermal analysis was performed to ensure that the spent fuel would not exceed a short term temperature limit of 1058°F during the loading process. Exceeding 1058°F could adversely affect cladding integrity based on PNL-4835, "Technical Basis for Storage of Zircaloy-Clad Spent Fuel in Inert Gases" (Pacific Northwest Laboratory). The thermal analysis considered the basket in the transfer cask with a helium atmosphere and the basket in the transfer cask with a vacuum. The thermal analysis used a finite element model generated using ANSYS, revision 5.0A. The thermal analysis modeled the materials in the basket for these two configurations. The results of the analysis were that the spent fuel cladding temperatures were 743°F (helium atmosphere) and 851°F (vacuum), which are considerably less than the 1058°F short term limit. Therefore, elevated temperatures experienced by the fuel cladding during the loading process would not affect cladding integrity in the short term.

In addition to the short term temperature limits, an analysis was performed to ensure that the fuel cladding strain that is accumulated during the vacuum drying process would not exceed 0.1% as recommended by PNL-6364, "Control of Degradation of Spent LWR Fuel During Dry Storage in an Inert Atmosphere". The 0.1% limit is recommended to ensure that cladding strain caused by elevated temperatures during the loading process does not cause cladding degradation during the long term storage period. The analysis determined that the amount of time that the spent fuel could be in the transfer cask with a vacuum in the basket is 20 hours. A conservative time limit will be incorporated into the spent fuel loading procedures to ensure that 0.1% fuel cladding strain is not exceeded during the vacuum drying process. Therefore, fuel cladding strain will not affect the integrity of the cladding during long term storage.

Fuel cladding integrity is also maintained by preventing oxidation that would be caused by prolonged exposure of the spent fuel to the atmosphere. Contact with the atmosphere is only for a few hours during the loading process, i.e., during basket draindown. The basket is then evacuated to 3 mm Hg. After evacuation, the basket is filled with helium which prevents oxygen from coming in direct contact with the fuel during long term storage. In addition, the basket lid is checked for helium leakage after being welded in place to ensure that the helium will remain in the

basket for the storage period. Therefore, the likelihood of fuel cladding degradation by oxidation is minimized during the loading and storage process.

The spent fuel to be stored in the ISFSI also includes fuel debris and fuel assemblies identified as having suspect or failed fuel rods. The fuel debris will be loaded into and sealed inside a separate container that will serve as a containment boundary. Although cladding integrity has not been maintained for the suspect/failed fuel, release of fission products from the suspect/failed fuel is not anticipated during the loading and handling process. The failed fuel cans are designed to contain fuel pellets for the maximum vertical and horizontal loads. Most of the suspect/failed fuel rods were identified on or before April 1982, thus, will have had 15 years of storage in the Spent Fuel Pool prior to loading into a spent fuel cask. Short-lived fission products will have decayed and the longer lived fission products will have had several years to be released from the suspect/failed fuel rods into the Spent Fuel Pool water. Therefore, even though the suspect/failed fuel do not have cladding for a fission product barrier, the lack of intact cladding will not represent a substantive radiological hazard during spent fuel loading and handling.

5.1.3 Radiation Shielding and Radiological Controls

The design of the basket, transfer cask, and concrete cask provide radiation shielding for the workers who will be loading and handling the spent fuel basket, transfer cask, and concrete cask. The loaded basket will be inside the transfer cask or concrete cask through out the loading and handling process including the time when the basket is being lowered from the transfer cask to the concrete cask. The working dose rates (at 1 meter) are estimated as 0.100 rem/hr for the side surface transfer cask, 0.120 rem/hr on top of the basket (where the basket lid welding will be performed), 0.010 rem/hr for the side surface of the concrete cask, and 0.083 rem/hr for the top of the concrete cask.

Spent fuel loading of the basket will be performed underwater in the Cask Loading Pit with water over the basket to provide radiation shielding. Individual fuel assemblies that are being moved from the Spent Fuel Pool to the Cask Loading Pit will be maintained about 10' underwater by the design of the Fuel Handling Bridge crane to provide radiation shielding for the fuel handlers. A shield lid will be placed on the basket before the loaded transfer cask is lifted from the Cask Loading Pit to provide radiation shielding while the basket is being moved to the Cask Wash Pit (where the shield lid is welded to the basket).

The exterior of the transfer cask will be washed down upon removal from the Cask Loading Pit to prevent the spread of contamination in the Fuel Building. Plastic sheeting or other material will be used on the bottom of the transfer cask to prevent spread of potential contamination from the bottom of the transfer cask to the top of the concrete cask. The basket, transfer cask, and concrete cask will be surveyed for contamination prior to moving the concrete cask out of the Fuel Building to ensure that contamination is not spread to the ISFSI storage pad.

The draining and vacuum drying process for the basket will use filtration equipment to minimize airborne contamination and will be performed in the Fuel Building which has a monitored ventilation exhaust to ensure that any radioactive release is quantified and verified to be within established limits.

The loading and handling operations for the casks will be subject to the Trojan Radiation Protection Program. The doses received by occupational workers will be in accordance with 10 CFR 20 and as low as reasonably achievable (ALARA) in accordance with the Trojan Radiation Protection Program.

5.2 POSTULATED OFF-NORMAL EVENTS AND ACCIDENTS

The postulated off-normal events and accidents discussed below are grouped into five categories: drops, tipovers, mishandling, operational errors, and support system malfunctions. Within these categories, the discussion is provided in approximately the chronological order that these off-normal events or accidents could occur during the loading process. The postulated off-normal events and accidents that result in radiological consequences at the site boundary are listed for reference in Table 1. As discussed in Section 5.1.2, there are specific limitations for ensuring fuel clad integrity, which require that recovery actions be performed within specific limits described in Section 5.3. Recovery procedures, as described in Section 5.3.8, will be developed consistent with these limits. The following event descriptions, therefore, only describe the immediate consequences of the event from a criticality and/or radiological release perspective.

5.2.1 Drops

5.2.1.1 Fuel Assembly Drop into a Basket Loaded with Spent Fuel

The fuel assembly drop is postulated to occur while spent fuel is being loaded into the basket when the basket is inside the transfer cask and submerged in the Cask Loading Pit. The design safety factors, load testing requirements, and administrative controls (i.e., procedures, training, maintenance, inspections) for the fuel handling equipment minimize the possibility of a fuel assembly drop actually occurring. As described below, the fuel assembly drop will not cause spent fuel damage that results in a radiological release that exceeds regulatory limits or a k_{eff} of more than 0.95. (Cask Loading Pit and Spent Fuel Pool liner damage from the dropped fuel assembly is discussed in section 5.2.3.1 below.)

By procedure, the basket will be loaded starting with the side furthest from the Spent Fuel Pool so that no assembly is carried over assemblies already loaded into the basket. Therefore, the potential for a dropped assembly to impact fuel assemblies already loaded into the basket is minimized.

The radiological consequences of a fuel assembly drop into the basket will be bounded by the existing analysis in the Defueled Safety Analysis Report (DSAR). The fuel will have had 5 years

for the fission products to decay. The analysis in the DSAR only considers 6 months of decay time. The radiological consequences at the site boundary for the DSAR analysis are 0.0005 rem whole body, 0.0006 rem thyroid, and 0.0455 rem skin. These doses are well below the EPA Protective Action Guides of 1 rem whole body, 5 rem thyroid, and 50 rem skin for the early phase of an event.

If the dropped fuel assembly is stacked vertically on top of another fuel assembly, or inclined at any angle on top of the basket, the fuel in the dropped assembly would be 12 inches or greater from the active fuel region of the fuel assemblies in the basket, which would neutronically decouple the two groups of fuel. Therefore, a dropped fuel assembly will not result in a k_{eff} that is 0.95 or greater.

5.2.1.2 Basket Shield Lid Drop onto a Basket Loaded with Fuel

A basket shield lid drop is not postulated to occur after spent fuel is loaded into the basket (while submerged in the Cask Loading Pit) and the shield lid is being lowered into the basket to provide top axial radiation shielding prior to lifting the transfer cask from the Cask Loading Pit. In lieu of determining the consequences of this event, the guidance of NUREG-0612 is being used to minimize the possibility of this event to the degree that the event need not be considered credible.

The design safety factors for the shield lid lifting equipment will be consistent with NUREG-0612 criteria, paragraphs 5.1.6(b)(ii) and 5.1.1(5) which specify using twice the safety factors specified in the guidelines of ANSI B30.9-1971, "Slings." Load testing requirements, and administrative controls (i.e., procedures, training, maintenance, inspections) will also be implemented. Implementing these design features and controls makes the possibility of a shield lid drop extremely small in accordance with NUREG-0612. Therefore, the consequences of a shield lid drop need not be determined.

5.2.1.3 Lifting Yoke Drop onto a Basket Loaded with Fuel

The lifting yoke drop is postulated to occur after spent fuel is loaded into the basket and the yoke is being lowered to lift the transfer cask out of the Cask Loading Pit. When the yoke is being lowered into the Cask Loading Pit, the shield lid is already inside the basket on the shield lid support ring. Therefore, the analysis of the lifting yoke drop considers the ability of the shield lid and support ring to withstand the yoke impact. The design safety factors, load testing requirements, and administrative controls (i.e., procedures, training, maintenance, inspections) for the load handling equipment minimize the possibility of a lifting yoke drop actually occurring. As described below, the lifting yoke drop will not cause spent fuel damage that results in a radiological release or a k_{eff} of more than 0.95. (Potential damage to the Cask Loading Pit liner from the lifting yoke is discussed in section 5.2.3.1 below.)

The analysis considered a drop of the 6600 lb yoke from 28' above the transfer cask, which would be the distance from the top of the basket to 1' above the top of the Cask Loading Pit where the

yoke would be suspended prior to lowering into the Cask Loading Pit. The lifting yoke drop is conservatively assumed to be in air for the entire 28', which results in a velocity at impact of 42.5 feet/sec and an impact energy of about 180,000 ft-lb.

The analysis shows that the shield lid, which is composed of a 3" and a 5" plate on top of each other, would plastically deform less than 2" and the shield lid would not grossly fail. In addition, the shield lid support ring inside the basket would not fail and would prevent the shield lid from continuing further into the basket. If the lifting yoke impact is evaluated for perforation only, i.e., no deformation of the shield lid other than the penetration, the lifting yoke would penetrate less than 2" through the 8" shield lid. Therefore, the fuel assemblies would not be damaged and there would be no radiological release and no increase in k_{eff}.

The lifting yoke entering the water could spill water from the Cask Loading Pit onto the Fuel Building floor at the 93' elevation. The water would cause minimal exposure to workers because the water would be only slightly contaminated. Most of the water would be captured by floor drains. Clean up of the remaining spilled water would be relatively straightforward and not hazardous.

5.2.1.4 Structural Failure of Transfer Cask Lifting Devices

Structural failure of the lifting yoke, a transfer cask trunnion, or other transfer cask lifting device, e.g., sling, ring, or hook, is postulated to occur after spent fuel is loaded into the basket. The result of one of these failures would be a transfer cask drop when the transfer cask contains a basket loaded with spent fuel.

The transfer cask drop analysis considers the spectrum of drops that could occur from the time the transfer cask is lifted from the Cask Loading Pit, after being loaded with fuel, until the time the basket loaded with fuel is lowered from the transfer cask into the concrete cask in the Fuel Building bay. The design safety factors and load testing requirements for the lifting yoke, trunnions, other transfer cask lifting devices, and load handling equipment minimize the possibility of structural failure actually occurring. In addition, the maximum handling height of the transfer cask is procedurally limited and impact limiters are used to ensure that the results of the analysis are bounding for any potential transfer cask drop. As described below, a transfer cask drop will not result in a radiological release that exceeds regulatory limits and will not result in a criticality concern. (Potential damage to Cask Loading Pit liner from the dropped transfer cask is discussed in section 5.2.3.1 below.)

The transfer cask drop analysis did not postulate a transfer cask drop into the Spent Fuel Pool. The safe load path is sufficiently far from the Spent Fuel Pool, including lowering and lifting the transfer cask into and out of the Cask Wash Pit and Cask Loading Pit. Mechanical stops and electrical interlocks on the crane used to lift the transfer cask will ensure that sufficient distance from the Spent Fuel Pool is maintained. The floor over which the transfer cask is carried, with impact limiters and steel plates at some locations, has sufficient capacity to absorb the impact of

the transfer cask in the unlikely event of a drop. The transfer cask will be not be able to tipover and roll into the Spent Fuel Pool because the transfer cask will only be carried at heights above Fuel Building 93' elevation floor that are well below the height at which the transfer cask would need to be carried for a tipover to occur.

If a transfer cask that contains only intact fuel is dropped, the analysis shows that a radiological release from intact fuel will not occur and k_{eff} will not increase to 0.95 or greater because the accelerations from these drops are less than the maximum allowable accelerations 82g vertical and 44g horizontal. After the shield and structural lids are welded to the basket, the basket serves as the confinement boundary. The analysis shows that the drops that occur after the shield and structural lids are welded to the basket do not exceed the maximum allowable accelerations of 124g vertical and 44g horizontal for the basket and shield/structural lid assembly. Therefore, a radiological release will not occur as a result of a transfer cask drop after the shield and structural lids are welded to the basket.

If a transfer cask that contains failed fuel is dropped, the accelerations from a transfer cask drop may cause fuel pellets to leak from the fuel pins. Accumulation of fuel pellets at the bottom of a failed fuel can was evaluated for criticality. For each fuel assembly type, the optimum pitch for a rod array inside the failed fuel can was determined. This is considered the most reactive possible contents for a failed fuel can, and is assumed in the TranStor™ basket criticality analyses. No possible configuration will be more reactive than the optimum pitch array, even if total rod failure is assumed and pellets are free to move about the failed fuel can. Thus, any number of failed fuel rods may be loaded into the failed fuel cans, even if it can not be determined that the rods will (structurally) survive a cask drop event. Therefore, failed fuel will not present a criticality concern as a result of a transfer cask drop.

If a transfer cask that contains failed fuel is dropped prior to the shield and structural lids being welded to the basket, a radiological release of fission product gases from the failed fuel could result because the failed fuel may not be able to withstand the same accelerations as the intact fuel in the basket. As discussed earlier, most of the suspect/failed fuel rods were identified on or before April 1982, thus, will have had 15 years of storage in the Spent Fuel Pool prior to loading into a spent fuel cask. Short-lived fission products will have decayed and the longer lived fission products will have had several years to be released from the suspect/failed fuel rods into the Spent Fuel Pool water. Therefore, the radiological release may be negligible. However, for conservatism, the radiological consequences for dropping the transfer cask prior to the shield and structural lids being welded to the basket were determined by assuming 100% failure of the fuel pins in 4 suspect/failed fuel assemblies that could be loaded into the 4 oversized storage cells in a basket, and 100% of the Krypton 85 was still in the fuel pins and was released. With these conservative assumptions, the dose at the site boundary would be about 0.003 rem. This dose is used in the drop event discussions that follow.

The postulated drops into the Cask Loading Pit, Cask Wash Pit, and Fuel Building hoistway and onto the floor in the Fuel Building are summarized in the paragraphs that follow.

5.2.1.4.1 Transfer Cask Drop into the Cask Loading Pit

A transfer cask drop into the Cask Loading Pit was assumed to occur from elevation 93' 8", which is about 6" above the curb elevation at the top of the Cask Loading Pit, to the top of an impact limiter at the bottom of the Cask Loading Pit (bottom is elevation 49' 4"). Only an upright drop was considered because the transfer cask will not fit sideways in the Cask Loading Pit. (Note that liner tears are addressed in section 5.2.3.1 below and a sideways tipover where the transfer cask impacts the opposite side of Cask Loading Pit is addressed in section 5.2.2.1.1 below.)

The analysis shows that the transfer cask would drop through air, enter the water, and fall through the water to the impact limiter at the bottom of the Cask Loading Pit. The bearing strength and punching shear strength calculated for the concrete at the bottom of the Cask Loading Pit were less than the force that would be created by the transfer cask decelerating at 82g (the fuel limit), hence, the concrete at the bottom of the Cask Loading Pit was determined to be the limiting component on which the height of the impact limiter is based.

The deceleration force on the fuel as a result of the impact would be less than the maximum allowed 82g for intact fuel. Therefore, no damage would occur to intact fuel. As discussed in 5.2.1.4 above, this deceleration may cause damage to suspect/failed fuel pins. Therefore, a radiological release is postulated with a dose at the site boundary of 0.003 rem, which is well below the EPA Protective Action Guide of 1 rem whole body for the early phase of an event.

There would no change to k_{eff} from the intact fuel and the failed fuel would not represent a criticality concern, as discussed in 5.2.1.4 above, if fuel pellets were to leak from the failed fuel pins and accumulate at the bottom of the failed fuel cans.

If the transfer cask is dropped into the Cask Loading Pit, any resultant spill of water caused by the transfer cask entering the Cask Loading Pit would cause minimal exposure to workers because the water would be only slightly contaminated and would not be unduly difficult to clean up.

5.2.1.4.2 Transfer Cask Drop into the Cask Wash Pit

A transfer cask drop into the Cask Wash Pit was assumed to occur from 93' 6", which is about 6" above the top of the Cask Wash Pit, to the top of an impact limiter at the bottom of the Cask Wash Pit (bottom is 72'). Only an upright drop was considered because the transfer cask will not fit sideways in the Cask Wash Pit. (Note that a sideways tipover where the transfer cask impacts the opposite side of Cask Wash Pit is addressed in section 5.2.2.1.2 below.)

The analysis shows that the transfer cask would be moving at about 26.6 feet/second upon initial contact with the impact limiter. The shear strength calculated for the 30" concrete slab at the bottom of the Cask Wash Pit, including the bending stress that would be imparted to two steel beams imbedded in the slab, was less than the force that would be created by the transfer cask

decelerating at 82g (the fuel limit), hence, the concrete slab at the bottom of the Cask Wash Pit was determined to be the limiting component on which the height of the impact limiter is based.

The deceleration force on the fuel would be about 3g which is considerably less than the maximum allowed 82g for intact fuel (assuming that the drop occurs prior to the shield lid being welded in the basket). If the drop were to occur after the shield and structural lids are welded to the basket, the deceleration force of 3g is also considerably less than the maximum allowed 124g for the basket pressure boundary. Therefore, no damage would occur to intact fuel. As discussed in 5.2.1.4 above, this deceleration may cause damage to suspect/failed fuel pins. Therefore, a radiological release is postulated (if the drop occurs prior to the shield and structural lids being welded to the basket in the Cask Wash Pit) with a dose at the site boundary of 0.003 rem, which is well below the EPA Protective Action Guide of 1 rem whole body for the early phase of an event.

There would no change to k_{eff} from the intact fuel and the failed fuel would not represent a criticality concern, as discussed in 5.2.1.4 above, if fuel pellets were to leak from the failed fuel pins and accumulate at the bottom of the failed fuel cans.

5.2.1.4.3 Transfer Cask Drop into the Fuel Building Hoistway

A transfer cask drop into the Fuel Building bay was assumed to occur from 93' 6", which is about 6" above the top of the Fuel Building hoistway, to the top of an impact limiter at the bottom of the Fuel Building bay (bay floor elevation is 45'). Both upright and side drops were considered because the Fuel Building hoistway is large enough for the transfer cask to drop through sideways. (Note that a sideways tipover where the transfer cask impacts the opposite side of the Fuel Building hoistway is addressed in section 5.2.2.1.3 below.)

The transfer cask would be moving at about 53 feet/sec upon initial contact with the impact limiter. The structural integrity of the concrete slab in the Fuel Building bay was not considered because the slab is at ground level.

The deceleration force for this drop would be about 17g for an upright drop and 40g for a side drop. These decelerations are less than the maximum allowables for the intact fuel of 82g and 44g, respectively, hence, no damage would occur to intact fuel and there would be no increase in k_{eff} from intact fuel. As discussed in 5.2.1.4 above, these decelerations may cause damage to suspect/failed fuel pins. The failed fuel would not represent a criticality concern, as discussed in 5.2.1.4 above, if fuel pellets were to leak from the failed fuel pins and accumulate at the bottom or sides of the failed fuel cans.

These decelerations are also less than the maximum allowables for the basket pressure boundary of 124g and 44g, respectively. Since the shield and structural lids are welded to the basket, the basket pressure boundary serves as the confinement boundary and there would be no radiological

release even from the suspect/failed fuel inside the basket because the basket pressure boundary would remain intact.

5.2.1.4.4 Transfer Cask Drop onto the Fuel Building Floor (93' Elevation)

A transfer cask drop onto the Fuel Building floor slab (elevation 93') was assumed to occur while moving the transfer cask along the safe load path from the Cask Loading Pit to the Cask Wash Pit and from the Cask Wash Pit to the Fuel Building hoistway. Only vertical drops were considered because the transfer cask will not be lifted high enough off the floor to tip over into a horizontal position. The maximum lift height will be from 5" to 6" above the floor depending on the location along the safe load path. The maximum lift height will be procedurally controlled and bounded by the analysis.

Along the safe load path, the transfer cask will be moved over floor slabs supported by a combination of rigid shear walls and steel beams. Multiple cases, which bound the floors structural configurations along the safe load path, were analyzed. The floors along the safe load path were shown to have sufficient strength to withstand a transfer cask drop with two exceptions: 1) a location along the safe load path near the Cask Wash Pit and 2) the floor slab adjacent to the Fuel Building hoistway. The analysis shows that the location on the safe load path between the Cask Loading Pit and Cask Wash Pit may need to be protected by an impact limiter. Alternately, a second safe load path may be used which circumvents the location if use of an impact limiter is not desired. The analysis also shows that the floor slab adjacent to the Fuel Building hoistway may be protected by placing a steel plate on the floor.

The range of forces experienced by the transfer cask as a result of these drops is about 1 to 20g depending on the drop location. These forces are considerably less than the maximum allowed force of 82g for intact fuel. Therefore, no damage would occur to intact fuel and there would be no increase in k_{eff} from intact fuel. As discussed in section 5.2.1.4 above, this deceleration may cause damage to suspect/failed fuel pins. Therefore, a radiological release is postulated for events that occur when the shield lid is not welded. The dose at the site boundary is projected to be 0.003 rem, which is well below the EPA Protective Action Guide of 1 rem whole body for the early phase of an event. The failed fuel would not present a criticality concern, as discussed in 5.2.1.4 above, if fuel pellets were to leak from the failed fuel pins and accumulate at the bottom of the failed fuel cans.

These decelerations are less than the maximum allowable acceleration for the basket pressure boundary of 124g. For drops that are postulated to occur after the shield and structural lids are welded to the basket, the basket pressure boundary serves as the confinement boundary and there would be no radiological release even from the suspect/failed fuel inside the basket because the basket pressure boundary would remain intact.

The safe load path on the 93' elevation of the Fuel Building has been selected to minimize the possibility of an adverse effect of a dropped load on safety related equipment. The safety related

equipment that could potentially be adversely affected by a load drop is the Spent Fuel Pool, including the spent fuel racks. The safe load path is sufficiently far from the Spent Fuel Pool to prevent a heavy load from dropping into the Spent Fuel Pool. Mechanical stops and electrical interlocks will prevent the Fuel Building overhead crane from moving over the Spent Fuel Pool. As stated above, loads are not lifted sufficiently far above the floor to allow a cask to tipover and roll into the Spent Fuel Pool. (Tipover events are discussed in section 5.2.2 below, but their occurrence is only postulated in locations where the cask could fall back into the pit or hoistway from, or into, which they are being lifted, or lowered). While it is no longer safety related, the safe load path crosses directly over the Service Water System spent fuel pool makeup flow piping located on the 45 foot elevation. As described above, the floors at the 93' elevation have sufficient strength to withstand the postulated load drops. In addition, various other sources of water are available for makeup to the Spent Fuel Pool. Therefore, the safe load path ensures that the Spent Fuel Pool and the Service Water System piping that provide makeup water for the Spent Fuel Pool are not adversely affected by a load drop.

5.2.1.5 Transfer Cask Lid Assembly Drop onto a Basket Loaded with Fuel

A transfer cask lid assembly drop is postulated to occur when the transfer cask is located in the Cask Wash Pit and the cask lid assembly is being removed to weld the shield and structural lids to the basket. The design safety factors, load testing requirements, and administrative controls (i.e., procedures, training, maintenance, inspections) for the load handling equipment minimize the possibility of a cask lid assembly drop actually occurring. As described below, a cask lid assembly drop will not cause basket damage that results in a radiological release or spent fuel damage that results in a k_{eff} of more than 0.95.

The consequences of dropping the cask lid assembly on the basket loaded with fuel are bounded by the lifting yoke drop onto the basket (section 5.2.1.3). A major difference would be that for this event, the cask lid assembly weighs about 600 lbs as compared to 6600 lbs for the lifting yoke. Also, the drop height would be less than 28'. The consequences of the cask lid assembly were not specifically determined because the lifting yoke drop consequences are bounding.

5.2.1.6 Basket Structural Lid Drop onto Basket Loaded with Fuel

A basket structural lid drop is postulated to occur when the transfer cask is located in the Cask Wash Pit after the shield lid has been welded to the basket which is loaded with fuel. The design safety factors, load testing requirements, and administrative controls (i.e., procedures, training, maintenance, inspections) for the load handling equipment minimize the possibility of a structural lid drop actually occurring. As described below, a structural lid drop will not cause basket damage that results in a radiological release or spent fuel damage that results in a k_{eff} of more than 0.95.

The consequences of dropping the structural lid on the basket loaded with fuel are bounded by the lifting yoke drop onto the basket (section 5.2.1.3). A major difference would be that for this

event, the structural lid weighs 270^ lbs as compared to 6600 lbs for the lifting yoke. Also, the drop height would be less than 28'. In addition, for a structural lid drop, the shield lid would be welded to the basket when the drop would occur. The shield lid would add considerable protection for the fuel. The consequences of the structural lid drop were not specifically determined because the lifting yoke drop consequences are bounding.

5.2.1.7 Basket Lift Ring Drop onto Basket Loaded with Fuel

The basket lift ring drop is postulated to occur when the basket loaded with fuel is being prepared for lowering from the transfer cask into the concrete cask in the Fuel Building bay. A basket lift ring drop would occur after the shield and structural lids have been welded to the basket. The design safety factors, load testing requirements, and administrative controls (i.e., procedures, training, maintenance, inspections) for the load handling equipment minimize the possibility of a basket lift ring drop actually occurring. As described below, a basket lift ring drop will not cause basket damage that results in a radiological release or spent fuel damage that results in a k_{eff} of more than 0.95.

The consequences of a basket lift ring drop are bounded by the lifting yoke drop onto the basket shield lid (section 5.2.1.3). The basket lift ring weighs about 20 lbs and would be dropped about 3' as compared to the yoke which weighs about 6600 lbs and is postulated to be dropped 28'. In addition, the shield lid would be welded in place and structural lid would be welded in place on top of the shield lid at the time that the basket lift ring drop is postulated to occur. The structural lid provides an additional 3" of steel for protection of the fuel assemblies in addition to both lids being welded in place, neither of which were considered in the lifting yoke drop. The consequences of the basket lift ring drop were not specifically determined because the lifting yoke drop consequences are bounding.

5.2.1.8 Basket Drop into Concrete Cask

The basket drop into the concrete cask is postulated to occur as the basket loaded with fuel is being lowered from the transfer cask into the concrete cask in the Fuel Building bay. The basket drop would occur after the shield and structural lids have been welded to the basket. The design safety factors, load testing requirements, and administrative controls (i.e., procedures, training, maintenance, inspections) for the load handling equipment minimize the possibility of a basket drop actually occurring. As described below, a basket drop will not cause basket damage that results in a radiological release or spent fuel damage that results in a k_{eff} of more than 0.95.

The basket drop analysis considered a drop of the basket from the top of the transfer cask bottom doors to the bottom of the concrete cask. The methodology of EPRI Report NP-7551, "Structural Design of Concrete Storage Pads for Spent Fuel Casks", was used to determine the resulting acceleration. The equivalent weight used to calculate the basket impact included the weight of the basket, the weight of the concrete cask steel liner, and the weight of the concrete in a spherical cone directly beneath where the basket would impact the concrete cask. The hardness

of the Fuel Building bay floor slab was calculated as 6.24 E4 (dimensionless) and the basket deceleration as 39g. This deceleration is considerably less than the maximum allowable for the basket (124g) and fuel (82g). Therefore, the basket drop would not result in a radiological release or an increase in k_{eff}.

5.2.1.9 Concrete Cask Shield Ring or Lid Drop onto a Basket Loaded with Fuel

The concrete cask shield ring or lid drop are postulated to occur after the basket loaded with fuel has been lowered from the transfer cask into concrete cask in the Fuel Building bay and the transfer cask has been removed from the concrete cask. The drop would occur after the shield and structural lids have been welded to the basket. The design safety factors, load testing requirements, and administrative controls (i.e., procedures, training, maintenance, inspections) for the load handling equipment minimize the possibility of this drop actually occurring. As described below, this drop will not cause basket damage that results in a radiological release or spent fuel damage that results in a k_{eff} of more than 0.95.

The consequences of a concrete cask shield ring or lid drop are bounded by the lifting yoke drop onto the basket shield lid (section 5.2.1.3). The concrete cask shield ring and lid each weigh about 1230 lbs and would be dropped about 3' as compared to the yoke which weighs about 6600 lbs and is postulated to be dropped 28'. In addition, the shield lid would be welded in the basket and the structural lid would be welded in place on top of the shield lid at the time that the concrete cask shield ring or lid drop is postulated to occur. The structural lid provides an additional 3" of steel for protection of the fuel assemblies in addition to both lids being welded in place, none of which were considered in the lifting yoke drop. The consequences of the concrete cask shield ring or lid drop were not specifically determined because the lifting yoke drop consequences are bounding.

5.2.2 Tipovers

5.2.2.1 Transfer Cask Tipover with Basket Loaded with Fuel

This transfer cask tipover is postulated to occur at the top of the Cask Loading Pit while being withdrawn (after being loaded with spent fuel assemblies), at the top of the Cask Wash Pit either while being lowered prior to lid welding or while being raised after the lids have been welded onto the basket, and at the top of the Fuel Building hoistway prior to being lowered to the storage cask at the 45' elevation. The tipover would be the result of a transfer cask drop while the transfer cask is partially over the Pit/hoistway and partially over the Fuel Building floor. The design safety factors, load testing requirements, and administrative controls (i.e., procedures, training, maintenance, inspections) for the load handling equipment minimize the possibility of a transfer cask tipover actually occurring. As described below, a transfer cask tipover will not cause spent fuel or basket damage that results in a radiological release that exceeds regulatory limits or spent fuel damage that results in a k_{eff} of more than 0.95.

5.2.2.1.1 Transfer Cask Tipover at the Cask Loading Pit

A transfer cask tipover at the Cask Loading Pit was assumed to occur at the east wall of the Cask Loading Pit where the transfer cask would be located after being withdrawn from the Cask Loading Pit.

The transfer cask is assumed to tip sideways from the east wall and impact the top of an impact limiter located on the west wall of the Cask Loading Pit. (The transfer cask is about 16' high and the Cask Loading Pit is about 12' across in the east-west direction.) For a worst case side impact, the transfer cask is assumed to tip such that its base remains at the top of the east wall and does not slide into the Cask Loading Pit which would create a glancing blow instead of a solid impact. (However, if the transfer cask slipped into the Cask Loading Pit, the results would be bounded by the drop into the Cask Loading pit discussed in section 5.2.1.4.1 above.)

The analysis shows that the deceleration force on the fuel would be about 7g which is considerably less than the maximum allowed horizontal load of 44g for intact fuel. Therefore, no damage would occur to intact fuel. As discussed in section 5.2.1.4 above, this deceleration may cause damage to suspect/failed fuel pins. Therefore, a radiological release is postulated with a dose at the site boundary of 0.003 rem, which is well below the EPA Protective Action Guide of 1 rem whole body for the early phase of an event.

There would no change to k_{eff} from the intact fuel and, as discussed in section 5.2.1.4 above, the failed fuel would not represent a criticality concern if failed fuel pellets were to leak from the failed fuel pins and accumulate at the bottom of the failed fuel cans.

The analysis also shows that the bearing strength of the concrete west wall of the Cask Loading Pit is sufficient to withstand the transfer cask impact.

When the transfer cask is lifted from the Cask Loading Pit, there will be about 40 to 50 gallons of Spent Fuel Pool water on top of the shield lid (3" between the shield lid and the top of the basket) that could spill on to the Fuel Building floor if the transfer cask tipped over. (The water in the transfer cask/basket annulus would drain into the Cask Loading Pit through the transfer cask bottom doors.) This amount of water would cause minimal exposure to workers because the water would be only slightly contaminated. Most of the spilled water would be captured in floor drains. Clean up of the remaining spilled water would be relatively straightforward. Further water leakage from the basket would be minimal because the shield lid is kept in place in the basket by the shield lid retainers.

5.2.2.1.2 Transfer Cask Tipover at the Cask Wash Pit

A transfer cask tipover at the Cask Wash Pit was assumed to occur at the north wall of the Cask Wash Pit where the transfer cask would be located prior to being lowered into and after being withdrawn from the Cask Wash Pit. The transfer cask is assumed to tip sideways from the north

wall and impact the top of an impact limiter located on the south wall of the Cask Loading Pit. (The transfer cask is about 16' high and the Cask Wash Pit is about 14' across in the north-south direction.) For a worst case side impact, the transfer cask is assumed to tip such that its base remains at the top of the north wall and does not slide into the Cask Wash Pit which would create a glancing blow instead of a solid impact. (However, if the transfer cask slipped into the Cask Wash Pit the results would be bounded by the drop into the Cask Wash Pit discussed in section 5.2.1.4.2 above.)

The analysis shows that the deceleration force on the fuel would be about 3g which is considerably less than the maximum allowed horizontal load of 44g for intact fuel. Therefore, no damage would occur to intact fuel. If this event were to occur prior to the shield and structural lids being welded in the basket in the Cask Wash Pit, then as discussed in section 5.2.1.4 above, this deceleration may cause damage to failed fuel pins. Therefore, a radiological release is postulated with a dose at the site boundary of 0.003 rem, which is well below the EPA Protective Action Guide of 1 rem whole body for the early phase of an event.

There would no change to k_{eff} from the intact fuel and, as discussed in section 5.2.1.4 above, the failed fuel would not represent a criticality problem if failed fuel were to leak from the failed fuel pins and accumulate at the bottom of the failed fuel cans.

The analysis also shows that the south wall, which is supported by a 33" steel beam, 76.5" steel girder, and block wall between the beam and girder, has sufficient strength to withstand the transfer cask impact. If the transfer cask tipover occurs prior to the lids being welded in place in the Cask Wash Pit, then the shield lid is kept in place on the basket by the shield lid retainers and any spill of water from the basket would be minimal.

5.2.2.1.3 Transfer Cask Tipover at the Fuel Building Hoistway

A transfer cask tipover at the Fuel Building hoistway was assumed to occur at the top of the south wall of the Fuel Building hoistway where the transfer cask would be located prior to being lowered into the hoistway. The transfer cask is assumed to tip sideways from the south wall and impact the top of the north wall of the Fuel Building hoistway. The transfer cask is about 16' high and the Fuel Building hoistway is about 12' across in the south-north direction. If the transfer cask slips into the Fuel Building hoistway, the results would be bounded by the drop into the Fuel Building hoistway discussed in section 5.2.1.4.3 above.

The analysis shows that the deceleration force on the fuel would be about 6g which is considerably less than the maximum allowed horizontal load of 44g for intact fuel. Therefore, no damage would occur to intact fuel and there would be no increase in k_{eff} from intact fuel. As discussed above in section 5.2.1.4, these decelerations may cause damage to failed fuel pins. The failed fuel would not represent a criticality concern, as discussed above section 5.2.1.4, if fuel pellets were to leak from the failed fuel pins and accumulate at the bottom of the failed fuel cans.

This deceleration is also less than the maximum allowable horizontal load of 44g for the basket pressure boundary. Since the shield and structural lids are welded to the basket, the basket pressure boundary serves as the confinement boundary and there would be no radiological release even from the failed fuel inside the basket because the basket pressure boundary would remain intact.

The analysis also shows that the north wall, which is supported by a complex arrangement of concrete walls and steel beams, would not have sufficient strength to withstand the transfer cask impact. Therefore, an impact limiter will be used on the top of the north wall of the Fuel Building hoistway to protect the wall from impact.

5.2.2.2 Transfer Cask Tipover during Concrete Cask Transfer Operations

This transfer cask tipover is postulated to occur when the transfer cask is being placed on the concrete cask in the Fuel Building bay. After the transfer cask has been lowered until it is just a few inches higher than the top of the concrete cask, the transfer cask is moved sideways or the concrete cask will be moved underneath the transfer cask, and the transfer cask will be lowered the last few inches onto the top of the concrete cask. If a vertical drop occurred while a portion of the transfer cask was over the concrete cask, but the transfer cask center of gravity was not over the concrete cask, the transfer cask could slide off the concrete cask and could tipover. The design safety factors, load testing requirements, and administrative controls (i.e., procedures, training, maintenance, inspections) for the load handling equipment minimize the possibility of a transfer cask tipover actually occurring. As described below, a transfer cask tipover will not cause spent fuel or basket damage that results in a radiological release or spent fuel damage that results in a k_{eff} of more than 0.95

The consequences of a transfer cask tipover during concrete cask transfer operations are bounded by the transfer cask side drop in the Fuel Building hoistway (5.2.1.4.3). The transfer cask will be over the impact limiter placed at the bottom of the Fuel Building hoistway. If the transfer cask is mispositioned on top of the concrete cask such that tipover were possible, its center of gravity would be over the impact limiter and if the transfer cask fell off the concrete cask, it would fall onto the impact limiter. The distance that the transfer cask could fall from the top of the concrete cask (about 17.5' high) to the top of the impact limiter is considerably less than the 43' drop used in the transfer cask drop for which the analysis showed that there would be no intact spent fuel or basket damage, no radiological release, and no increase in k_{eff}.

<u>5.2.3 Mishandling Events</u>

5.2.3.1 Cask Loading Pit or Spent Fuel Pool Liner Tear/Breach during Handling Operations

The Cask Loading Pit or Spent Fuel Pool liner tear/breach is postulated to occur by the drop of a fuel assembly or heavy load such as the transfer cask. The design safety factors, load testing requirements, and administrative controls (i.e., procedures, training, maintenance, inspections) for

the fuel and load handling equipment minimize the possibility of a liner tear/breach actually occurring. As described below, a liner tear/breach will not cause increased radiation levels in the Fuel Building as a result of water loss from the Cask Loading Pit or water loss from the Spent Fuel Pool.

The water level in the Cask Loading Pit will be at the same level as the Spent Fuel Pool because the Spent Fuel Pool gate, which separates the Cask Loading Pit and Spent Fuel Pool, will be open for moving spent fuel from the Spent Fuel Pool to the Cask Loading Pit. The Spent Fuel Pool water level is maintained 23' or more above the spent fuel stored in the Spent Fuel Pool per the Trojan Technical Specifications. The Trojan Technical Specification Bases state that 10' of water over the spent fuel provides an adequate heat sink for the fuel and shielding for personnel working in the area.

If the Cask Loading Pit liner is torn or breached, the leakage from the tear or breach will be collected by tell-tale drains. The size of the drain lines from the Cask Loading Pit will restrict the leakage to 44 gpm. If the Spent Fuel Pool gate is closed and is not damaged by the event, the Cask Loading Pit would drain to the minimum acceptable height of water over the Transfer Cask, which is 10', in approximately 4 hours. This would be ample time to stop the leak by shutting the valves on the Cask Loading Pit tell-tale drain lines, patch/repair the liner, or place the shield lid on the basket (to prevent unacceptable radiation levels due to the loss of water shielding). In addition, water may be supplied from the various sources to makeup the water loss if more time is needed to stop the leakage. If the Spent Fuel Pool gate was also damaged such that water from the Spent Fuel Pool could flow into the Cask Loading Pit, the leak rate would be the same 44 gpm, but the level decrease would be much slower due to the increased volume to be drained, i.e., the combined volume of the Cask Loading Pit and Spent Fuel Pool. Once again, there would be ample time to secure the leak by shutting the valves on the Cask Loading Pit tell-tale drain lines. Water may be supplied from the various sources to makeup the water loss if more time is needed to stop the leakage.

If the Spent Fuel Pool liner is torn or breached, the leakage from the tear or breach will be collected by tell-tale drains. The size of the drain lines from the Spent Fuel Pool will restrict the leakage from a tear or breach of the Spent Fuel Pool liner to 42 gpm. This leakage is less than leakage from a Cask Loading Pit liner tear/breach and the Spent Fuel Pool is considerably larger than the Cask Loading Pit. Therefore, there will be more than 4 hours to stop the leak by shutting the valves on the Spent Fuel Pool drain lines (with or without the gate closed between the Cask Loading Pit and Spent Fuel Pool). As previously stated, water may be supplied from the various sources to makeup the water loss if more time is needed to stop the leakage.

The Trojan DSAR, Section 6.3.3, evaluates the effects of the loss of forced spent fuel cooling with concurrent spent fuel pool inventory loss. The evaluation credits only 10 feet of water being present over the fuel (due to seismic failure of the gates and spent fuel cooling system piping). This evaluation demonstrates that there is ample time for operator action to provide make up

water, from a variety of sources, to the spent fuel pool before level decreases below 5 feet above the top of the fuel.

5.2.3.2 Crane Mishandling Operation with Transfer Cask/Basket Resulting in Horizontal Impacts

A crane mishandling operation is postulated to occur while moving the transfer cask along the safe load path or when lowering the basket from the transfer cask into the concrete cask. A crane mishandling operation is unlikely because of the administrative controls (procedures, inspections, maintenance, and testing) that are implemented. As described below, a crane mishandling operation may cause a radiological release but will not result in k_{eff} of more than 0.95.

The analysis of a crane mishandling operation assumed a horizontal impact of 2' per second. (Vertical impacts are bounded by the spectrum of drops addressed in sections 5.2.1.1 through 5.2.1.9.) The impact deflection was calculated as 0.0055" which corresponds to a deceleration of 17.5g. This deceleration is considerably less than the maximum allowable horizontal load of 44g for the intact fuel. Therefore, no intact fuel damage would occur and k_{eff} would not increase.

If this event were to occur prior to the shield and structural lids being welded in the basket in the Cask Wash Pit, then as discussed in section 5.2.1.4 above, this deceleration may cause damage to failed fuel pins. Therefore, a radiological release is postulated with a dose at the site boundary of 0.003 rem, which is well below the EPA Protective Action Guide of 1 rem whole body for the early phase of an event. If the crane mishandling operation occurred prior to the shield lid being welded in place, then the shield lid retainers will keep the shield lid in place on the basket and prevent any significant quantity of potentially contaminated water from spilling out of the basket.

The Spent Fuel Pool is the only safety related equipment that could be potentially impacted by inadvertent horizontal movement of the transfer cask. However, this type of impact is not credible because the Fuel Building overhead crane's mechanical stops and electrical interlocks would prevent movement of the load over/into the Spent Fuel Pool. Therefore, safety-related equipment would not be adversely affected by a crane mishandling event.

5.2.3.3 Interference while Lowering Basket during Transfer Operations

Interference while lowering the basket is postulated to occur while transferring the basket from the transfer cask to the concrete cask in the Fuel Building bay. The interference would result from the basket catching on the top edge of the concrete cask while being lowered which could be caused by misalignment of the transfer cask on top of the concrete cask or some sort of misalignment of the basket lifting rig. The potential for interference is minimized because the concrete cask internal cavity is about 8" larger in diameter than the basket which allows additional horizontal clearance as the basket is being lowered into the concrete cask. In addition, alignment holes are used to accurately position the transfer cask on top of the concrete cask prior to the basket lowering operation. As described below, interference while lowering the basket will not cause basket damage that would result in a radiological release or fuel damage.

The only force acting on the basket during lowering is gravity (1g). Therefore, the worst case condition would be a load of 1g on the basket bottom or side if it were to be completely supported by the interference. The stresses applied to the basket by the interference are bounded by those analyzed for the basket drop in the concrete cask described in section 5.2.1.8 above, which concluded that the basket accelerations were considerably less than the maximum allowed and would not result in a radiological release. Therefore, interference would not result in basket damage that could cause a radiological release.

5.2.3.4 Misalignment of Transfer Cask Lifting Yoke

Misalignment of the transfer cask lifting yoke (i.e., less than full engagement of both transfer cask trunnions) is postulated to occur when the yoke is being placed on the transfer cask after fuel has been loaded into the transfer cask. The yoke is placed on the transfer cask, while the transfer cask is in the Cask Loading Pit, in preparation for lifting the transfer cask out of the Cask Loading Pit and in the Cask Wash Pit after the shield and structural lids have been welded into the basket and the transfer cask is ready to be moved to the concrete cask for transfer of the basket. As described below, misaligning the transfer cask lifting yoke will not cause a drop of the transfer cask.

Misalignment of the transfer cask lifting yoke is highly unlikely because the design of the yoke ensures simultaneous full engagement of both transfer cask trunnions. The designed difference in diameter between the trunnion and cutout in the yoke arm into which the trunnion is placed will be a maximum of about 0.2", which ensures that the yoke fits tightly on the trunnions with little chance for misalignment. The transfer cask diameter will be about 0.5" less than the distance between the yoke arms, therefore, there is very little play between the yoke arms and the transfer cask which ensures that the yoke is not placed on the transfer cask in a misaligned position. Once the yoke is placed on the transfer cask trunnions, the yoke will not be able to spread apart and slip off the ends of the trunnions to a misaligned position because the trunnions are fitted with endcaps that are larger in diameter than the cutout in the yoke into which the trunnions are placed. In addition, the yoke, trunnions, and transfer cask are checked for fit-up after fabrication.

5.2.4 Operational Errors

5.2.4.1 Opening the Transfer Cask Bottom Doors Prior to Attaching the Basket Lifting Rig

Opening the transfer cask bottom doors is postulated to occur when the transfer cask has been placed on top of the concrete cask in the Fuel Building bay in preparation for transfer of the basket (loaded with fuel) from the transfer cask to the concrete cask. Opening the transfer cask bottom doors without first attaching the basket lifting rig to the basket will result in a drop of the basket into the concrete cask. Opening the transfer cask bottom doors prior to attaching the basket lifting rig is unlikely because procedural controls will minimize the possibility of occurrence of both of the two independent actions that are required for opening the transfer cask bottom doors. As described below, this event is not considered credible.

Opening the transfer cask bottom doors will not occur because two separate and independent procedural errors are required to cause the bottom doors to be opened. The bottom doors are moved by hydraulic actuators that are attached to the sides of the transfer cask once the transfer cask is in position on top of the concrete cask in the Fuel Building bay. Operators must take deliberate action to actuate the hydraulics to open the bottom doors. This action would not be procedurally allowed until the basket lifting rig is attached to the basket. In addition, the transfer cask bottom doors are prevented from being inadvertently withdrawn from their closed position by locking bolts (2 per door, 1 on either side). Operators must take deliberate action to remove the locking bolts to open the bottom doors. This action also would not be procedurally allowed until the basket lifting rig is attached to the basket. Therefore, opening the transfer cask bottom doors before the basket lifting rig is attached is not considered a credible event. Even if a basket drop were to occur, as described in section 5.2.1.8 above, the accelerations are less than the maximum allowable and there would be no radiological release or increase in k_{eff}.

5.2.4.2 Closing the Transfer Cask Bottom Doors while Lowering the Basket

Closing the transfer cask bottom doors on the basket is postulated to occur when the transfer cask has been placed on top of the concrete cask in the Fuel Building bay and the basket (loaded with fuel) is being lowered from the transfer cask into the concrete cask. Closing the transfer cask bottom doors could damage the basket. As described below, closing the transfer cask bottom doors on the basket is not considered a credible event.

Closing the transfer cask bottom doors on the basket is highly unlikely because two separate and independent operator actions or spurious actuations are required to cause the bottom doors to be closed while the basket is being lowered into the concrete cask. After the bottom doors are opened by the hydraulic actuators, the hydraulic pump (source of hydraulic motive force) will be stopped, and the hydraulic pump will be isolated from the hydraulic actuators by repositioning three way valves. Operators would need to reposition or misposition a three way valve and inadvertently start the hydraulic pump to close the bottom doors. Neither of these actions will be procedurally allowed until the basket is lowered completely into the concrete cask. Alternately, a spurious actuation of the hydraulic pump concurrent with the three way valve being physically repositioned or mispositioned is also unlikely. Therefore, closing the transfer cask bottoms doors while the basket is being lowered into the concrete cask is not considered a credible event.

5.2.4.3 Brittle Fracture of the Transfer Cask

Brittle fracture of the transfer cask will not occur because a service temperature of -3 °F has been established for the load bearing components of the transfer cask and procedures will not allow handling the transfer cask when ambient temperatures are below -3 °F.

Charpy v-notch energies have been determined for the transfer cask inner and outer shells, cask trunnions, lifting yoke, and lift yoke pins using a service temperature of -3 °F, which is the lowest recorded temperature for Portland, Oregon. The fabrication specifications require that the results

of Charpy v-notch tests for these components are equal to or greater than the specified energies. Although temperatures below -3°F are unlikely at the ISFSI site, procedures will require that the ambient temperature be measured prior to handling the transfer cask when it is loaded with fuel to ensure that the ambient temperature is more than -3°F to minimize the possibility of brittle fracture.

5.2.4.4 Boron Dilution of Cask Loading Pit, Basket, or Spent Fuel Pool

A boron dilution event is not likely because borated water will be used for operations involving the Cask Loading Pit and/or Spent Fuel Pool. The water may be filtered to reduce radioactivity/ contamination levels or to improve water clarity, but the filtration equipment will be designed and operated to not reduce the boron concentration of the water being used to flush the basket/transfer cask annulus, wash down the outside of the transfer cask, etc.

As described above in section 5.2.3.1 above, a tear/breach of the Cask Loading Pit or Spent Fuel Pool although unlikely, could occur as the result of a load drop. One of the actions in response to a large leak would be addition of water to the Cask Loading Pit or Spent Fuel Pool from various non-borated water sources. Addition of non-borated water would result in dilution of the Cask Loading Pit [illegible] Spent Fuel Pool. The criticality analysis for a basket loaded with spent fuel shows that k_{eff} is less than 0.95 even in non-borated water. Similarly, the Trojan Technical Specification Bases (B 3.1.2) state that the k_{eff} in the Spent Fuel Pool racks will be less than 0.95 even in non-borated water. Therefore, if a boron dilution did occur as a result of adding non-borated makeup water to the Cask Loading Pit or Spent Fuel Pool, the spent fuel in the basket and Spent Fuel Pool racks would remain subcritical.

5.2.4.5 Spread of Transfer Cask and/or Basket Contamination

Spread of contamination is not likely because the surface contamination levels of the basket and concrete cask will be controlled and measured. The need for decontamination will be evaluated if loose surface contamination levels are above 10^{-4} $\mu Ci/cm^2$ β-γ or 10^{-5} $\mu Ci/cm^2$ α. This control ensures that even if the small amount of contamination that could be affixed to the basket became loose and was released, the resulting dose would be negligible (0.0024 rem at 100 meters). The loose surface contamination level is determined by taking swipes on the exterior of the basket, the internal surface of the transfer cask (which is representative of the contamination level of the inaccessible basket external surface), and the concrete cask external surface.

In addition, the NRC's Dry Storage Action Plan identifies weeping as a potential source of contamination from casks with bare metals, especially stainless steels, and states that weeping may be alleviated by coating the metal surfaces of the cask. Normally, contamination caused by weeping would occur only if the transfer cask and basket were submerged in the Cask Loading Pit over a period of days. Since the loading operation will normally only require the transfer cask and basket to be submerged in the Cask Loading Pit for a short period of time, and the water in the Cask Loading Pit will not contain significant quantities of loose contamination, absorption of

contamination by the transfer cask and basket is not expected. However, as a precaution, the inner surfaces of the transfer cask metal liner and the external surface of the basket will be coated with a hard, smooth epoxy to prevent absorption of contamination by the transfer cask and basket which should further preclude the potential for weeping.

5.2.4.6 Inadvertent Basket Over Pressurization during Draining/Drying Operations

Inadvertent basket over pressurization during draining and drying operations is not likely because multiple equipment failures and a procedural error are required. The basket is hydrostatically tested to approximately 22 psia (7.3 psig), therefore, basket pressures over 7.3 psig are not allowed. Until the shield lid is welded to the basket, pressure from the basket could relieve through the shield lid vent penetration, shield lid drain penetration, or the gap between the shield lid and basket. After the shield lid is welded the shield lid vent penetration and drain penetration could relieve pressure except during hydrostatic testing, basket drying (with pressurized air), and helium filling. Hydrostatic test procedures will closely control the pressure in the basket and the hydrostatic test rig will have a relief valve to protect the basket from overpressurization. The air supply used to dry the basket and the helium supply used to fill the basket after vacuum drying will have regulators that are set at less than the hydrostatic test pressure (7.3 psig). In addition, a pressure relief valve will be installed downstream of the regulator and upstream of the basket inlet penetration. The regulator and the relief must both fail in order to overpressurize the basket. In addition, the procedure will require that an operator watch a pressure gauge installed on the basket drain port and manually close the supply valve if the pressure reaches 7.3 psig (less the gauge tolerance). Therefore, over pressurization of the basket is not likely because multiple failures/errors must occur.

5.2.5 Support System Malfunctions

5.2.5.1 Welding System Failures

Welding system failures are postulated to occur while the shield and structural lids are being welded to the basket in the Cask Wash Pit. Welding system failures would include loss of electrical power or component failures that prevent completion of the welding process. As described below, delays in the basket draining/drying process caused by welding system failures will not result in fuel cladding temperatures that exceed short term temperature limits

A calculation shows that at least 35 hours of heat-up are required for the water in the basket to reach boiling. This provides ample time to restore electrical power or repair/replace failed components. In the unlikely event that electrical power cannot be restored or failed components cannot be repaired/replaced prior to steam being generated, procedures will specify appropriate methods and the equipment needed to be available to cool the basket or vent the steam generated by the basket until the power is restored or the failed components are repaired/ replaced. If the water inside the basket boils, the fuel cladding will not exceed any short term temperature limits

nor experience significant strain that could cause long term cladding degradation because the temperature of boiling water is well below the normal fuel cladding operating temperature.

5.2.5.2 Basket Draindown/Vacuum Drying System Failures

Basket draindown/vacuum drying system failures are postulated to occur after the shield and structural lids are welded to the basket and while water is being pumped or blown from the basket or while air is being evacuated from the basket. Basket draindown/vacuum drying system failures would include loss of electrical power, component failures that prevent completion of the draindown/ vacuum drying process, or rupture of a pressurized line. The basket draindown/ vacuum drying system are commercial grade components which means that failures may occur although the potential for failure would be unlikely. Passive failure of a pressurized line is unlikely because the operating pressures for the basket are very low, i.e, atmospheric to 7.3 psig. As described below, delays in the basket draining/drying process caused by basket draindown/ vacuum drying system failures will not result in fuel cladding temperatures that exceed short term temperature limits and passive failure of a pressurized line will not result in a radiological release that exceeds regulatory limits.

5.2.5.2.1 Loss of Electrical Power or Component Failures

As stated in section 5.2.5.1 above, the loss of electrical power or component failures that delay completion of the draindown/drying process do not result in fuel cladding temperatures that exceed short term limits. Procedures will specify appropriate methods and the equipment needed to be available to vent the steam generated by the basket (e.g., back into the Spent Fuel Pool through the line that will be used to return the basket water to the Spent Fuel Pool) until the power is restored or the failed components are repaired/ replaced.

Once water is removed from the basket and the vacuum drying process begins, fuel cladding temperatures are higher because heat transfer from the fuel to the basket is less in a vacuum. However, the fuel cladding temperature in a vacuum will not exceed short term fuel cladding temperatures. Because of the higher fuel cladding temperatures in a vacuum condition, an administrative time limit is imposed to minimize fuel cladding strain. If the failed vacuum drying system components could not be repaired within this time limit, then the basket could be backfilled with helium until the failed components were repaired or replaced. The helium atmosphere would increase heat transfer from the fuel to the basket and lower the fuel cladding temperatures as well as minimizing fuel cladding contact with an air (oxidizing) atmosphere.

5.2.5.2.2 Rupture of a Pressurized Line

Two cases were considered for a rupture of a pressurized line: the discharge line on the draindown pump ruptures while the basket is being pumped dry which results in a spill of contaminated water in the Fuel Building, and the helium supply line to the basket ruptures while filling the basket which would release airborne radioactivity to the Fuel Building atmosphere.

For the rupture of the discharge line on the draindown pump, the analysis assumes that the basket is filled with water and there is no operator action which results in the entire water volume of the basket, about 1557 gallons, being pumped onto the Fuel Building floor at the 93' elevation. With an assumed Spent Fuel Pool activity of 4.59 E-5 μCi/ml gross β, 8.78 E-5 μCi/ml gross γ, and 1.56 E-2 μCi/ml tritium, the radioactivity released in the Fuel Building would by 2.70 E-4 Ci gross β, 5.17 E-4 Ci gross γ, and 9.21 E-2 Ci tritium which would result in a negligible dose at the site boundary due to the lack of airborne radioactivity. The water would cause minimal exposure to workers. Most of the water would be captured by floor drains. Clean up of the remaining spilled water would be a relatively straightforward and not hazardous.

For the rupture of the helium supply line, the analysis assumes that the basket is at 7 psig and that the effective surface contamination levels are 12 μCi/square cm with a normalized decay fractional activity for each radionuclide as of January 1, 1998. Fifteen percent of this contamination is assumed to be released as airborne particulate during the depressurization transient. The release to the Fuel Building atmosphere would result in dose at the site boundary of about 0.000282 rem whole body if Auxiliary Building/ Fuel Building ventilation is running and about 0.143 rem whole body if the Auxiliary Building/ Fuel Building ventilation is not running. These doses are well below EPA Protective Action Guide of 1 rem whole body for the early phase of an event.

5.2.5.3 Air Pad System Failures

Air pad system failures are postulated to occur after the basket has been loaded in the concrete cask, the concrete cask cover lid has been installed, and the concrete cask has been lifted by the air pad system for movement to the concrete storage pad. Air pad system failures would be malfunctions of the compressor, the air hoses that feed the air pads, or the air pads themselves that result in the loss of air pressure to the air pads. As described below, an air pad system failure will not cause basket damage that results in a radiological release or spent fuel damage that results in a k_{eff} of more than 0.95.

Failure of the air compressor, the air hoses that feed the air pads, or the air pads themselves will cause loss of air pressure that will result in the concrete cask being lowered to the concrete pad or surface over which the concrete cask is being moved. If a catastrophic failure of one of the four air pads underneath the concrete cask occurs, then the concrete cask would be lowered rapidly on the corner being supported by the failed air pad. The air manifold would automatically feed more air to the failed pad which would partially cushion the impact. If the failure is in the compressor or the air hoses that feed the airs pads, then air pressure loss in the air pads would be slower and the concrete cask would be lowered to the concrete pad slower than in the case of the catastrophic failure of one of the air pads. In any event, the concrete cask will be lowered to the concrete pad or surface over which the concrete cask is being moved from the lift height of the air pads, which is about 3". An analysis of a drop of the concrete cask onto the concrete reinforced pad shows that the concrete cask may be dropped from 53" and not result in damage to the basket or intact fuel (dropping the basket into the concrete cask in the Fuel Building bay results in less deceleration force). The drop analysis is from a considerably higher distance with no credit for air

cushioning by the air pads. Therefore, an air pad system failure would not result in a radiological release or intact spent fuel damage that results in a k_{eff} of more than 0.95 as described in Section 5.2.1.4.

5.2.6 Natural Phenomena

5.2.6.1 Natural Phenomena

The spectrum of natural phenomena include tornados, floods, tsunami, and earthquakes.

5.2.6.1.1 Tornadoes

Procedures will be in place to preclude spent fuel loading and handling during high winds and unstable atmospheric conditions that could lead to a tornado threat.

5.2.6.1.2 Floods and Tsunami

Spent fuel loading and handling will take place inside the Fuel Building at elevations above credible external flood (internal flooding is not postulated due to the limited sources of water) and tsunami levels.

5.2.6.1.1 Earthquakes

Earthquakes will have a negligible effect on the transfer cask, basket, and concrete cask individually because of their rigid design. Therefore, an earthquake was only postulated to occur and cause toppling of the transfer cask when the transfer cask is stacked on top of the concrete cask in the Fuel Building bay while preparing to lower the basket loaded with fuel from the transfer cask to the concrete cask. For the transfer cask to topple, the earthquake would need to occur during the few minutes that the lifting yoke is detached from the transfer cask and the basket lifting rig has not been attached to the basket. Toppling would not occur while the basket or transfer cask were attached to the lifting equipment because the design safety factors would support the load. Toppling while the basket and transfer cask are both not attached to lifting equipment is highly unlikely because the probability is extremely small that an earthquake will occur during the short period of time that is required to shift the lifting equipment from the transfer cask to the basket. As described below, an earthquake will not cause basket damage that results in a radiological release or spent fuel damage that results in a k_{eff} of more than 0.95.

An analysis was performed assuming that a Seismic Margin Earthquake occurred while the transfer cask (basket loaded with fuel inside) is stacked on top of a concrete cask in the Fuel Building bay, the lifting yoke is detached from the transfer cask, and the basket lifting rig has not been attached to the basket. The total effect of the earthquake is calculated by assuming kinetic energy input to the transfer cask corresponding to the square-root-of-the-sum-of-the squares combination of the peak horizontal and peak vertical ground velocities. Using this kinetic energy

and assuming that the earthquake's periodic motion is only in one direction, the transfer cask would slide only about 6" across the top of the concrete cask, which would not be sufficient for the transfer cask center of gravity to move to the edge of the concrete cask. If the sliding motion described above is neglected and only the rocking motion imparted by the earthquake is considered, the transfer cask by itself and the transfer cask coupled with the concrete cask would only be tipped less than 1° from the vertical, which is much less than would be needed to tip the transfer cask or transfer cask/concrete cask combination (about 24°). Therefore, the transfer cask would remain on top of the concrete cask during a Seismic Margin Earthquake, and no basket damage or spent fuel damage would occur because the Seismic Margin Earthquake accelerations are well below the maximum allowable accelerations for the basket (124g vertical, 44 horizontal) and fuel (82g vertical, 44g horizontal). Criticality for damaged fuel within the basket is not a concern as described in Section 5.2.1.4.

5.3 OPERATIONAL CONTROLS

The operational controls that are implemented to ensure that the assumptions of the safety evaluation and supporting analyses are satisfied are summarized below.

5.3.1 Handling Height for the Transfer Cask

The handling height of the transfer cask (the height at which the transfer cask will be lifted above the floor) during movement along the designated safe load path will be limited to 5"- 6", depending on the location along the safe load path, to ensure that the floor over which the transfer cask is moved has sufficient strength to withstand a transfer cask drop in the unlikely event that a drop occurs. The handling height used in (or derived by) the transfer drop analysis is a minimum of 6", except at the top of the Cask Loading Pit, where the analysis used a height of 5" above the floor and over an impact limiter near the Cask Wash Pit, where the analysis derived a range of heights depending on the impact limiter thickness. Impact limiters will also be placed in the Cask Loading Pit, Cask Wash Pit, and Fuel Building hoistway, where the handling heights will be greater than the maximum allowed handling height, and at the top of the Cask Loading Pit, Cask Wash Pit, and Fuel Building hoistway where tipover of the transfer cask was analyzed, to ensure the structural integrity of the floors and the transfer cask in the unlikely event of a drop or tipover. Procedures will specify actions required if the maximum nandling height is exceeded.

5.3.2 Basket Draindown Time

The basket draindown time is administratively limited as described in ISFSI SAR Section 5.1.1.2 to ensure that the water inside the basket does not boil prior to removal of the water from the basket. The draindown time starts when the top of the transfer cask is lifted from the water in the Cask Loading Pit and ends when the service air used to blow the last of the water out of the basket has been secured. This ensures that steam does not form which could potentially pressurize the basket above the hydrostatic test pressure or could result in a radiological release (via steam escaping from the basket) into the Fuel Building. Keeping water from boiling in the

basket also ensures that the fuel cladding temperature remains well below the short term limits and does not cause fuel cladding strain which could potentially cause long term fuel cladding degradation. (Note that even without water, i.e., in a vacuum, an analysis shows that fuel cladding temperatures will not reach the short term temperature limits.) Procedures will specify appropriate methods and the equipment needed to be available in the event that the basket draindown is not completed within the calculated time to boil.

5.3.3 Vacuum Drying Time

The vacuum drying time is conservatively limited to less than 20 hours to ensure that the fuel cladding strain that is accumulated during the vacuum drying process does not exceed 0.1%. The vacuum drying time starts when the service air used to blow the last of the water out of the basket has been secured and ends when the last helium backfill has been completed. The time is limited as recommended by PNL-6364, "Control of Degradation of Spent LWR Fuel During Dry Storage in an Inert Atmosphere." Procedures will specify appropriate methods and the equipment needed to be available in the event that vacuum drying of the basket will not be completed within the administrative limit.

5.3.4 Handling Temperature of the Transfer Cask

The transfer cask will not be handled/lifted when ambient air temperatures in the transfer cask handling area are less than -3°F or the transfer cask has been stored at temperatures less than -3°F, unless direct temperature measurement of the transfer cask handling/lifting components shows that they are at temperatures higher than -3°F. This temperature limit minimizes the possibility that the transfer cask components will experience a brittle fracture during handling/lifting operations.

5.3.5 Air Pad Inflation Time

The air pad system that is used to lift and move the concrete cask may inhibit natural circulation air flow through the concrete cask, which would prevent decay heat removal from the basket and cause the spent fuel cladding temperature to rise. Calculations show that blockage of the air inlets will not result in fuel cladding temperature limits that exceed the short term temperature limit. However, the amount of time that the air pad system can be inserted into the air inlet openings will be limited to 12 hours, which corresponds to the normal surveillance interval for measuring the concrete cask air outlet temperature. Procedures will specify appropriate methods and the equipment needed to be available in the event that the air pads inhibit natural circulation air flow for more than 12 hours.

5.3.6 Concurrent Decommissioning Activities

The postulated off-normal events and accidents in the safety evaluation do not consider interactions with concurrent decommissioning activities. Similarly, the postulated events in the

Decommissioning Plan do not consider interactions with spent fuel loading and handling activities. Therefore, a procedure will be written that specifies the spent fuel loading and handling activities and decommissioning activities that will not be performed concurrently because the activities could potentially interact with each other. This administrative control will ensure that concurrent activities will not increase the probability or consequences of a postulated event or accident.

5.3.7 Auxiliary/Fuel Building Ventilation

Auxiliary/Fuel Building ventilation will be in operation during spent fuel loading and handling inside the Fuel Building to minimize the amounts of airborne particulate radioactivity released from the Fuel Building to the environment. Procedures will specify alternate ventilation and/or equipment needed to be available in the event that the Auxiliary/Fuel Building Ventilation becomes inoperable during spent fuel loading and handling operations.

5.3.8 Recovery from Off-Normal Events and Accidents

Procedures will be written that specify appropriate methods and equipment that will be needed to recover from credible off-normal events and accidents. As a minimum, procedures will address recovery from a 1) fuel assembly drop, 2) transfer cask/basket drops of greater than 5" to 6" when the basket is loaded, 3) transfer cask tipovers when the basket is loaded, 4) Failures of pressurized lines connected to the basket loaded with fuel, 5) vacuum drying time exceeding administrative limits and 6) spent fuel pool/pit liner tears/cracks.

5.3.9 Fuel Inspection Acceptance Criteria

Procedures will be developed for the inspection of spent fuel assemblies, prior to loading into the PWR basket, with acceptance criteria that are consistent with the criticality evaluation described in Section 5.2.1.4.

6. SIGNIFICANT HAZARDS CONSIDERATION DETERMINATION

In accordance with the requirements of 10 CFR 50.92(c), implementation of the requested license amendment, spent fuel loading and handling in the Fuel Building, is analyzed using the following standards and found: 1) not to involve a significant increase in the probability of an accident previously evaluated; 2) not to involve a significant increase in the consequences of an accident previously evaluated; 3) to create the possibility of a new or different kind of accident from any accident previously evaluated; and 4) not to involve a significant reduction in a margin of safety.

1. The requested license amendment does not involve a significant increase in the probability of an accident previously evaluated.

   With the issuance of a Possession Only License, the number of potential accidents was reduced to those types of accidents associated with the storage of irradiated fuel and

radioactive waste storage and handling. Additional events were postulated for decommissioning activities due to the difference in the types of activities that were to be performed. The postulated accidents described in the Defueled Safety Analysis Report (DSAR) are generally classified as: 1) radioactive release from a subsystem or component, 2) fuel handling accident, and 3) loss of spent fuel decay heat removal capability. The postulated events described in the Decommissioning Plan are grouped as: 1) decontamination, dismantlement, and materials handling events, 2) loss of support systems (offsite power, cooling water, and compressed air), 3) fire and explosions, and 4) external events (earthquake, external flooding, tornadoes, extreme winds, volcanoes, lightning, toxic chemical release). These types of accidents are discussed below.

Radioactive release from a subsystem or component involves failure of a radioactive waste gas decay tank (WGDT) or failure of a chemical and volume control system holdup tank (HUT). For the failure of a WGDT, the radioactive contents were assumed to be principally noble gases krypton and xenon, the particulate daughters of some of the krypton and xenon isotopes, and trace quantities of halogens. For the failure of a HUT, the assumptions were full power operation with 1-percent failed fuel, 40 weeks since power operation, and 60,000 gallons of 120°F liquid released over a 2 hour period. However, the WGDTs and HUTs are no longer active and have been drained. Therefore, spent fuel loading and handling activities cannot increase the probability of occurrence of a failure of a WGDT or HUT.

The fuel handling accident involves a stuck or dropped fuel assembly which results in breaking the cladding of the fuel rods in one assembly and releasing the gaseous fission products. Spent fuel handling and loading will move the spent fuel assemblies, one by one, from the Spent Fuel Pool to the baskets that will be located in the Cask Loading Pit. The fuel handling equipment will be the same as before with the exception of special tools that will be used to manipulate the failed fuel. These special tools will be similar in size and weight to other tools used for underwater manipulation, and therefore, would not present a new hazard. In addition, the same administrative controls and physical limitations imposed on any fuel handling operation will be used for spent fuel loading and handling. Thus, there is no increase in the probability of occurrence of a fuel handling accident over what would be expected for any routine fuel handling operation.

The loss of spent fuel decay heat removal capability involves the loss of forced spent fuel cooling with and without concurrent Spent Fuel Pool inventory loss. The only requirement to assure adequate decay heat removal capability for the spent fuel is to maintain the water level in the Spent Fuel Pool so that the spent fuel assemblies remain covered (i.e., the capability to makeup water to the Spent Fuel Pool must be available when required). The potential events which could result in a loss of spent fuel decay heat removal capability include external events (explosions, toxic chemicals, fires, ship collision with intake structure, oil or corrosive liquid spills in the river, cooling tower collapse, seismic events, severe meteorological events), and internal events including Spent Fuel Pool makeup water system malfunctions (Service Water System, electrical power, instrument air). Spent fuel loading and handling will not require the

use of explosive materials (the gases used for electric arc welding are inert), toxic chemicals, or flammable materials (routine use of plastic sheeting or absorbent materials for contamination control is not considered significantly hazardous). The probability of other external events (e.g., cooling tower collapse) would be unaffected by the spent fuel loading and handling activities inside the Fuel Building. Spent fuel loading and handling activities will not directly interface with the Spent Fuel Pool makeup water systems, therefore, could not affect their probability of failure. (The Cask Loading Pit will be filled with borated water from the Spent Fuel Pool that will be cooled by the Spent Fuel Pool Cooling System, but use of this water in the Cask Loading Pit would not increase the failure probability of the Spent Fuel Pool or makeup water systems.) As described in the safety evaluation above, the safe load path and handling height limitations will ensure that a load drop does not adversely affect the Spent Fuel Pool or the makeup water systems. Therefore, there is no significant increase in the probability of a loss of spent fuel decay heat removal capability.

The events postulated in the Decommissioning Plan are similar to the DSAR with the exception of the decontamination, dismantlement, and materials handling events. Decontamination events involve gross liquid leakage from in-situ decontamination equipment (e.g., tanks), or accidental spraying of liquids containing concentrated contamination. Dismantlement events involve segmentation of components and structures, or removal of concrete by rock splitting, explosives, or electric and/or pneumatic hammers. Dismantlement events potentially result in airborne contamination. Material handling events involve the dropping of contaminated components, concrete rubble, or filters or packages of particulate materials. As described in the operational controls above, administrative controls will be implemented to ensure that spent fuel loading and handling activities and decommissioning activities will not be performed concurrently if they interact with each other and could increase the probability or consequences of a postulated event or accident. Therefore, the probability of decontamination, dismantlement, and materials handling events would not be significantly increased.

Based on the above, the spent fuel loading and handling activities would not significantly increase the probability of any accident previously evaluated.

2. The requested license amendment <u>does not involve</u> a significant increase in the consequences of an accident previously evaluated.

   The accidents described in the DSAR are generally classified as: 1) radioactive release from a subsystem or component, 2) fuel handling accident, and 3) loss of spent fuel decay heat removal capability. The events described in the Decommissioning Plan are grouped as: 1) decontamination, dismantlement, and materials handling events, 2) loss of support systems (offsite power, cooling water, and compressed air), 3) fire and explosions, and 4) external events (earthquake, external flooding, tornadoes, extreme winds, volcanoes, lightning, toxic chemical release).

As described above, the failure of a WGDT and HUT are no longer credible since these tanks have been deactivated. Therefore, the consequences of a failure of a WGDT or HUT cannot significantly increase as a result of spent fuel loading and handling.

As discussed in the safety evaluation, if a fuel assembly was dropped while loading a basket in the Cask Loading Pit, then only 1 fuel assembly could be damaged. The previous analysis described in the DSAR postulated the same results. Therefore, the consequences of a fuel assembly drop while loading a basket in the Cask Loading Pit would be the same as the consequences of the analysis described in the DSAR. Therefore, the consequences of a fuel assembly drop while loading a basket in the Cask Loading Pit are not significantly increased as a result of spent fuel loading and handling.

There are no credible adverse consequences of the loss of spent fuel decay heat removal because the DSAR demonstrates that adequate time is available to establish a source of makeup water to the Spent Fuel Pool such that uncovering the fuel and an actual loss of spent fuel cooling is not credible. As described by the safety evaluation above, the postulated events that could affect the Spent Fuel Pool (liner tear/breach and heavy load drop) do not have a significant adverse effect. In addition, establishment of the makeup water path and recovery of spent fuel cooling would not be affected because postulated off-normal events and accidents would not affect the capability to provide makeup water to the Spent Fuel Pool by various water sources. Therefore, spent fuel loading and handling cannot significantly increase the consequences of the loss of spent fuel decay heat removal.

The events postulated in the Decommissioning Plan that are different from the DSAR are decontamination, dismantlement, and materials handling events. As described in the operational controls above, administrative controls will be implemented to ensure that spent fuel loading and handling activities and decommissioning activities will not be performed concurrently if they interact with each other and could increase the probability or consequences of a postulated event or accident. Therefore, the consequences of decontamination, dismantlement, and materials handling events will not be significantly increased.

Based on the above, the spent fuel loading and handling activities do not involve a significant increase in the consequences of an accident previously evaluated.

3. The requested license amendment <u>does create</u> the possibility of a new or different kind of accident from any accident previously evaluated.

The accidents described in the DSAR are generally classified as: 1) radioactive release from a subsystem or component, 2) fuel handling accident, and 3) loss of spent fuel decay heat removal capability. The events described in the Decommissioning Plan are grouped as: 1) decontamination, dismantlement, and materials handling events, 2) loss of support systems (offsite power, cooling water, and compressed air), 3) fire and explosions, and 4) external

events (earthquake, external flooding, tornadoes, extreme winds, volcanoes, lightning, toxic chemical release).

As described in the safety evaluation of the proposed spent fuel loading and handling activities, only three types of off-normal events/accidents were determined to have radiological consequences: a fuel assembly drop into a basket loaded with spent fuel, a transfer cask drop or mishandling event prior to the shield and structural lids being welded in the basket, and a basket draindown/vacuum drying system failure (passive failure of a pressurized line).

The postulated fuel assembly drop into a basket loaded with spent fuel is considered the same type or kind of event as the previously analyzed fuel handling accident, mainly because the initiator for this postulated event is the same, i.e., a (non-specified) failure of the fuel handling equipment or the Fuel Handling Bridge Crane. The previous evaluation considered a dropped fuel assembly in Spent Fuel Pool. During spent fuel loading and handling, a fuel assembly may be dropped in the Spent Fuel Pool or the Cask Loading Pit. As the Cask Loading Pit is similar in construction to the Spent Fuel Pool and the Cask Loading Pit will be flooded with borated water of the same concentration as the Spent Fuel Pool, the differences between the two events are negligible and the two events may be considered the same type or kind of event. Therefore, the fuel assembly drop is not a new or different type or kind of accident.

The postulated transfer cask drop or mishandling event prior to the shield and structural lids being welded in the basket is similar to a fuel handling accident. However, the fuel handling accident only considers dropping one fuel assembly because routine fuel handling operations only involve moving one fuel assembly at a time. In addition, normal fuel handling involves movement of the single fuel assembly underwater in the Spent Fuel Pool, transfer canal, etc. In the case of the transfer cask/basket, 24 fuel assemblies will be moved at one time, and for the portion of their movement where a radiological release is postulated, will not be within the confines of the Spent Fuel Pool or transfer canal. The postulated transfer cask drop or mishandling events are considered to be a different kind of accident than any previously evaluated. As stated in the safety evaluation, the consequences of transfer cask drop or mishandling event prior to the shield and structural lids being welded in the basket are about 0.003 rem whole body at the site boundary. This dose is well below EPA Protective Action Guides of 1 rem whole body for the early phase of an event. Therefore, the consequences of a transfer cask drop or mishandling event prior to the shield and structural lids being welded in the basket would not represent a significant hazard to public health and safety.

The postulated passive failure of a pressurized line on the basket during the vacuum drying process is similar to events described in the Decommissioning Plan. The Decommissioning Plan considers airborne release of radioactive materials as a result of cutting, dropping, demolishing, etc., plant subsystems and components during decommissioning activities. The postulated passive failure of a pressurized line on the basket constitutes a different kind of accident because it involves the airborne release of radioactive material by a different

initiation process than previously evaluated. As described in the safety evaluation, the passive failure of a pressurized line connected to a basket loaded with spent fuel results in a whole body dose at the site area boundary of about 0.000282 rem if Auxiliary/Fuel Building ventilation is running and 0.143 rem if Auxiliary/Fuel Building ventilation is not running. The 0.143 rem dose without ventilation is well below the 1 rem EPA Protective Action Guide for the early phase of an event. In addition, the Auxiliary/Fuel Building ventilation will be operating during spent fuel handling evolutions as a precaution (see operational controls above). Therefore, the consequences of a passive failure of a pressurized line would not represent a significant hazard to public health and safety.

Based on the above, spent fuel loading and handling activities create new types of accidents, but the consequences of the new types of accidents are well below EPA Protective Action Guide of 1 rem whole body for the early phase of an event. Therefore, although different kinds of accidents are created by spent fuel handling and loading, the consequences of the different kinds of accidents do not represent a significant hazard to public health and safety.

4. The requested license amendment <u>does not involve</u> a significant reduction in the margin of safety.

   The Trojan Permanently Defueled Technical Specifications contain four limiting conditions of operation that address: 1) Spent Fuel Pool Water level, 2) Spent Fuel Pool Boron Concentration, 3) Spent Fuel Pool Temperature, and 4) Spent Fuel Pool load restrictions. These Technical Specifications will remain in effect as long as spent fuel is stored in the Spent Fuel Pool, which is in accordance with their applicability statements. The spent fuel loading and handling activities will not affect these Technical Specifications nor their bases.

   The Cask Loading Pit, where spent fuel will be loaded into the basket, is immediately adjacent to the Spent Fuel Pool. The gate between the Cask Loading Pit and Spent Fuel Pool will be opened to allow spent fuel assemblies to be moved from the spent fuel storage racks in the Spent Fuel Pool to the basket in the Cask Loading Pit. Opening the gate will allow free exchange of the water between the Cask Loading Pit and the Spent Fuel Pool. The water in the Cask Loading Pit must be at essentially the same level, boron concentration, and temperature as the Spent Fuel Pool prior to the first opening of the gate to ensure that the limiting conditions of operation are continuously satisfied for the Spent Fuel Pool. Therefore, the Cask Loading Pit will be initially filled, to about the same level as the Spent Fuel Pool, with water that is about the same boron concentration and temperature as the Spent Fuel Pool. With these precautions, the limiting conditions of operation pertaining to Spent Fuel Pool level, boron concentration, and temperature will be continuously maintained for the Spent Fuel Pool and the margin of safety will be unaffected.

   Spent fuel loading and handling activities will involve lifting and moving heavy loads (e.g., transfer cask). Loads that will be carried over fuel in the Spent Fuel Pool racks and the heights at which they may be carried will be limited in such a way as to preclude impact

energies over 240,000 in-lbs if the loads are dropped in accordance with LCO 3.1.4, "Spent Fuel Pool Load Restrictions." With this precaution, the limiting condition of operation pertaining to load restrictions over the Spent Fuel Pool will be satisfied for fuel stored in the Spent Fuel Pool racks and the margin of safety will be unaffected. The safe load path for heavy loads being lifted and moved outside the Spent Fuel Pool will be located sufficiently far from the Spent Fuel Pool as to not have an adverse effect on the Spent Fuel Pool in the unlikely event of a load drop. In addition, the mechanical stops and electrical interlocks on the Fuel Building overhead crane will provide additional assurance that heavy loads are not carried over the fuel in the Spent Fuel Pool racks.

Based on the above, the spent fuel loading and handling activities will not reduce the margin of safety.

7. ENVIRONMENTAL ASSESSMENT

Spent fuel loading and handling will be conducted in a manner having minimal impact on the environment. The spent fuel loading and handling process will comply with applicable Nuclear Regulatory Commission (NRC) and State of Oregon requirements to ensure that the activity does not adversely affect the environment or the health and safety of workers or the public. As discussed in the safety evaluation above, potential off-normal events and accidents have been postulated and analyzed for the spent fuel loading and handling process. The results of those analyses show that the potential adverse environmental impact of credible off-normals events and accidents for the spent fuel loading and handling process are well below the EPA Protective Action Guides for the early phase of an event.

This environmental assessment addresses spent fuel loading and handling in preparation for storage of the spent fuel on the reinforced concrete storage pad. The environmental impact of construction of the ISFSI components and operation of the ISFSI is addressed in the Trojan ISFSI Environmental Report (PGE-1070), which was included as part of the 10 CFR 72 license application that PGE submitted to the NRC in March 1996.

7.1 ENVIRONMENTAL IMPACT OF PROPOSED ACTION

The overall environmental impact of spent fuel loading and handling is beneficial because moving the spent fuel and GTCC waste to the ISFSI will allow further decommissioning activities in the Fuel Building and Containment Building which will reduce the site inventory of radionuclides and return much of the Trojan site to a condition suitable for unrestricted use.

7.1.1 Effects on Human Activities

The activities related to spent fuel loading and handling will take place primarily inside the Fuel Building, with the exception of GTCC waste handling which will need to be moved from the Containment Building to the Fuel Building for cask loading. These buildings are on the portion of

the Trojan site that has already been developed and used as an industrial facility. Portions of the existing Trojan site are set aside for recreational use by the public. These areas include a 28-acre recreational lake, picnic area, hiking and bicycle paths, and parking facilities. These public use areas are located separate from the industrial portion of the site and will be unaffected by the spent fuel loading and handling.

The work force required to complete the spent fuel loading and handling will be comparable to that associated with minor projects previously conducted at the Trojan site and will be much smaller than the work force required for refueling outages and the initial construction of the facility. The surrounding communities have experienced the construction of several large industrial facilities in the past and facilities exist to accommodate the temporary workers that may be required for spent fuel loading and handling. Therefore, there will be no significant adverse impacts on temporary housing or schools as a result of the additional work force that may be required for spent fuel loading and handling.

Spent fuel loading and handling will have negligible effects related to ambient noise in the area of the Trojan site. Any noise generated will be localized and of temporary duration. The Trojan site is bordered on the east by the Columbia River and on the west by a state highway. There nearest residential area is located approximately one mile north of the facility. Therefore, there will be no significant impact due to noise generated during spent fuel loading and handling.

Dust generation will be minimized during spent fuel loading and handling by using existing building ventilation systems and supplemental high efficiency particulate air filtration units, if necessary. Other dust control measures will be implemented if necessitated by forklift/truck movement of the concrete cask to the ISFSI pad.

Spent fuel loading and handling will be conducted in accordance with the existing Portland General Electric (PGE) safety program to minimize the risk of an industrial accident. The PGE safety program has contributed to a solid safety record during Trojan's seventeen years of operation and includes detailed procedures on topics such as emergency preparedness; hazard communication; accident investigation and reporting; electrical hazards; welding and cutting practices; placement and use of ladders and scaffolding; use of cranes, hoists, and associated rigging; and fire protection and prevention. Vendor organizations participating in the project will be required to submit industrial health and safety programs for PGE approval or work under the PGE program.

7.1.2 Effects on Terrain, Vegetation and Wildlife

As stated above, spent fuel loading and handling activities will take place in the Fuel Building and Containment Building, which are located on a portion of the Trojan site that has been previously developed for industrial usage. Portions of the site which have been left in their natural state will not be disturbed by these activities. Following loading of the basket into a concrete cask, the concrete cask will be moved by a forklift or similar vehicle to the ISFSI reinforced concrete

storage pad. The storage pad and the route to the storage pad are also within the portion of the Trojan site previously developed for industrial use, hence, are also separated from the areas of the site that have been left in their natural state. Therefore, there will be no impacts on terrain, vegetation, or wildlife on or near the Trojan site.

7.1.3 Effects on Adjacent Waters and Aquatic Life

The Columbia River is adjacent to the Trojan site. The Service Water System uses water from the Columbia River to cool the Component Cooling Water System, which in turn cools the Spent Fuel Pool water. In this way, decay heat from the spent fuel is rejected to the Columbia River. As the spent fuel is removed from the Spent Fuel Pool and loaded into casks, fewer spent fuel assemblies will be left in the Spent Fuel Pool, which will reduce the amount of decay heat that is rejected to the Columbia River. Therefore, the loading of spent fuel casks will reduce the impact of the Trojan Nuclear Plant on the Columbia River and aquatic life.

Water usage on-site during the spent fuel loading and handling will be a small fraction of previous water usage at Trojan Nuclear Plant during power operations.

7.1.4 Nonhazardous/Hazardous Waste

Radioactive wastes generated during spent fuel loading and handling will be handled and disposed of in accordance with the existing Radiation Protection Program. Such wastes include airborne particulate activity, filters used for processing liquid/gaseous radioactive wastes, and liquids associated with decontamination activities. Liquid and gaseous radioactive wastes will be processed, sampled, monitored, and discharged in accordance with the plant effluent requirements specified in the Offsite Dose Calculation Manual. The process control program and approved plant procedures will be used to radiologically monitor, handle, and dispose of solid radioactive waste.

No hazardous or mixed (radiologically contaminated and chemically toxic) wastes are expected as a result of spent fuel loading and handling. However, handling and disposal of any radiologically uncontaminated hazardous waste that is encountered will be controlled by the existing hazardous materials processes. These processes involve evaluation of the hazardous material and approval of methods for its handling and disposal. Approved plant procedures are in place to reduce the potential for generation of mixed wastes and to control its handling and storage onsite.

Nonhazardous, nonradiologically contaminated waste will be handled in accordance with Trojan's normal waste disposal practices.

7.1.5 Occupational/Public Radiation Exposure

Occupational radiation exposures resulting from spent fuel loading and handling are anticipated to be low. The activities, number of personnel required, estimated duration, estimated working dose rate, and estimated exposure for the loading and handling of spent fuel and GTCC waste casks are provided in Tables 2 and 3. Based on the exposure estimates shown in Tables 2 and 3, the collective dose for loading and moving to storage the 34 fuel casks and 2 GTCC casks is:

Exposure (person-rem)			
	GTCC (2 casks)	Fuel (34 casks)	Total
Load Cask	1.56	49.07	50.63
Move to Storage	0.37	2.04	2.41
Total	1.93	51.11	53.04

The aggregate occupational exposure that workers are projected to receive as a result of spent fuel loading and handling is approximately 53 person-rem. This exposure compares favorably to that typically experienced by workers at operating nuclear plants.

The spent fuel loading and handling operations will occur inside the Fuel Building. The general radiation levels in the proposed work areas near the Spent Fuel Pool, Cask Loading Pit, and Cask Wash Pit inside the Fuel Building are about 0.0002 roentgen per hour. Once the basket is loaded with spent fuel or GTCC waste and the transfer cask containing the loaded basket is lifted from the Cask Loading Pit, occupational workers will be near the sides of the transfer cask or on top of the basket to weld the lids into the basket, connect vent and drain lines, etc. The radiation levels adjacent to the transfer cask and on top of the basket will be considerably higher than the general radiation levels near the Spent Fuel Pool, Cask Loading Pit, and Cask Wash Pit because the radiation source (spent fuel or GTCC waste) will no longer be at a distance of 23' with 23' of intervening water for radiation shielding.

The design of the basket, shield lid, and transfer cask reduce the radiation levels on top of the basket and sides of the transfer cask to accommodate the work that must be performed in close proximity to the basket. The working dose rates (at a distance of 1 meter from the surface) for the spent fuel are estimated as 0.100 and 0.120 roentgen per hour on the side and top of the transfer cask, respectively. For GTCC waste, the estimated working dose rates are 0.068 and 0.006 roentgen per hour on the side and top of the transfer cask, respectively. In addition to the radiation shielding provided by the design of the basket, shield lid, and transfer cask, the design of the basket assembly, such as quick disconnect couplings on the basket vent and drain lines, and the choice of equipment, such as the automatic welding machine for the basket lids, reduces the time that workers need to be in close proximity to the basket.

Procedures and practices will be employed to maintain occupational worker exposures ALARA because the estimated working dose rates are in excess of those specified for a radiation area and a high radiation area as defined by 10 CFR 20. These measures will include: 1) fuel loading procedures that follow accepted practice and build on existing experience; 2) loading spent nuclear fuel in the basket within the controlled environment of the Fuel Building to minimize the spread of contamination; 3) loading the most radioactive fuel in interior basket positions; 4) injecting filtered, borated water into the annulus between the transfer cask and basket to minimize contamination of the basket external surface; 5) placing the shielding lid on the basket while the transfer cask and basket remain in the Cask Loading Pit; 6) decontaminating the exterior of the transfer cask and welding the basket lid while the basket is still filled with water; 7) draining the basket while still housed in the transfer cask; 8) using portable shielding as necessary; 9) using the shielded transfer cask with remotely operated bottom doors to transfer the basket to the concrete cask; 10) placing a shielding ring over the annular gap between the concrete cask and basket; 11) using ALARA pre-job briefings prior to fuel movement and cask loading sequence.

In addition to using procedures and practices to maintain personnel exposure ALARA, controls and monitoring are implemented to ensure that workers do not receive an annual dose in excess of Trojan's administrative dose guidelines. These controls and monitoring are governed by the Trojan Radiation Protection Program.

In summary, the design of the basket, shield lid, and transfer cask includes radiation shielding to accommodate the spent fuel loading and handling work processes that must be performed in close proximity to the radiation source (spent fuel or GTCC waste). Also, the basket, transfer cask, and support equipment have been designed (or chosen if commercially available) to be operated quickly or remotely to minimize personnel radiation exposures. Additional procedures and practices will be implemented to ensure that personnel radiation exposures are ALARA and are controlled and monitored to ensure that regulatory limits are not exceeded. As a result of these design features, procedures, controls, and monitoring, spent fuel loading and handling will not significantly increase individual and cumulative occupational exposures.

Public exposure was not separately determined because no significant amounts of radioactive materials will be transported out of the industrial area and no significant amounts of gaseous or liquid radioactive effluents will be released to unrestricted areas as a result of spent fuel loading and handling activities.

7.2 ENVIRONMENTAL IMPACT OF OFF-NORMAL EVENTS AND ACCIDENTS

As discussed in the safety evaluation above, postulated off-normal events and accidents and natural phenomena that could potentially have an adverse impact on the environment or on the health and safety of workers or the public have been analyzed. The results of those analyses demonstrate that the postulated events have minimal significance from a public health and safety and environmental impact standpoint. Of the postulated off-normal events and accidents, only three types were determined to have radiological consequences: a fuel assembly drop into a

basket loaded with spent fuel, a transfer cask drop or mishandling event prior to the shield and structural lids being welded in the basket, and a basket draindown/vacuum drying system failure (passive failure of a pressurized line).

7.2.1 Fuel Assembly Drop into a Basket Loaded with Spent Fuel

The potential for a fuel assembly drop into a basket loaded with spent fuel is highly unlikely because the fuel handling equipment is designed with safety factors that ensure that the structural and lifting capability of the equipment well exceeds the weight that will be lifted. In addition, the fuel handling equipment will be load tested prior to use to ensure that the structural and lifting capability are verified to be adequate. Finally, administrative controls in the form of approved load handling procedures, training and certification of fuel handlers, maintenance of the fuel handling equipment, and inspections of the fuel handling equipment provide additional assurance that a fuel assembly drop will not actually occur.

The consequences at the site boundary from a postulated fuel assembly drop into a basket loaded with spent fuel would be about 0.0005 rem whole body, about 0.0006 rem thyroid, and about 0.0455 rem skin. These doses are well below the EPA Protective Action Guides of 1 rem whole body, 5 rem thyroid, and 50 rem skin for the early phase of an event. These doses are conservatively estimated by assuming failure of 100% of the fuel rods in the dropped assembly and a cooling time of 6 months (Trojan fuel will have been cooling for a minimum of 5 years and some fuel will have cooled for 17 years when cask loading will occur). In addition, this event was previously evaluated for the defueled condition. Therefore, this event does not introduce any consequences that have not been previously evaluated and the environmental impact is negligible.

7.2.2 Transfer Cask Drop and Mishandling Events Prior to Shield and Structural Lids Being Welded into the Basket

The potential for a transfer cask drop or mishandling event is highly unlikely because the load handling equipment is designed with safety factors that ensure that the structural and lifting capability of the equipment well exceeds the weight that will be lifted. In addition, the load handling equipment will be load tested and interlock operation verified prior to use to ensure that they are adequate. Finally, administrative controls in the form of approved load handling procedures, training of operators, maintenance of the load handling equipment, and inspections of the load handling equipment provide additional assurance that the potential for transfer cask drop or mishandling event is minimized.

7.2.3 Basket Draindown/Vacuum Drying System Failure

The potential for passive failure of a pressurized line connected to a basket loaded with spent fuel is unlikely because the lines that would need to fail are 150 psig rated piping on the basket draindown/vacuum drying system skid or 200 psig rated flexible hose that connects the skid to the basket. The probability of a passive failure of one of these lines is low, especially considering that

the maximum operating pressure of these lines is about 7 psig. The consequences at the site boundary from a postulated passive failure of a pressurized line connected to a basket loaded with spent fuel would be about 0.000282 rem whole body if Auxiliary Building/ Fuel Building ventilation is running and about 0.143 rem whole body if the Auxiliary Building/ Fuel Building ventilation is not running. These doses are well below the EPA Protective Action Guide of 1 rem whole body for the early phase of an event. These doses are conservatively estimated by assuming 15 percent of the contamination on the fuel becomes airborne.

Based on the limited likelihood of an off-normal event or accident occurring during spent fuel loading and handling, the conservatisms used in estimating the potential radiological consequences of postulated off-normal events and accidents, and the potential radiological consequences of postulated off-normal events and accidents being well below the EPA Protective Action Guides, it is concluded that the potential for and radiological consequences of off-normal events or accidents during the spent fuel loading and handling at the Trojan Nuclear Plant will not significantly impact the environment.

7.3 ALTERNATIVES TO PROPOSED ACTION

The proposed action is to place spent fuel in spent fuel storage casks inside the Fuel Building in order to transfer spent fuel from the Spent Fuel Pool to the Trojan ISFSI. The alternative to this proposed action would be to not remove the spent fuel from the Spent Fuel Pool (i.e., no action) or to ship the fuel to another facility for storage.

7.3.1 Not Removing Spent Fuel from the Spent Fuel Pool

Alternatives that do not remove the spent fuel from the Spent Fuel Pool are not viable decommissioning alternatives. The objective of decommissioning is to restore a radioactively contaminated facility to a condition such that there is no unreasonable risk to the public health and safety following license termination. If the spent fuel is not removed from the Spent Fuel Pool, then the Trojan Nuclear Plant could not be decommissioned.

The Trojan Nuclear Plant will be decommissioned using the DECON method as described in NUREG-0586. DECON is a decommissioning alternative that provides for equipment, structures, and portions of a facility containing radioactive contaminants to be removed or sufficiently decontaminated to allow release of the property for unrestricted use relatively soon after cessation of power operations. PGE anticipates terminating the 10 CFR 50 license in 2001. Therefore, spent fuel must be removed from the Spent Fuel Pool far enough in advance of 2001 to allow the completion of decommissioning activities and free release surveys. As the DECON decommissioning option has been chosen, removing the spent fuel from the Spent Fuel Pool will be necessary.

The Trojan Nuclear Plant Decommissioning Plan, which describes use of the DECON method for decommissioning, has been reviewed and found to be acceptable by the Nuclear Regulatory

Commission Staff. The Staff's review and conclusions were issued on December 18, 1995 in a Safety Evaluation Report, Environmental Assessment, and Final Finding of No Significant Impact.

In summary, the DECON method has been chosen for decommissioning of the Trojan Nuclear Plant and the Nuclear Regulatory Staff has found the Trojan Nuclear Plant Decommissioning Plan acceptable. The Trojan Nuclear Plant Decommissioning necessitates removing the spent fuel from the Spent Fuel Pool and the DECON option necessitates removing the spent fuel from the Spent Fuel Pool relatively soon after cessation of power operations. For these reasons, not removing the spent fuel from the Spent Fuel Pool was not considered a viable alternative.

7.3.2 Shipment of Trojan Spent Fuel to Another Facility

As stated previously, PGE anticipates terminating the 10 CFR 50 license in 2001. Therefore, spent fuel must be removed from the Spent Fuel Pool far enough in advance of 2001 to allow the completion of decommissioning activities and free release surveys. As the DECON decommissioning option has been chosen, removing the spent fuel from the Spent Fuel Pool will be necessary. There are currently no other facilities that can or will accept Trojan's spent fuel for wet or dry storage.

8. SCHEDULE CONSIDERATION

As described in the 10 CFR 72 license application submitted to the NRC in March 1996, PGE plans to begin loading spent fuel into casks and moving the casks to the ISFSI concrete storage pad in January 1998. Accordingly, PGE requests approval of this 10 CFR 50 license amendment by October 31, 1997, which is 3 months prior to the beginning of spent fuel loading, to allow adequate time for finalization of spent fuel loading and handling procedures as a result of mock-up and dry run testing, and NRC review of preoperational test results which will be submitted 30 days prior to the beginning of spent fuel loading.

Table 1

Radiological Consequences of Spent Fuel Loading and Handling Off-Normal Events or Accidents

Off-Normal Event or Accident	Whole Body Dose (rem) at Site Boundary	% of EPA Protective Action Guide Early Phase
Fuel Assembly Drop into Basket Loaded with Spent Fuel	0.0005	0.05%
Transfer Cask Drop/Mishandling (Prior to the Shield and Structural Lids Being Welded into the Basket)	0.003	0.3%
Passive Failure of Pressurized Line Connected to Basket Loaded with Spent Fuel:		
With Fuel/Auxiliary Building Ventilation	0.000282	0.0282%
Without Fuel/Auxiliary Building Ventilation	0.143	14.3%

Table 2

Estimated Personnel Exposure while Loading/Handling a Spent Fuel Cask

Activity	Personnel Work Groups	Exposure Time (hrs)	Working Dose Rate (mrem/hr)	Exposure (person-mrem)
Load Transfer Cask	2 Operators	5.5	0.2[a]	2.2
Monitor	1 R.P.	5.5	0.2[a]	1.1
Decontaminate Cask	2 R.P.	4.0	100[b]	800
Monitor	1 R.P.	4.0	10	40
Weld Shield and Structural Lid	2 Welders/ 1 Inspector	1.0	120	360
Vacuum Dry	1 Technician	8.0	10	80
Monitor	1 R.P.	1.0	120	120
Load Concrete Cask	2 Operators	1.5	10	30
Monitor	1 R.P.	1.0	10	10
Totals		31.5	----	1443.3
Move to Storage	2 Operators	2.0	10	40
Monitor	1 R.P.	2.0	10	20
Totals		4.0	----	60

a Radiation reading in Spent Fuel Pool area.

b Assumes worst case of dry basket. If water is left in basket as planned, dose rate will be less.

Table 3

Estimated Personnel Exposure while Loading/Handling a GTCC Cask

Activity	Personnel Work Groups	Exposure Time (hrs)	Working Dose Rate (mrem/hr)	Exposure (person-mrem)
Load Transfer Cask	2 Operators	5.5	0.2[a]	2.2
Monitor	1 R.P.	5.5	0.2[a]	1.1
Decontaminate Cask	2 R.P.	4.0	68[b]	544
Monitor	1 R.P.	4.0	7	28
Weld Shield and Structural Lid	2 Welders/ 1 Inspector	1.0	6	18
Vacuum Dry	1 Technician	8.0	7	56
Monitor	1 R.P.	1.0	6	6
Load Concrete Cask	2 Operators	1.5	31	93
Monitor	1 R.P.	1.0	31	31
Totals		31.5	----	779.3
Move to Storage	2 Operators	2.0	31	124
Monitor	1 R.P.	2.0	31	62
Totals		4.0	----	186

a Radiation reading in Spent Fuel Pool area.

b Assumes worst case of dry basket. If water is left in basket as planned, dose rate will be less.

ATTACHMENT II